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Abstract

Information and Communication Technologies (ICTs) are increasingly recognised for their potential contributions to health service delivery in Low-and Middle-Income Countries (LMICs). As well as playing a role in improving the provision of health services under everyday "normal" circumstances, ICTs can also be important in preparing for, mitigating, responding to, and recovering from disasters. This research explores the use of ICTs in a natural disaster situation in Nepal, a country affected by a series of strong earthquakes in 2015. In March and April 2016, in-depth semi-structured interviews (n=24) and focus group discussions (n=4) were conducted with key informants: those affected by the earthquake, and those forming part of the formal or informal health system responses. Data was collected and analysed across three levels, from the bottom "upwards", namely: (i) village level; (ii) district level, and (iii) central/national level. Perceptions of the role and value of ICTs varied greatly – as did patterns of use. While access and capability were found to be key barriers to use rurally, ICTs were nevertheless an important part of the informal response, helping people to gather information, express needs, and cope emotionally. They also helped relief agencies in allowing for networking and coordination among actors. Use of ICTs in the formal health system response, however, was severely lacking in many areas, relying more on traditional methods of disaster management. This reflects a general deficiency in, and underuse of, ICTs in the pre-earthquake Nepali healthcare system. We conclude by calling for a redoubling of efforts to improve and increase the adoption, diffusion, integration and regular use of ICTs within the Nepali health system – an approach that will assist with day-to-day service delivery but also provide a crucial platform upon which to build during future crises.

Introduction

Health systems, encompassing, broadly, "any set of activities whose primary intent is to improve or maintain health" (Murray and Frenk, 2000) have the potential to benefit substantially from the rapid developments in Information and Communication Technologies (ICTs) over recent decades (Chandrasekhar & Ghosh, 2001). ICTs comprise both physical technologies such as radios, computers, mobile phones and tablets, as well as virtual technologies that these devices give access to, such as surveillance tools, document sharing platforms and social media sites – also known as "Web 2.0" – which allow real time virtual interactions through online "Web-based" platforms (O'Reilly, 2005). In resource-limited settings in particular, increased and regular use of ICTs in the health sector holds huge potential. Examples include further developing the health workforce through remote training and management of healthcare workers, and delivering some health services remotely through "telemedicine" (Bhatta 2015). In addition to such benefits under usual ("normal") conditions, ICTs also have the potential to help transform health information collection and sharing, as well as access to healthcare and disaster management services for all, in times of crises (Sendai Framework, United Nations, 2015).

Disaster management includes specific measures undertaken in preparation for, as well as in response to, a disaster. Although this study focuses primarily on the response stage of a recent disaster, it is important to note that response forms part of a broader disaster management cycle, which includes mitigation, preparation, response and recovery stages (Alexander, 2002).

Disaster management has historically utilised a top-down approach: the remit of formal and, generally, government-led systems that are often – especially in low- and middle-income countries (LMICs) – supported by (International) Non-Governmental Organizations, International Organizations, and foreign aid donors. The health system's roles in disaster

management are varied, including search and rescue operations, treating the wounded and sick, effecting medical evacuations, managing contamination and the spread of diseases, and communicating with the public to reduce potential threats to public health, amongst other tasks (Auf der Heide and Scanlon, 2007).

However, more recently, there has been an increased focus on people, relationships and communities as instrumental in disaster management processes (Wulf *et al*., 2013; Yates and Paquette, 2011; Palen *et al.,* 2010; Palen and Liu, 2007) and, more generally, in health systems strengthening and promoting resilience (Sheikh *et al*., 2011). Not only do people contribute to the coping ability of their communities, they are also active agents in seeking out, distributing, and validating information which is of use to other members of their community, as well as to the formal health system response. Even though disaster management has traditionally privileged a top-down command and control approach, it has recently been argued that resilience can be increased by shifting to a model of collaboration and decentralisation (O'Sullivan *et al*., 2010), which involves empowering those not traditionally considered as agents in the health system – the disaster victims themselves. As Palen *et al*. (2010) suggest, ordinary people tend to be the true first responders. Indeed, efforts of individuals and communities acting outside of the formal system may have large impacts, especially where compensating for a deficit in the formal response. For example, in the aftermath of the Haiti earthquake in 2010, informal local responders played critical roles in fundraising and providing information to media outlets (PEJ New Media Index, 2010), as well as other roles which may have traditionally been perceived as responsibilities of the formal system. A more recent goal of disaster management has therefore been to enable and empower individuals and communities to access, create, and act on information in response to disasters, as well as to strengthen links between affected communities and those responsible for coordinating disaster management.

Correlating with their increased general use, ICTs have been playing a growing role in all stages of disaster management. In the response stage, coordination between emergency personnel, media, government bodies and other actors involved in the relief effort is key (Watson *et al*., 2007). ICTs are valued for their ability to provide a common platform for interaction between these groups (Yates and Paquette, 2011) and to gather, share and analyse large amounts of data to assist in determining priorities (Williams and Phillips. 2014). The informal community-level response is similarly often facilitated by ICTs, which have enabled new communication channels between citizens and government as well as private sector organizations, with potential for health information and health services to be more readily available and more responsive to the needs of citizens (Pearce *et al.*, 2015). ICTs may also play a role in fulfilling people's health, safety, and social needs after disasters. However, ICTs are merely tools; they are only as good as their adoption, diffusion, integration and actual use, during pre-disaster ("normal") conditions allows them to be (Wulf *et al.,* 2013).

Whilst the involvement of ICTs in disaster management is not a new field of research, studies have historically focused primarily on high-income countries, where access to, use of, and capability to use ICTs are more widespread (Yap, 2011). However, in the context of LMICs, although penetration of ICTs such as mobile phones is steadily increasing (International Telecommunication Union, 2015), poverty, poor education, and lack of communication infrastructure present common barriers to the process of developing collective intelligence and communication channels for use in responding to disasters. If the full potential of using ICTs to enhance resilience in the face of disaster is to be realised, research must now also focus on the relationship between formal and informal response efforts in LMICs, and the potential use of ICTs in both (as well as between them), for the benefit of those most affected by disasters.

In April 2015, a series of earthquakes – the largest of which measured a magnitude of 7.8 – and numerous resulting landslides and aftershocks struck central Nepal, with the epicentre of the first earthquake being located near the rural village of Barpak, Gorkha District (Figure 1). The effects were devastating; nationwide there were a total of 8,856 reported deaths and 22,309 reported injuries (Nepal Disaster Risk Reduction Portal, 2015), as well as significant damage to transportation routes and to sites of cultural value (Roy *et al*., 2015). With ICT use in Nepal growing (NTA 2015; NTA 2016), there were many diverse and innovative uses of ICTs in the response and recovery efforts by Nepalis, as well as by the international community and diaspora. For example, Facebook's Safety Check was activated, allowing friend networks to check on the wellbeing of their family and friends. Many young people were reported to have started up small organisations that leveraged mobile and web platforms, such as the Rapid Response Team, which started a "text for information" service (www.facebook.com/rrtnepal). The day after the earthquake, Kathmandu Living Labs deployed a map (www.QuakeMap.org) which accepted, verified, and published information from citizens, adding over 2,000 reports and exemplifying ICT's capacity for organising large quantities of data. Hashtags also served to group information, with "#nepalphotoproject", created by one individual in Nepal, being used on Twitter and Instagram to collate visual depictions of damage and to link people to relevant relief organisations. Whilst ICTs clearly had a role in this informal (and often ad hoc) disaster response, these efforts were often separate from the formal institutional response, which was criticised for its slow progress due, in part, to "political instability and inadequate institutional mechanisms for disaster risk reduction nationally" (Sharma, 2015), as well for more general bureaucratic inefficiencies (seen, for example, in the delays in forming the National Reconstruction Authority (NRA), which took nine months to become active (NRA, 2016)).

An estimated 83% of Nepal's population lives in rural and remote parts of the country (Central Bureau of Statistics, 2012) and, whilst the most recent figures produced by the Nepal Telecommunications Authority show mobile phone ownership is widespread, and Internet penetration is reportedly at 47% nationally (NTA, 2016), this obscures a situation of vastly different rates of ownership and use by gender, geography, socio-economic status, and caste. As such, those outside of the relatively modern capital city may have experienced this disaster, and the formal and informal responses to it, very differently from their urban counterparts. With the 2015 Gorkha earthquake as a point of departure, here we explore how individuals, communities, organizations and the Nepali health system used ICTs to meet health and wellbeing needs, and how this impacted on resilience of the formal and informal health systems in the broadest sense, which includes not only the "hardware" structures such as hospitals and health centres, but also the "software" of people and their communities acting informally to protect and support each other's health.

Methods

Study area and sampling population

A total of 24 in-depth interviews and 4 Focus Group Discussions (FGDs) were conducted across rural and urban settings of Nepal in March and April 2016, one year post-disaster. Data collection took place at three key locations, namely: (1) at village level in Barpak, the rural village closest to the epicentre of the earthquake; (2) at district level in Gorkha, the capital of the district in which Barpak is located; and (3) at central level, in Kathmandu (Figure 1, Table 1). A "bottom-up" approach was taken, which intended to focus primarily on the voices of individuals with personal experience of the earthquake at village-level before triangulating with the views of those representing agencies (government and non-government) at the district and central levels. This was done in order to allow for comparison

147 between the reported experiences of those most directly affected with the "official views" of
148 local and central government, national and international humanitarian aid providers, and
149 others involved in the response.
150
151 *< insert Figure 1 about here >*
152
153 Purposive sampling was used to select study participants at all levels to ensure
154 representation of both men and women, young adults, older adults, those of Dalit caste,
155 village health care workers, pharmacy workers, representatives of national and international
156 non-governmental organisations (NGOs), and those who had become activists or ad hoc
157 responders as a result of the earthquake. In addition, snowball sampling was used to aid in the
158 identification of hard to reach individuals or groups. At village level, we attempted to include
159 a representative sample of the community as a whole, assisted by a local 'fixer'. At district
160 and central/national levels, participants were invited according to their roles in disaster
161 management and recovery, ensuring representation from as many key groups as possible.
162 Members of the research team have worked both directly and indirectly with the Government
163 of Nepal and many of the agencies involved in responding to the earthquake over a number of
164 years. These professional networks were drawn upon at district/national levels to identify
165 potential participants. All participants had direct experience of responding to the earthquake,
166 either as a victim of the earthquake, an informal "first responder", or a professional involved
167 in the formal earthquake response, relief and recovery processes, and all were thus well
168 placed to offer insights specific to the phenomenon in question (Patton 2002). All participants
169 agreed to take part in the study. Interviews/FGDs took place in a range of settings depending
170 on the location of the participant, including in/surrounding domestic residences, private
171 offices and board rooms. All village level (and in some cases at district level)

172 interviews/FGDs were conducted in Nepali, due to necessity and/or participant preference,
173 with the aid of an experienced translator trained in nursing and social science research, whilst
174 at central/national level all interviews/FGDs were conducted in English.
175
176 *< insert Table 1 about here >*
177
178 The study of ICT use set out in this paper is part of a larger ongoing collaboration between
179 the University of Sheffield, UK and Tribhuvan University, Nepal, examining health system
180 resilience and reconstruction in the aftermath of the 2015 earthquakes.
181
182 In-depth interviews
183 Semi-structured, in-depth interviews were conducted in-person at all three levels of data
184 collection, lasting between 35 and 90 minutes each. Comfort of the participants was fostered
185 by situating interviews, where possible, in locations familiar to them (e.g. workplace or
186 communal area), and care was taken to ensure privacy. Dress reflected appropriate cultural
187 norms and was more formal for interviews in Kathmandu, where participants were often
188 interviewed in their professional capacity. With the informed consent of participants,
189 interviews were recorded using an audio device; where consent for recording was not given,
190 notes were taken and the researcher recorded an audio summary immediately following the
191 interview. A detailed reflective field diary was also kept and updated promptly. All audio
192 data was anonymised using a code, and then professionally transcribed, whilst also checking
193 for accuracy of the translation where appropriate.
194 An interview guide, designed to allow probing and follow-up questions (Bryman,
195 2016), was informed by key themes identified during an extensive inter-disciplinary literature
196 review. The guide aimed to identify the roles of the individual; their use and understanding

of, and beliefs about ICTs; behaviour change since the earthquake; cultural ways of using ICTs; instances and examples of ICTs impacting health, wellbeing, and service delivery. The guide remained somewhat adaptable and flexible enough to incorporate new or spontaneously arising information, in order to minimise hypothesis-confirmation bias (Kumar, 1987). Recordings were listened to and discussed between all team members in the field to determine when sufficient data had been collected; practical concerns such as time and cost constraints also contributed to this decision-making.

Focus Group Discussions

At village level in Barpak, 3 FGDs were conducted with separate groups for men, women and young women (aged 18-25 years). Women were split into two groups by age in order to enable greater participation of young women, who are more likely than young men to not participate when older members of the same gender are present. Women and men were separated to ensure cultural appropriateness in a generally patriarchal society (Dhungana, 2006), as well as to explore potential age- and/or gender-based digital divide(s) (Antonio and Tuffley, 2014). The FGDs were held in Nepali, and translated into English, and were recorded upon consent of all group members. The recording was then professionally transcribed, whilst also checking for accuracy of the translation.

At central/national level an "executive" FGD was held, in English, in the form of an all-day workshop with 17 senior members of (I)NGOs, government, international organisations and donors. Of these attendees, seven represented International Non-Governmental Organisations (INGOs), all of which specialised in either health, emergencies, or both. Three attendees were from Nepali non-Governmental Organisations (NGOs); five represented the Government of Nepal (three from the Ministry of Health, one from the Department of Water Supply & Sewerage, and one member of the Disaster Preparedness and

Response Committee); one represented a UN agency; and one represented a foreign government aid department. The meeting was divided into three sections: (i) the immediate period after the first earthquake; (ii) the remainder of the year; and (iii) lessons learned from the disaster. In order to encourage candid responses, the meeting was held under the Chatham House rule and thus not recorded, but extensive hand-written notes were taken by 4 members of the research team and then shared and discussed internally. Additionally, an audio-summary was recorded by the team immediately after the workshop ended.

Data analysis

A standard framework for analysis was used (Ritchie and Spencer, 1992). This involved, firstly, familiarisation with data through repeated exposure and self-immersion in the raw data from the interviews/FGDs, in combination with notes on body language and other forms of written or recorded information. Secondly, using the constant comparison method, significant sections of the interview transcripts were highlighted and coded as both pre-figured and new themes were identified, with frequent revisiting of data, as well as comparison and triangulation across levels. Thirdly, themes were indexed using the qualitative data analysis software programme NVivo (QSR International Pty Ltd. Version 11, 2015), in order to facilitate data organization and retrieval. Data was searched for "general statements" and relationships (Marshall and Rossman, 1999), explanations for which were tested by looking for contrasting evidence using negative case analysis, as described by Lincoln and Guba (1985), in order to increase the quality and rigour of the findings, which are presented in the following section from the community level, "upwards", mirroring the research design. Finally, exemplary quotations from the data were selected to illustrate key findings.

Results

Participant characteristics

Participants of interviews and FGDs (total n = 99) contributed a wide range of experiences, both professional and personal, as the earthquake had a significant impact on all areas of their lives. All participants were adults. Women made up 44% of all participants (53% of FGD participants and 25% of interview participants) (Table 2). Nine interviews (n = 9) and three FGDs (n = 58) took place at village level; ten interviews at district level (n = 10), and 5 interviews (n = 5) and one FGD (n = 17) at central/national level (Table 3). Most participants had been present in the country during the time of the earthquake, although a handful of men in Barpak had been working overseas and returned home as a direct result of the earthquake. Likewise, some NGO staff in Kathmandu had arrived immediately following the earthquake. The majority had never experienced a natural disaster of this scale (or indeed any) previously.

< insert Tables 2 and 3 about here >

Although initial consideration had been given to the interaction of ICTs with all stages of disaster management, during data collection there was a clear and strong focus by participants on the response phase. This was due to the ongoing nature of that stage at the time of data collection (many participants noted that the country had not by that stage moved from the response into the longer-term reconstruction phase). These results are reflected here.

ICTs in the community-level response

Interviews and focus groups conducted with rural participants in the village of Barpak contributed to the understanding of community-level use of ICTs. Participants used ICTs to

meet many of their practical and emotional needs – including around physical health and mental wellbeing – in this time of crisis, which can be seen to have contributed to their coping ability in the response phase. Rather than being passive victims of the earthquake, or later passive recipients of aid, we found that some at the village level had exercised considerable agency in seeking to meet their own needs, and that ICTs had (for some) been an important facilitator of this.

Contact with family and diaspora

At village level, participants reported an immediate and strong desire to contact family members living away from home, nationally and internationally:

> *If the family members are dispersed during a catastrophic situation we* [are] *really, really worried.* (FGD 2, females, village level)

Reasons given for this were both practical (e.g. requirements for financial aid) and emotional (reassurance), both of which appeared vitally important to respondents' wellbeing. Mobile phone calls, the usual method of contact prior to the earthquake, were relied on heavily. Although some telecommunications infrastructure sustained damage, NCell, the provider whose systems fared best after the earthquake, was widely praised:

> *We could not imagine life at that time if phones were not there. It would have been impossible for us to contact our family member overseas if NCell were not* [functioning]. *Now everybody has understood the importance of mobile phones... NCell was a lifeline.* (FGD 1, males, village level)

Communication with family helped participants feel emotionally safe and connected to their loved ones, and it also helped them gather and share information from, and with, other parts of the country and internationally.

297

298 *Information gathering and need expression*

299 Participants at village level focused on the value of ICTs for gathering information about the
300 wider effects of the earthquake and news of family living elsewhere, as well to express their
301 own and their family's needs to those they saw as able to help them, particularly the need for
302 supplies such as food, shelter and medication. Need expression, although vital, was clearly
303 determined by a level of status and social capital:

304 *People who can talk* [have their voice heard], *they have received* [relief
305 materials] *but people who were not able to talk* [have their voice heard],
306 *didn't get anything.* (FGD 2, females, village level)

307 ICTs conferred some power, enabling needs to be met from further afield. Interestingly,
308 although provision of emergency material would usually be seen as a role of the formal
309 disaster response system, the formal system was bypassed by some participants, who instead
310 went directly to their own contacts. This may indicate that the formal system was not
311 perceived to be accessible or reliable. Needing to rely on personal contacts may disadvantage
312 groups without such advantageous networks, creating inequality in recovery processes:

313 *We requested materials like solar because there was no power supply, tents*
314 *because there was heavy rain. We requested these materials through our*
315 *personal contacts via phone and SMS.* (FGD 1, males, village level)

316 However, in the immediate aftermath of the earthquake, damage to network towers
317 temporarily rerouted communication from mobile phones to face-to-face, bringing affected
318 groups into contact with representatives of the formal response, who were at that time more
319 easily reachable in person. When digital or virtual forms of information sharing and
320 communication were not available, people living in Barpak are reported to have travelled on
321 foot for an entire day or longer via earthquake-affected roads in order to speak with district

level staff. Aid workers took motorbikes or, where roads were too damaged, walked to rural areas to assess the situation. Meanwhile, members of the Nepali diaspora living overseas, whose access to ICTs had not been affected, used internet and email to contact local radio stations to request lists of the injured and dead. Although radio station staff reportedly obtained this information from local police and rescue efforts (part of the formal system) (Participant 14, male, district level), it was informal channels which had been chosen by individuals to act as a liaison.

ICTs were used opportunistically in rural Barpak: provision of free WiFi for a number of months by NCell in an attempt to aid response efforts resulted in an upturn of interest in and use of online platforms. Whilst it was widely praised, this effect was reversed once free WiFi was removed.

> *Yes, we used it* [social media] *at that time but not now. There isn't free WiFi now.* (FGD 1, males, village level)

Grief and coping

There was some evidence that ICTs interacted with people's grief processes, with potential implications (both positive and negative) for mental wellbeing. For example, one participant told us about how a foreign film crew exploited him by making a documentary about the physical injuries he sustained during the earthquake and the effect this had had on his life and family. The footage was made available for profit in which the participant did not share. Despite occasional instances of such exploitative practices, technology was recognised as vital for expressing grief and trauma by many village-level participants, whether online or, more commonly, by telephone or radio. Its only limitation was insufficient intimacy when compared with a face-to-face conversation:

346 *…only phone was not enough to express our loss…* (FGD 2, females, village
347 level)
348
349 *Barriers to greater ICT use*
350 Patterns of ICT use at the community level were shaped by barriers such as low access and
351 lack of capability, which are often concentrated in rural areas like Barpak. Capability and
352 access are clearly played out in a "digital divide" and low representation of certain groups in
353 the Web 2.0 domain (Chandrasekhar and Ghosh, 2001), caused by and resulting in increased
354 inequality and resource power imbalance.
355 Capability was found to be a key determinant of ICT use in Barpak. Many rural
356 respondents confessed to knowing about tools such as social media sites, but never having
357 used them, nor knowing how to use them. In some instances this stemmed from illiteracy – a
358 major barrier to accessing online spaces and information through channels other than voice,
359 especially for older generations. Online operating language was found to be an additional
360 barrier, particularly in rural areas. A Kathmandu-based relief worker who used social media
361 to gather volunteers acknowledged this:
362 *I write in English you know, and people don't read English, so there is*
363 *obviously that barrier that exists.* (Participant 22, female, central/national
364 level)
365 Importantly, capability and access issues appeared to also be age-related, with young people
366 more likely to use social media platforms in particular. Young people were professed by the
367 older generations to "use Facebook" (FGD1, FGD2, males and females, respectively, village
368 level), which appeared to be a catch-all phrase for Internet use and familiarity.
369 *Yes these days we know about Facebook but we don't know how to use it.*
370 *Only young people use it*. (FGD2, females, village level)

371 However, there was evidence of resourcefulness in overcoming such barriers. Two female
372 participants owned and operated basic phones despite their illiteracy, through setting speed-
373 dial numbers and memorising keyboard placement. Additionally, communal use of ICTs, as
374 in groups listening to the radio on one mobile phone (Participant 11, male, district level),
375 partially alleviated inequalities of access within the community, although control of devices
376 remained primarily with those of higher socioeconomic status.
377 The earthquake created additional barriers to ICT use both through damage to
378 physical technologies and by worsening electricity provision – existing load shedding was
379 added to by physical damage. Although mobile phones were largely spared from damage
380 because "everybody had mobile [with them]…. usually it's in [their] pocket" (Participant 11,
381 male, district level), physical damage claimed many televisions, computers and radios, which
382 were left in people's homes as they escaped. In Barpak, distribution of small solar charging
383 devices soon after the earthquake was said to have enabled easier charging of devices,
384 compensating for lower and more sporadic supply from regular means. This damage to
385 equipment and fluctuation in power supply appeared to have no lasting (negative) effect on
386 ICT use, as people re-built their lives. Indeed, participants both at rural community level and
387 district (town) level reported an increased ownership of mobile phones as a result of their
388 perceived value during the earthquake response, particularly among females:
389 *...now in the remote area mothers and sisters they have got one simple*
390 *mobile phone and they easily use that.* (Participant 13, male, district level)
391 The "mothers and sisters" in our focus groups concurred that levels had increased, noting also
392 that their own awareness of the importance had been raised.
393 *We have realised the importance of communication.* (FGD 2, females,
394 village level)

However, despite these reports, men still appear to have greater access and connectivity, demonstrated anecdotally by the 11 phone calls that interrupted the male FGD compared with only one in the female FGD. Additionally, phone ownership does not necessarily correlate with use of Internet and other online tools due to limited functionality of older "non-smart" phones and high costs of data. This raises the question of whether increased access to ICTs for women in particular might support coping capabilities of the families and networks they are part of, especially when families are spread across countries:

ICTs in the informal response

There was extensive evidence of an informal response to the earthquake which was motivated both by altruism and as a direct reaction to the perceived lack of action taken by the formal system. The informal response was made up of individuals often acting outside of their conventional roles, whether the conventional role was as a citizen, radio broadcaster, international diaspora, or even as part of the formal health system itself. Most participants generally agreed with the sentiment that:

> *First responders were not INGOs, NGOs, or the government. The first responders were the people of Nepal* (Participant 22, female, central/national level)

For example, in Barpak, a small private pharmacy dispensed all their stock in the first day, treating fellow villagers for free before the army and additional medical services arrived, as the health post was largely inaccessible due to damage. Men in the focus group asserted that:

> *Respondent 1: Before actual support, there is one private doctor from Medical Hall* [pharmacy] *who provided free treatments.*
>
> *Respondent 2: She is not a doctor: pharmacist.*

Respondent 1: She provided free treatments to all as much as she can… she distributed all the medicine which she had in her Medical Hall [pharmacy] *free of cost*

Further from the epicentre, many people living in Kathmandu or in other less-affected parts of the country rapidly returned to their home villages, taking emergency supplies with them, or sought to collect materials and money to send home. One Kathmandu-based activist said:

What happened in Nepal was something I have really never seen. You know people just like coming together, literally digging their own purses, sleeping out at night, whatever it took people did. (Participant 22, female, central/national level)

The informal response was seen rurally, at district level, and in the urban capital, but ICT use was higher the more urban the setting, facilitating coordination and efficiency.

Information gathering and need expression

Social media was recognised for its ability to express need to an audience with whom interaction might normally be limited. Informal responders reached global audiences using social media to "make [donating money] a trend" (Participant 21, male, central/national level) through the use of public approval/rating functions of these tools. The needs (especially health needs) of affected groups living rurally were picked up by urban activists and broadcast more widely. One participant stated that "young people in the capital got information of where was particularly in need and posted it on Facebook" (Participant 24, male, central/national level) and indeed several other participants at central/national level reported doing this themselves, bypassing the formal system.

Decision-makers and politicians were able to be reached and lobbied by broadcasting, through radio and online channels, issues perceived as important, such as receiving the house rebuilding grant in a lump sum rather than in separate instalments:

> *...the phone call made by a single individual might be forgotten, but if the same thing goes via* [mass] *media it will give pressure to them* [the government/politicians]. (Participant 14, male, district level)

In this way, ICTs were used to apply social pressure, with shame and reward being powerful motivators.

Coordination

The dispersed nature of the informal response led to more creative uses of ICTs to create and coordinate networks, and to connect and partially integrate with the formal system. Examples include a radio station broadcaster taking calls from remote areas and broadcasting them by holding his personal phone up to the microphone, thereby alerting army and government personnel to conditions in rural areas (Participant 14, male, district level). At national level, volunteers used phone cameras to make videos and social media to share them to raise funds, posted pictures of damage online for verification, and collected materials to take to affected areas themselves. Some verified trustworthiness of potential project partners through mutual friends on Facebook (Participant 22, female, central/national level).

Resilience and flexibility to adapt

In urban settings the informal responders adapted their use of ICTs as a result of earthquake-caused disruption, improving resilience and, ultimately, effectiveness. One participant, a woman who had returned to Nepal after the earthquake to assist in the response from the

capital city, reported recording scheduled load-shedding times and "café hopping" between powered areas, using free WiFi to coordinate her grassroots response efforts.

ICT also facilitated resilience through its capacity for validation. In the aftermath of the earthquake rumours were rife, spreading suspicions regarding the cause of the earthquake (Participant 25, male, central/national level), the spread of diseases (FGD 4, mixed gender, national level), an ensuing volcanic eruption (Participant 14, male, district level) and that another earthquake would strike on the 1-year anniversary (Participant 21, male, central/national level). If not well managed, ICTs had the potential to intensify the spread of incorrect information, creating further fear and conflict. However, participants observed that the system policed itself to an extent; several participants at central/national level spoke positively about a rumour tracking website named the Accountability Lab (www.accountabilitylab.org), which identified and clarified misleading or potentially damaging information.

ICTs in the formal response

The formal health system response was made up of the Nepali government and its coordination of other agencies via its One Door policy (The Asia Foundation, 2015); the UN cluster system which covered both health and other relevant clusters such as shelter and communication, and which operated at both district and national levels; as well as hospitals, health posts and other structures of the formally managed government health system. Views on ICT use from both within this response, and from others about this response, highlighted its difference from the informal response. Although some individuals with roles in the formal response reported using ICTs, this was not in a systematic, integrated or formalised way, and traditional communication methods were more common. For example, the health post in Barpak had not introduced electronic patient records and, apart from the Officer in Charge

using his personal mobile phone for work purposes, there were no other physical or virtual ICTs available for use prior to the earthquake or during the response phase. Rather, paper records were kept and periodically forwarded to district HQ. Aside from the mobile phone, no means of accessing online information was available either before or after the earthquakes.

Coordination

The extent to which ICTs were used to organise and co-ordinate relief activities was lower in the formal compared with the informal response. ICT use within the formal health system was less frequent and generally limited to more conventional methods: of the fourteen participants who had roles within the formal system, only two particularly dynamic individuals spoke about ICTs other than mobile phones, with one describing his use of Google Drive, Dropbox, Internet, websites, and Skype, among others. This was partly due to the importance of face-to-face coordination both at district and national level, where key players involved in coordinating the response effort tended to be located physically close to one another, and to know each other personally. This allowed representatives of the various agencies involved to be drawn together quickly without using ICTs to enable coordination. Some informal volunteer responders, frustrated by perceived low levels of ICT use by the formal responders, emphasised that what was necessary was not complicated "rigorous regression analysis or linear programming" (Participant 22, female, central/national level), but rather simple methods of document sharing and flexible means of virtual connection.

ICTs in future planning and resilience

Some participants, particularly those involved in the informal response, claimed that there had been a surge in general ICT use, which was expected to connect and empower people, potentially increasing the coping capacity of rural areas. However, those representing formal

response agencies appeared to place very little emphasis of the potential role of ICTs in future resilience. Their primary focus for future-proofing against further disasters was on physical structures, stemming from a very literal translation of the concept of "building back better", and from agreement with the common refrain that "it's not the earthquake that killed people, rather it was the [poor] construction" (Participant 15, male, district level).

Barriers to ICT use

Factors shaping the often-limited use of ICTs by those working in the formal system were alluded to by some participants. The first factor is a general sense of uncertainty which prevented the formal system – which could be seen as more risk averse than the informal response, or needing to act with greater accountability – from providing information in public and recordable ways using ICTs. After the earthquake, the paucity of provision of reliable information was attributed by one participant to organisations' fear of being held accountable within an uncertain and fluid context:

> *Different partner organisation are afraid to disseminate those information because it will be changing and they think they will be responsible in front of beneficiaries later on.* (Participant 20, male, district level)

Instead, information was said to be withheld from the public.

The second potential barrier to use of ICTs in the formal system may be capability. Although literacy and language issues are much less likely to be a barrier than at rural community level, it may be that some individuals acting as part of the formal response are not familiar with some forms of ICT which are beginning to be thought of as a standard part of disaster management elsewhere: for example geographical mapping databases. This is supported by the impression that the quality of the formal response was shaped by chance,

being “more down to who was where and the different personalities involved” (Participant 25, male, central/national level).

Discussion

This work is concerned with community-level, informal, and formal response uses of ICTs during times of emergency, and the reasons behind these patterns of use. The results focus on the immediate response phase following the 2015 Gorkha earthquake, starting at the village closest to the epicentre and working “upwards” and outwards. It extends the limited body of literature linking the use of ICTs with disaster response and resilience in LMICs.

To claim that Nepal was resilient is partly to fail to recognise the severity of the disaster and the failures to create systems and structures to protect people against its effects. Failures included cases of poor preparedness witnessed even in aid organisations; reports of failures to communicate some plans or advice from the formal system – not just the health system, but the interaction of all responders who had formal responsibility for action – to affected groups; and a delay in setting up the NRA which led to unapproved, self-funded and less-safe rebuilding work being undertaken through necessity. This research did, however, find multiple examples of human agency and inventiveness in the face of disaster, although these were coupled with a range of systemic barriers. McKinsey (2014) found four key barriers to ICT use globally, including lack of incentives, affordability, user capability, and poor infrastructure. We found that incentives for, and affordability of, ICT use temporarily increased, through sheer need and also due to innovative policy responses to the disaster. The telecommunications infrastructure coped better than expected in this setting, with the NCell tower in Barpak, for example, continuing to function. Problems of capability and access, however, persisted in the rural area.

In disaster situations, lack of ICT access and capability restricts voices, particularly when these barriers are unevenly distributed, as is the case in Nepal. Although older literature suggests that only key people such as health workers need access to ICTs for a community to gain benefit (Chandrasekhar and Ghosh, 2001), this arguably no longer applies. ICTs have moved beyond devices such as radios and phones, to Web 2.0 platforms, which achieve maximum benefit only when access is near universal, as in many high-income country settings. In low-income settings such as Nepal, these technologies are now starting to become more accessible across different social groups, and can be seen to be democratising information access and sharing. They create online communities which support collective intelligence (Liu *et al*., 2008), enabling affected individuals to "become a serious, valuable and respectful partner during and after emergencies" (Jaroslav Varuch, Ushahidi cited in Harvard Humanitarian Initiative, 2011:32).

Indeed, this study confirms the assertion that disaster victims and the informal response are often the first true responders (Palen *et al.,* 2010). Their empowerment, and connection with other sectors that have disaster management responsibilities, is needed to take advantage of their motivation to help and their access to local information. The formal systems involved in disaster response must recognise the value of informal responders and work to partner with them. These individuals also need to be able to transmit information to each other in the face of a dearth of local information from official sources (Shklovski *et al*., 2008). As such, we concur that ICTs can be key tools to "leverage the power of the collective intelligence of the citizenry" (Palen *et al.,* 2010: 2). Moreover, innovative approaches described by participants have the potential to reach a greater audience than traditional means, making them highly valuable in managing information and misinformation during crises (Starbird *et al*., 2014). Further research in Nepal, and in other settings, may indicate how this can be harnessed for crisis resilience.

589 This study supports previous theories that ICTs are only as effective as their
590 congruence with cultural methods of communication (Wulf *et al*., 2013; Dodson *et al.,* 2013).
591 The data also suggests that micro-cultures may be as influential as national ones within the
592 study setting. The culture of networking within the informal response was facilitated by
593 social media, which also allowed "vetting" of new connections through mutual friends. Other
594 disasters have presented evidence of the same function being served in formal systems, as
595 seen after the Haiti earthquake, where Wikipedia pages visible to all government agencies
596 superseded the traditional formal liaison structures by allowing all staff access to other
597 agencies and their information (Yates and Paquette, 2011). In this study, examples from
598 within the formal system were typically from individuals going above and beyond their
599 official duties, blurring their role between formal and informal responses. Although social
600 media may begin to blur boundaries between the formal and the informal through facilitation
601 of activities such as citizen journalism, a key challenge remains connecting the two groups to
602 each other in order that the information held by each group may be transmitted for the benefit
603 of the other (van Gorp, 2014). There is an urgent need for formal systems – both health and
604 governance systems more widely – to become more interactive, communicative, and creative
605 in order to capitalise on the additional roles of "new" citizen actors. Technologies enabling
606 this may have a crucial role in future disasters, particularly where formal responses remain
607 under-budgeted, poorly staffed, rigid or non-existent. Literature agrees that use of ICTs by
608 the formal health system facilitates faster decision-making and information sharing (Yates
609 and Paquette, 2011).
610 One of the main problems the formal health system faced in using ICTs in the disaster
611 response was the scant use of ICTs before the crisis. As mentioned above, the Barpak health
612 post had no ICT facilities other than the mobile phone belonging to the OIC, which was used
613 pre-earthquake to communicate with higher-ranked health system officials at the district level

614 when necessary. This meant that post-earthquake there was little in terms of routine ICT use
615 for the formal emergency response to build upon. Furthermore, the OIC was away from his
616 health post at the time of the first earthquake, increasing the reliance on community-led and
617 informal responses such as the work of the private pharmacist.

618 The potential for greater health system use of ICTs in the village was there. Although
619 there was some disruption to electricity and mobile phone communications, in Barpak
620 communication services continued for the most part – to the surprise (and relief) of many
621 informants. The barriers to greater ICT use within the formal health sector response were not,
622 at least in the case of Barpak, primarily technical ones. Although efforts are underway in
623 Nepal to expand the use of ICTs within the health system, coverage remains patchy and is not
624 country-wide. As in Barpak, this means that there is limited ICT infrastructure within the
625 day-to-day running of the health system that can be leveraged in response to future
626 emergencies. This highlights the important relationship between health system functions in
627 "normal" times and during times of emergency. A resilient ICT infrastructure within the
628 formal health system would ideally deliver benefits in both times.

629 When considering these results it is important to acknowledge some limitations. First,
630 given the sensitive nature of the research topic, is the difficulty of separating participants'
631 interviews (especially at district and central levels) as either professional or personal, as the
632 earthquake impacted on all areas of participants' lives. As such, there is a significant level of
633 inherent complexity which must be recognised. Second, this research was conducted one year
634 after the earthquakes struck, during which time migration may have removed those with
635 sufficient resources from the study area, and many aid workers would have left. An event as
636 traumatic as the earthquake studied here could cause memory to be preserved, or to decay,
637 perhaps being intentionally left behind and therefore affecting the data collected. Third, as the
638 epicentre of the earthquake, and with historically strong military links with the UK and with

India, Barpak is also not typically representative of Nepal's earthquake-affected areas. This may limit generalisability to other rural areas in Nepal which may not have had such relatively high resource power, access to ICTs, or contacts living overseas or in urban Nepal to leverage for help. However, Barpak was chosen specifically because of some of its unusual characteristics: the link with the Gurkhas meant that frequent international connections increased the population's exposure to ICTs, and its location as the epicentre meant that it was the focus of much attention from the media (and social media) and the recipient of relatively high levels of early relief efforts. Fourth, the role of the researcher is crucial in qualitative research and can affect the kinds of data collected. The experience and diversity of the research team in terms of nationality, age, gender, and disciplinary background allowed particular interviewers to be chosen based on appropriateness, i.e. female interviewers for the young women's focus group, and interviewer bias to be minimised (Kumar, 1987). Fifth, social desirability bias may have resulted from participants' desires to be seen in a positive light, potentially heightened by the research team's perceived authoritative status. However, this is not believed to be the case; care was taken to establish rapport and to express empathy in interactions. Continuous discussion within the project team throughout the study allowed for challenges to be raised and for discrepancies to be addressed, thereby increasing robustness and transparency.

This study has highlighted the need to take context into account when considering how to improve and capitalise on the use of ICTs in formal and informal health system disaster responses, particularly in resource-poor settings where there may be educational and literacy implications much broader than the field of disaster management. Improving access is likely to require research involving telecommunications companies, current government policy, and feasibility studies to explore access measures such as physical infrastructure to expand signal coverage and ways of providing financially viable access to the Internet. This

could capitalise on the desire, seen especially in the young, to connect, and would inform progress to overcome current barriers to ICT use for the general population.

Overall, we have illustrated that ICTs play important roles in community-level responses, in local and national-level informal response activities, and (at least potentially) in the formal health system response. It was in the latter case that ICTs appear to have been most underused in relation to their potential, pointing for a need for greater adoption, diffusion, integration and use of ICTs within the formal Nepali health system.

Methods to better connect the informal with the formal health system responses should also be explored. Research has found that formal health systems, particularly in developing countries, may lack the resources or capability for innovative ICT use for needs analysis and for information, education and communication purposes. However, information provided by, or about, local community contexts after disaster could be of great benefit to government efforts, as well as to NGOs and INGOs. At present, this is a vastly unfulfilled opportunity.

In summary, this work highlights the importance of integrating a variety of ICTs – both physical and virtual – into health systems during "normal" times, to make the health system more resilient in all stages of disaster management by creating means of capitalising on the agency of people and communities at the centre of the disaster. Qualitative data from a range of sources provided new and rich insights to understand the events during, and after, the 2015 Gorkha earthquake, and to inform future health systems strengthening, including the formal health system which plays a key role in disaster management activities in Nepal and more widely.

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