Journal of Epidemiology and Global Health (2016) xxx, xxx–xxx

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Disaster response under One Health in the aftermath of Nepal earthquake, 2015

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Received 3 December 2015; received in revised form 2 March 2016; accepted 8 March 2016

KEYWORDS
Disaster response;
Earthquake;
One Health;
Zoonoses

Abstract Until now, an estimate quotes that 1100 healthcare facilities were damaged and over 100,000 livestock lost in the two earthquakes that occurred in April and May of 2015 in Nepal. Threats of infectious diseases, mostly zoonoses, could affect Nepal's economy, trade, and tourism, and reaching the targets of the United Nations Millennium Development Goals. Historically, outbreaks of infectious diseases, including zoonoses, were largely associated with the aftereffects of the earthquakes. It has been documented that zoonoses constitute 61% of all known infectious diseases. Therefore, the purpose of this communication was to examine the infectious disease outbreaks after earthquakes around the world and explore the risk assessment of the zoonoses threats reported in Nepal and highlight adopting One Health. Our summaries on reported zoonoses in Nepal have shown that parasitic zoonoses were predominant, but other infectious disease outbreaks can occur. The fragile public health infrastructure and inadequately trained public health personnel can accelerate the transmission of infections, mostly zoonoses, in the post impact phase of the earthquake in Nepal. Therefore, we believe that with the support of aid agencies, veterinarians and health professionals can team up to resolve the crisis under One Health.

1. Introduction

Each year, more than a million earthquakes occur in the world [1], and over 530,000 deaths have been reported from earthquakes in the past 25 years [2]. The 2015 Nepal earthquake which killed more than 8622 people (as of May 21, 2015) and injured more than twice as many, occurred in Barpak,

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Peer review under responsibility of Ministry of Health, Saudi Arabia.

http://dx.doi.org/10.1016/j.jegh.2016.03.001

Gorkha district (epicenter) on April 25, 2015 with a moment magnitude of 7.8. Following this, a second earthquake occurred on May 12, 2015 with a moment magnitude of 7.3 in Chilankha, Dolakha district (epicenter). At least 3000 landslides have been triggered consequent to the earthquakes causing large land mass movement in the Himalayan nation, as assessed by the International Centre for Integrated Mountain Development, Kathmandu. The death toll in the neighboring countries of China, India, and Bangladesh was 126 [3].

Nepal may be one of the most beautiful countries in the world, but it is also one of Asia's poorest, with a total Gross Domestic Product of US $19.921 billion [4], and requires external support for a major reconstruction. Nepal's total health expenditure per capita is US$80 [5]. Geographically, the country is divided into the capital Kathmandu along with a few district headquarters and the rest of the country of rugged mountainous terrain. Two distinct modes of healthcare delivery exist; one that is dominated by district and zonal hospitals in the capital and district headquarters, and the remainder of the country served by primary healthcare centers and village health posts with inferior infrastructure and inadequately trained healthcare personnel that cannot sufficiently support the healthcare needs of the rural people [6]. Until now, an estimate quotes that 1100 healthcare facilities were damaged and >100,000 livestock lost in the two earthquakes. Consequently, 87 international medical teams have been mobilized which have treated >100,000 people [7].

Taylor et al. [8] documented that among the 1415 species of infectious organisms known to be pathogenic to humans, zoonoses constitute 61%, with humans as the primary reservoir for just 3%. Among 175 infectious species considered to be emerging, 75% are zoonotic. In addition, of all human food-borne illnesses, about 90% are from foods of animal origin. In the past, infectious disease outbreaks following natural disasters have been reported as a result of the interruption of public health measures ensuing destruction of the local infrastructure [9]. Hence, the potential for zoonoses outbreaks and transmission is high in the earthquake devastated Nepal. Nonetheless, the impact of zoonotic diseases on human and animal health is not monitored, prevented, and treated in an integrated way, despite the fact that the etiologies and treatments of these diseases are generally similar across species. Therefore, the purpose of this communication was to examine the infectious disease outbreaks after earthquakes around the world, explore the risk assessment of the zoonoses reported threats in Nepal, and highlight adopting the systems approach based One Health to control prevailing zoonoses and preempt postearthquake outbreaks in Nepal. All of our search results were restricted to publications in PubMed–the largest free access health information database for human and veterinary disciplines.

2. Infectious disease outbreaks after earthquakes

Broadly, earthquakes (geophysical disasters) and landslides (geomorphologic disasters) followed by secondary effects of the disaster exacerbate synergic risk factors (change in the environment, in human conditions and in the vulnerability to existing pathogens) for outbreaks and infectious disease transmission resulting from substantial population displacement into unplanned and overcrowded shelters and degradation of sanitary conditions, with limited access to food and safe water [8]. The prolonged health impacts associated were: collapse of healthcare facilities and healthcare systems, interruption of ongoing healthcare delivery, disruption of surveillance and health programs (immunization and vector control programs) and limitation or destruction of farming activities leading to food insecurity.

Some of the outbreaks of infectious diseases associated with earthquakes and landslides that occurred in different parts of the world in the past three decades are succinctly provided here as an overview for a foresight in Nepal, as we did not find any documentation in PubMed pertaining to Nepal. In 1991, a huge increase in the incidence of malaria was recorded after the earthquake and floods in Costa Rica as a result of an increase in mosquitoes caused by deforestation and changes in river flow patterns [10]. In Southern California, after the 1994 earthquake, an unusual outbreak of coccidioidomycosis, caused by the fungus *Coccidioides immitis*, occurred; the infection was associated with exposure to increased levels of arthrospores in dust clouds generated by the earthquake [11]. A report [12] after the 2001 El Salvador earthquake showed that 30% of 594 affected people experienced upper respiratory tract infection. In Iran, 1.6% of the 75,586 persons displaced by the Bam earthquake in 2003 were infected with diarrheal diseases due to poor hygiene, crowding, lack of potable water, and ineffective sanitation, and 14% had respiratory tract infections due to lack of protection in freezing winter nights [13]. In Turkey, 2004, following epidemiological and social factors arising after the earthquakes, there were

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increased rates of *Giardia lamblia* and *Enterobius vermicularis* infections [14].

Following the 2005 earthquake in Pakistan, a rise in the incidence of acute respiratory infections, diarrheal diseases, and tetanus, 400 cases of measles, outbreak of meningitis, and >1200 cases of hepatitis A and E were reported among the displaced population in areas where access to safe water was limited [15]. After a landslide in the Karnaphuli estuary of Bangladesh in May 2007, the rise of waste levels and changes in turbidity and salinity in already polluted waters resulted in an increase in bacterial growth, including a 10-fold increase in fecal coliforms and an increase in *Vibrio cholerae* populations [16]. In 2007, following a massive earthquake in the Solomon Islands, urban residents were at risk of malaria [17]. Following a landslide in 2010 in Eastern Uganda, there was a significant burden of infectious diseases; malaria (47.7%) and respiratory infections (58.3%) were more common [18]. Ten months after an earthquake in 2010, Haiti experienced the largest cholera epidemic ever reported in a single country [19].

Respiratory tract infections from dust clouds, diarrheal diseases from contaminated water, malaria from the increased mosquito population, and tetanus and measles among the vaccine preventable diseases were the commonly reported infectious diseases consequent to earthquakes. Relief providing aid agencies warned that there is a risk of serious outbreaks of disease in the earthquake ravaged Nepal [20]. Typically, in the impact phase of an earthquake, infectious disease outbreaks are inexistent and may occur several days, weeks, or months in the post impact or recovery phases of the earthquake [21]. Therefore, several infectious diseases reported from the past experience of earthquakes should be considered important in the current post-disaster situation in Nepal in the absence of any documentation from there.

3. Zoonoses in Nepal

To present the zoonoses reported threats in Nepal, our search in PubMed was restricted to ''zoonoses" or ''zoonosis" AND ''earthquakes" AND ''Nepal". We did not explore the term ''natural disasters" in PubMed, as this was considered broad. Briefly, zoonoses reported from Nepal and documented in PubMed are outlined here that comprise bacterial, parasitic, and viral zoonoses.

3.1. Bacterial zoonoses

Yak seropositivity for *Brucella* spp. was reported to be widespread in the region, and was associated with human disease [22]. Leptospirosis has been detected since the 1980s in Nepal and was mostly underreported [23]. The causes of undifferentiated febrile illnesses found serological evidence of acute murine typhus in 17% of patients and 57% of patients positive for *Rickettsia typhi* [24].

3.2. Parasitic zoonoses

Parasitic zoonoses present a significant burden for public health, particularly in poor and marginalized communities of Nepal. It was found that a large number of parasitic zoonoses present include: neurocysticercosis, congenital toxoplasmosis, trichinellosis, toxocariasis, diphyllobothriasis, food-borne trematodosis, and zoonotic intestinal helminthic and protozoal infections. Sufficient data were not available to quantify, nevertheless, they impose a higher impact than malaria and are comparable to human immunodeficiency virus/AIDS. Sporadic cases of alveolar echinococcosis, angiostrongylosis, capillariasis, dirofilariasis, gnathostomiasis, sparganosis, and cutaneous leishmaniasis have been reported. These results therefore suggest that parasitic zoonoses deserve greater attention and more intensive surveillance [25,26]. Although leishmaniasis is regarded as a significant health problem by the Ministry of Health in Nepal, the incidence of visceral leishmaniasis in Nepal was found to be increasing at a faster rate, as there is no active case detection program in the country [27]. *Cyclospora cayetanensis*, an emerging parasitic pathogen of humans, is being increasingly recognized in Nepal. *C. cayetanensis*-like oocysts were found in sewage water and from vegetable washings, and were also recovered from mice, rats, chickens, and dogs [28].

3.3. Viral zoonoses

Nepal has been classified as a high-risk region for rabies [29] and highly pathogenic avian influenza [30]. An investigation of enzootic infectious agents in the temple primate populations of Nepal found that the antibody seroprevalence was 94.9% to *Rhesus cytomegalovirus*, 89.7% to *Simian virus* 40, 64.1% to *Cercopithecine herpesvirus* 1, and 97.4% to *Simian foamy virus* [31]. Hepatitis E virus RNA and antibodies to hepatitis E virus were detected in domestic swine in the Kathmandu Valley of Nepal [32]. Japanese encephalitis risk factors were common across pig farms and pig farming districts [33] and the reported incidence of Japanese encephalitis among patients with an acute encephalitic syndrome in Nepal ranges between 20% and 62% [34].

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Analogous to a report which identified that 95% of helminths that infect human beings are considered zoonotic [8], our summary on reported zoonoses in Nepal showed that parasitic zoonoses were predominant, but other zoonotic disease outbreaks can occur in the current post earthquake scenario of Nepal. In addition, the most common practices of animal slaughter in Nepal involve dumping animal feces, intestinal contents, and offal directly into a river that gets accumulated downstream along the banks, especially during the dry season. As the river is also used for drinking water, bathing, and washing clothes and dishes, exposure to infections is high [35]. Other factors that can contribute to the dissemination of zoonoses are: unhygienic living conditions, lack of education, poor personal hygiene, poverty, and occupation. This major public health concern in Nepal coupled with a fragile public health infrastructure and inadequately trained public health personnel can accelerate the transmission of zoonoses in the post impact phase of the earthquake.

4. One Health response to earthquake

A study that analyzed the importance of zoonoses and communicable diseases common to man and animals, as potential public health emergencies of international concern, recorded in the World Health Organization (WHO) event management system database for the Americas, found 70% of communicable diseases are within the animal/human health interface [36]. There has been a paradigm shift in epidemiology, from mere risk factor identification to the next level of focusing on the underlying interactions within the whole system-the system's approach is suited for the management of zoonotic diseases.

One Health, by definition, amalgamates the ''collaborative effort of multiple disciplines working locally, nationally, and globally to attain optimal health for people, animals and our environment" [37]. It can be seen as a strategy for expanding interdisciplinary collaboration and communication in all aspects of healthcare for humans and animals, especially within the context of zoonoses [38].

More than 70% of Nepal's population works in the agriculture sector, which is in close contact with domestic animals and poultry, with frequent exposure to sick or infected animals. Due to the aftereffects of the earthquake, families have lost livestock, crops, agricultural inputs, feedstocks, and food [39]. Animals are injured, starved, and at high risk of diseases, and are in dire needs of healthcare like humans.

Although, many international organizations have offered support to prevent the spread of human and animal diseases, the contribution of different disciplines and sectors in disaster preparedness and response is important to reduce morbidity and mortality. The management of zoonoses is outside the scope of clinical medicine (bedside practice) and veterinary medicine (stall side practice). The One Health comparative clinical approach, which takes into consideration the ''shared risks" between humans and animals, concerning zoonoses, promotes better cooperation and collaboration between human and animal health professionals to identify and reduce such risks.

Existing surveillance systems for zoonoses have substantial gaps, especially in developing countries like Nepal. The two general surveillance systems for early warning and preparedness: ''syndromic surveillance" and ''risk surveillance" should be commissioned for unbridled joint signaling for a regular rapid flow of information between veterinary and health sectors, give early warning of pathogen emergence, and focus on determinants of disease emergence [40]. Therefore, a One Health understanding is essential for the identification of opportunities at the interface of Himalayan livestock populations and the pastoralists that depend on them.

4.1. Diagnosis and intervention of communicable diseases and zoonoses

4.1.1. Augmenting clinical services

Effective and early diagnosis and treatment of communicable diseases and zoonoses, prevents excess mortality and morbidity post natural disaster [41]. Augmenting access to the primary care services is critical, followed by secondary and tertiary care based on the need [42].

The Interagency Emergency Health Kit (IEHK) 2006 of WHO [43] to meet the primary healthcare needs of a displaced population is useful. In the aftermath of a natural disaster or during an emergency, this can be set with essential medicines, e.g., oral rehydration salts for management of diarrheal diseases, antibiotics for acute respiratory infections, medical facilities and also clinical protocols needed. In parallel, a veterinary medical facility may be set aligning with the IEHK to treat animal diseases and prevent spillover of zoonoses to the human population.

4.1.2. Establish basic laboratory facilities

Establishing a clinical laboratory is not a priority during the initial phase of most disasters. The diagnosis of the most common communicable diseases

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and zoonoses can usually be done by clinical diagnosis. For confirmation, laboratory testing is useful during an epidemic for a mass vaccination strategy that may be required or where culture and antibiotic sensitivity testing is effective in clinical decision making.

In a post natural disaster phase, the immediate impact of communicable diseases and zoonoses can be mitigated with the following interventions: emergency medical and veterinary medical care, provision of shelter and site planning, chlorination of water and sanitation, promoting safe food preparation and handling, nutrition, case management, medical and veterinary medical supplies, and vector control. Moreover, health promotion and safeguarding the health of humanitarian workers is essential [44].

5. Conclusion

Zoonoses constitute 61% of all known infectious diseases, with humans as the primary reservoir for just 3%. Historically, the risk factors for increased infectious diseases, including zoonoses outbreaks and transmission, are associated with the aftereffects of the earthquakes rather than with the primary disaster itself. Our review found that Nepal is under enormous threats of infectious diseases, mostly zoonoses, which could severely hamper the economy, trade, and tourism, as well as reaching the targets of the health-related United Nations Millennium Development Goals set for 2015. Yet, to prevent and control the spread of infections, improvements in public health hinge on the expeditious application of public health measures under the umbrella of One Health.

Although, Nepal has limited resources and not enough trained personnel to carry out the tasks by themselves, we believe that with the support of aid agencies, veterinarians, and health professionals can team up to resolve the crisis under One Health. Transparency builds public trust and scientific progress; through syndromic and risk surveillance, information can be shared between veterinary and medical health sectors in the post impact or recovery phases of the earthquake to control and prevent infectious diseases, specifically zoonoses.

In addition, preventing the after effects of the earthquake, including providing shelter to displaced populations, safe water and sanitation conditions, balanced nutrition, reducing vector breeding sites, removal and safe disposal of dead bodies and carcasses, access to healthcare services, vaccination, and health promotion, can largely support Nepal to get back to normalcy.

Conflicts of interest

None declared.

Acknowledgements

We thank Dr. Aneesa Al-Sindi, Dean, College of Health Sciences, University of Bahrain for the support and encouragement provided to us.

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