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Epidemic activity after natural disasters without high mortality in developing settings

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Natural disasters with minimal human mortality rarely capture headlines but occur frequently and result in significant morbidity and economic loss. We compared the epidemic activity observed after a flood, an earthquake, and volcanic activity in Peru. Following post-disaster guidelines, healthcare facilities and evacuation centers surveyed 10–12 significant health conditions for ~45 days and compared disease frequency with Poisson regression. The disasters affected 20,709 individuals and 15% were placed in evacuation centers. Seven deaths and 6,056 health conditions were reported (mean: 0.29 per person). Health facilities reported fewer events than evacuation centers (0.06–0.24 vs. 0.65–2.02, $P < 0.001$) and disease notification increased 1.6 times after the disasters (95% CI: 1.5–1.6). Acute respiratory infections were the most frequent event (41–57%) and psychological distress was second/third (7.6% to 14.3%). Morbidity increased after disasters without substantial casualties, particularly at evacuation centers, with frequent respiratory infections and psychological distress. Post-disaster surveillance is valuable even after low-mortality events.

Introduction

Natural disasters are important epidemiological events, causing death, disability and disruption of infrastructure.[1,2] They usually lead to increased disease occurrence for up to several months.[3] Most natural disasters described in the literature are those with the highest mortality, the most population affected and largest economic impact.[4] However, disasters with substantial mortality are infrequent but capture major news headlines[5-8] and often receive resources and support from the international community. Less severe disasters, in contrast, are substantially more frequent.[9] Even with few or no human casualties, these events may impose a substantial burden on the population and healthcare system of less affluent countries. The impact of non-calamitous natural disasters, however, has not been studied systematically.

Peru is a tropical country of 28 million inhabitants and has a gross national income per capita of US$ 2,920 (2006), being classified by the World Bank as a lower middle income or 'developing' economy.[10] Peru has a great diversity of climates and geography throughout its desert coast, mountain highlands and rainforest.[11] Located in the southeast side of the "Pacific Ring of Fire" and with nearly 2200 km of coastline, Peru has witnessed a broad diversity of natural disasters in the last four decades. In 1970, a massive earthquake killed 47,000 people[12] and the El Niño phenomenon in 1997–1998 caused approximately $3.5 billion losses.[13] Every year, however, a number of less dramatic disasters occur that continuously challenge the ability of the public sector to respond to them in a timely and proper manner.

The General Directorate of Epidemiology of the Peruvian Ministry of Health (acronym in Spanish: DGE) has contributed to building alert and response capacities for all disasters at the central and regional levels. In 2001 DGE created a national Outbreak, Disaster and Emergency Response Unit (ODERU) to develop guidelines for post-disaster surveillance based on the experience from the response to the 1997–1998 El Niño phenomenon.[14] Post disaster surveillance aimed to a) assess the profile of healthcare needs, b) establish baseline disease rates in order to detect epidemic outbreaks, and c) prioritize individual and population-wide healthcare needs. Three activities are needed to implement post-disaster surveillance: 1) identifying health events of epidemic potential to be surveyed, 2) selecting health facilities for sentinel surveillance, and 3) establishing a 'situation room' to continuously monitor disease trends and evaluate alternative response actions. During 2004 and 2005, the ODERU offered nine disaster alert and response courses to strengthen response capacities at the regional levels and advance the implementation of post-disaster surveillance guidelines.

The Peruvian Civil Defense Institute coordinates all disaster relief actions, and provides on-site guidance to the Ministry of Health's regional offices to implement and monitor post-disaster surveillance. During significant disasters, the ODERU deploys an additional team to the affected areas to provide support and coordinate health-related response activities working under the

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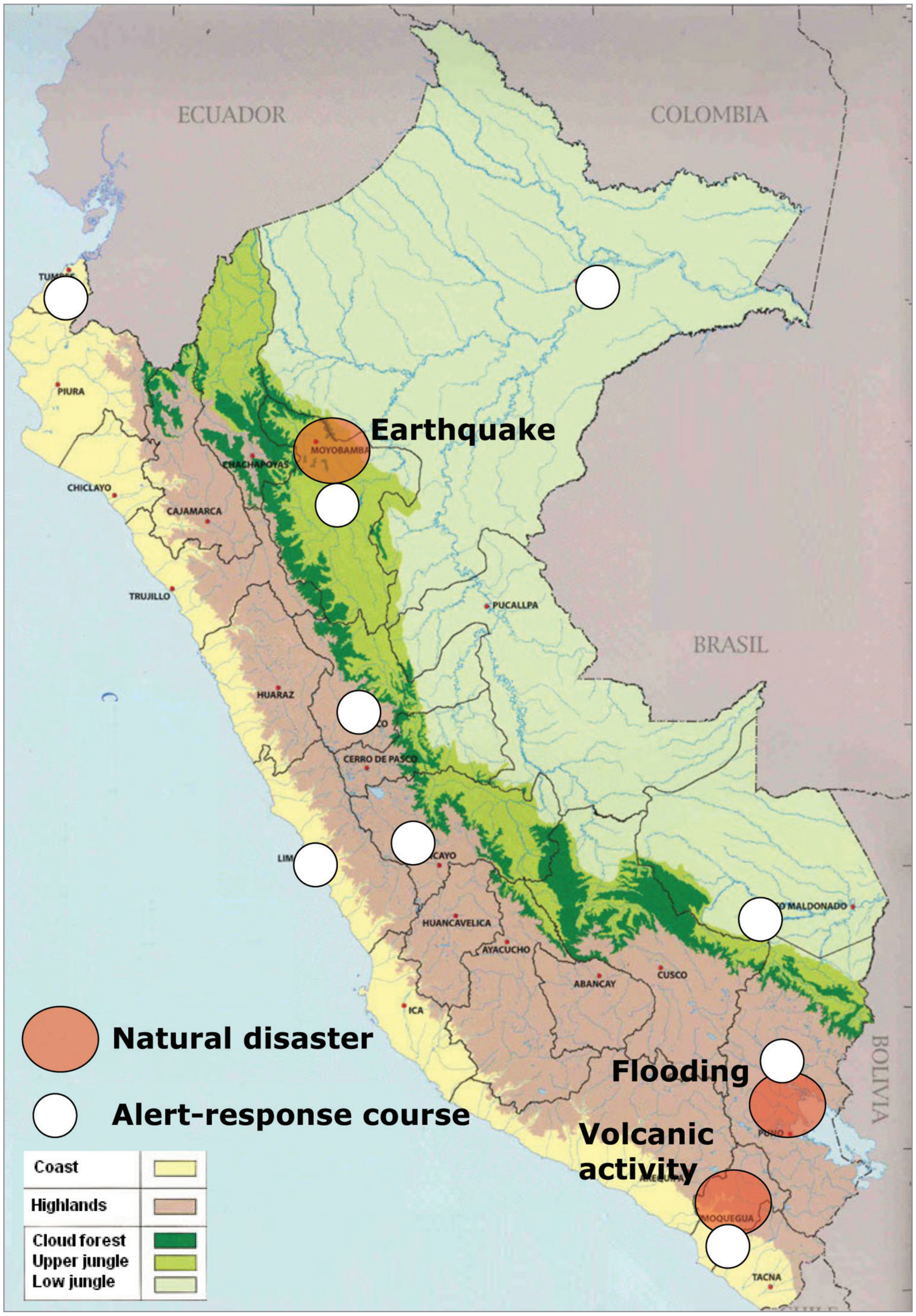

Figure 1. Areas affected by three major natural disasters and location of alert-response courses taught, Peru 2005–2006. Map is an edited version of www.fotosimagenes.org/regiones-geograficas-tradicionales-del-peru.

leadership of the Ministry of Health. Between 2005 and 2006, five major natural disasters triggered the deployment of an ODERU team and the implementation of post-disaster surveillance. Two events were landslides that affected only agricultural land, caused no deaths or significant damage to human health, and had a low risk for potential epidemics. The other three disasters – the focus of the analyses presented here - included a flood, an earthquake, and volcanic activity, each affecting towns and small cities but causing five or fewer deaths. We analyzed and compared the epidemic activity observed after these events to describe the health impact associated to disasters with minimal mortality.

Material and Methods

Ten to 12 outbreak-prone diseases and significant health conditions were surveyed in the areas affected by each disaster for an average of 45 d. Surveillance took place at both healthcare facilities and evacuation centers. We calculated the incidence rate of each health condition for each natural disaster and surveillance site (health facilities or evacuation centers). Population denominators for incidence rates were determined using updated census data (2004) and estimations of the population living in evacuation centers.

Poisson regression was used to compare the incidence rate of each health event under surveillance in two dimensions: 1) among the three natural disasters, and 2) between people living in evacuation centers compared with people who remained at their homes. Additionally, the number of consultations recorded by the Ministry of Health's health information system (HIS) was compared before and after the disasters. Only records from health facilities covering the area affected by the disasters were included in this analysis, and the length of the comparison period before and after the disaster was equal to the duration of intensified post-disaster surveillance activities. Incidence rate ratios were calculated for the number of consultations before and after each disaster, and a robust average was estimated across all three events using Poisson regression. All analyses were performed using Stata 9.2 (Stata Corporation, College Station, TX) and confidence intervals (CI) were calculated at the 95% level.

Results

The natural disasters selected, a flood, an earthquake, and volcanic activity, illustrate Peru's geo-ecological diversity. These events occurred in three different natural regions of Peru during different periods and seasons (**Fig. 1**). This figure also shows the cities where disaster response training had been conducted.

Flooding

On January 5, 2005, after 12 d of intense rain in the southern Andes of Peru, the rivers that drain to Lake Titicaca overflowed an area of 200 km^2 in the area surrounding the city of Juliaca (S15°50′ W70°2′, 3830 min altitude), in the Puno Department. Fortunately, the increase in the river load was progressive and there were only two drowning-related deaths. An emergency was declared on the day of the flood. Among the 6,028 people living in a 94 km^2 flood-affected area, 702 (11.7%) were placed in temporary evacuation centers set up in schools and sports fields. Surveillance was conducted in eight health facilities and two evacuation centers for 46 d from the day of the event. Before the flooding, 70% of households had drinking water service, solid waste disposal mainly occurred by open defecation, and the area lacked garbage removal services. The risk assessment warned about a high probability for respiratory disease due to overcrowding in the evacuation centers and diarrheal disease due to the disruption of infrastructure. Rainfall levels returned to average rates around January 20th, and the emergency status was suspended on February 26.

DGE sent two separate teams of two epidemiologists each, in sequence, staying for a total of seven days. The first team arrived three days after the flooding and conducted a rapid epidemiological assessment. The team evaluated current health effects, identified potential threats, selected health events for investigation and initiated post-disaster surveillance focusing on these identified needs. The second team re-evaluated the health status of the population, monitored the execution of post-disaster surveillance, implemented a situation room and initiated information exchange with other actors involved in the response, actively involving them in surveillance activities.

Earthquake

On September 25th, 2005 at 8:58PM, a 7.0 Richter scale earthquake hit the town of Lamas (S6°25′ W76°31′, 805 min altitude), in the Peruvian department of San Martin. The earthquake killed five people and directly affected 10,082 people spread over a 35 km^2 urban area in Lamas and smaller neighboring villages. Surveillance at three health facilities and 14 evacuation centers was conducted for 44 d starting the day after the event. Before the earthquake, 90% of the households had drinking water service and 80% had sewage connections in the city of Lamas, in addition to a permanent garbage collection system. Forty percent of the ~2500 households were destroyed and another 14% were severely damaged, resulting in the relocation of 1,635 individuals (16.2%) from the affected area to eight evacuation centers. Surveillance at three health facilities and 14 evacuation centers began on September 26th and continued until November 8th. Emergency status was declared and continued until November 2nd.

Three DGE teams, each composed of three medical epidemiologists and a computer technician were sent to the affected area for 5–6 d. A total of 12 people were deployed, staying for 27 d overall. The first team arrived one day after the earthquake and conducted the initial assessment, evaluating the damage to water and sanitation systems and looking for potential increases in risk for disease transmission. This team also selected sites and health events for sentinel surveillance and coordinated its execution with the Regional Ministry of Health Directorate and Social Security health services.

Volcanic activity

On March 27, 2006, the Ubinas volcano began to release a column of ash that could be seen 4 km away from the crater. The Ubinas volcano (S 16°22′ W70°54′, 5672 min altitude), located in the Moquegua Department, is the most active volcano in Peru, with 23 documented eruptions since 1550. On April 6, the volcano increased the amount of released ash, which prompted the establishment of response activities and surveillance on April 10. The San Agustin Geophysics Institute in Arequipa, Peru, documented an explosion at the volcano on April 13, which was followed by emissions of ash, acids and sulfur affecting 4,599 inhabitants in a 14 km radius, and 854 people (18.6%) were relocated to two evacuation centers. An emergency status was declared for the period April 14–26. Before the event only 60% of households in this area had potable water and there was no formal garbage disposal system. Acute respiratory infections, reactive airways disease, conjunctivitis due to exposure to ash and psychological distress were considered the main threats for the population. Surveillance continued through May 21st at six health facilities and two evacuation centers, while the volcanic activity persisted until July 24th.

Table 1. Consultations for selected health conditions after three natural disasters, Peru 2005–2006.

Place and condition	Consultations			Incidence (100 person-years)		
	Evacuation centers	Healthcare facilities	Total	Evacuation centers	Healthcare facilities	Total
Flooding, Jan 5–Feb 19, 2005**						
Respiratory illness	678	392	1,070	101.1	443.4	140.9
Diarrhea	197	131	328	29.4	148.2	43.2
Psychologic disorders	97	46	143	14.5	52.0	18.8
Injuries, wounds and trauma	67	64	131	10.0	72.4	17.3
Conjunctivitis	41	30	71	6.1	33.9	9.4
Skin infections	31	31	62	4.6	35.1	8.2
Urinary tract infection	47	12	59	7.0	13.6	7.8
Febrile, non focalized	7	0	7	1.0	0.0	0.9
All combined	1,165	706	1,871	173.7	798.5	246.5
Population	5,326	702	6,028			
Earthquake, Sep 26–Nov 8, 2005						
Respiratory illness	560	73	633	278.0	7.0	51.0
Psychologic disorders	94	134	228	46.7	12.9	18.4
Injuries, wounds and trauma	51	164	215	25.3	15.8	17.3
Skin infections	67	29	96	33.3	2.8	7.7
Diarrhea	83	8	91	41.2	0.8	7.3
Urinary tract infection	71	18	89	35.2	1.7	7.2
Non-communicable, chronic	67	19	86	33.3	1.8	6.9
Febrile, non focalized	46	14	60	22.8	1.3	4.8
Conjunctivitis	9	23	32	4.5	2.2	2.6
Dog/spider bite	9	4	13	4.5	0.4	1.0
All combined	1,057	486	1,543	524.7	46.7	124.2
Population	1,635	8,447	10,082			
Volcanic activity, Apr 10–May 21, 2006*						
Respiratory illness	678	420	1,098	157.4	427.7	207.6
Conjunctivitis	431	170	601	100.1	173.1	113.6
Psychologic disorders	257	121	378	59.7	123.2	71.5
Headache	152	77	229	35.3	78.4	43.3
Diarrhea	108	59	167	25.1	60.1	31.6
Digestive system disorders	55	44	99	12.8	44.8	18.7
Skin infections	42	20	62	9.8	20.4	11.7
Injuries, wounds and trauma	4	4	8	0.9	4.1	1.5
All combined	1,727	915	2,642	374.3	869.6	466.3
Population	3,745	854	4,599			
All three disasters						
All consultations combined	3,949	2,107	6,056	299.1	180.9	243.7
Population	10,706	10,003	20,709			

*No consultations for non-communicable, chronic, urinary tract infection, dog/spider bite, febrile without a foci; **No consultations for non-communicable, chronic conditions or dog/spider bites.

The Regional Health Directorate initiated surveillance activities in the area, and two DGE-Ministry of Health teams of 4 epidemiologists each were sent 12 d after the beginning of volcanic activity, staying in the area for a total of 11 d. The first team evaluated possible environmental health threats, assessed disease risks in evacuation centers, and identified key health

Figure 2. Images from the affected areas and the response implemented. Credits for the photos go as follows: Top left corner, La Republica newspaper, www.larepublica.pe/28-09-2005/despues-de-terremoto-lamas-es-una-ciudad-por-reconstruir; Top right corner, General Directorate of Epidemiology of the Peruvian Ministry of Health; Bottom row, Manuel J Loayza-Alarico, General Directorate of Epidemiology of the Peruvian Ministry of Health.

conditions to be surveyed. After increased consultations for psychological distress and anxiety were observed in a small town, another six-person DGE team was sent two months after initiation of surveillance specifically to study the prevalence of these and other disorders in the displaced population.

Post-disaster surveillance

The three disasters affected over 20,000 people and caused nearly 3,200 of them (15.4%) to be placed in temporary evacuation centers (**Fig. 2**). No subsequent deaths were recorded during the post-disaster surveillance period due to events under surveillance. There were 6,056 medical consultations, accounting for a rate of 243 consultations per 100 person-years (**Table 1**). The highest rate of consultations was observed during the volcanic event, followed by the flooding event and the earthquake (both $P < 0.001$). The rate of medical consultations seen at the evacuation centers was 78% and 57% lower than at health facilities during both the flooding and volcanic activity, respectively. During the earthquake, however, evacuation centers reported a substantially higher rate of health visits than health facilities (525 vs. 47 medical consultations per person-year), possibly as a result of damages to the health system infrastructure.

Acute respiratory infections were the most frequent cause of consultation (41% to 57%), and psychological distress was either second or third (8% to 14%), followed by injuries, conjunctivitis or diarrhea. The frequency of the other events under surveillance varied significantly between the three disasters.

Three outbreak alerts were issued during the post-disaster period with one alert occurring in each of the three disasters. The first was an outbreak of diarrheal disease at an evacuation center detected 12 d after the flooding, apparently due to poor-quality water. Another outbreak of gastroenteric disease was detected after the earthquake, apparently associated with the consumption of canned foods. Finally, an increase in the number of cases of respiratory cases and conjunctivitis was observed four days after implementing surveillance during the volcanic activity, possibly related to the inhalation of toxic gas and ash.

During the earthquake, numbers of consultations were elevated starting in the first week and peaking in the second week, mainly due to the early appearance of respiratory infections, injuries and psychological disorders (**Fig. 3**). Respiratory infections accounted for 24–40% of the daily visits during the first week and increased to 49–75% of the daily medical consultations by the sixth week. During the flooding and volcanic activity, the number of

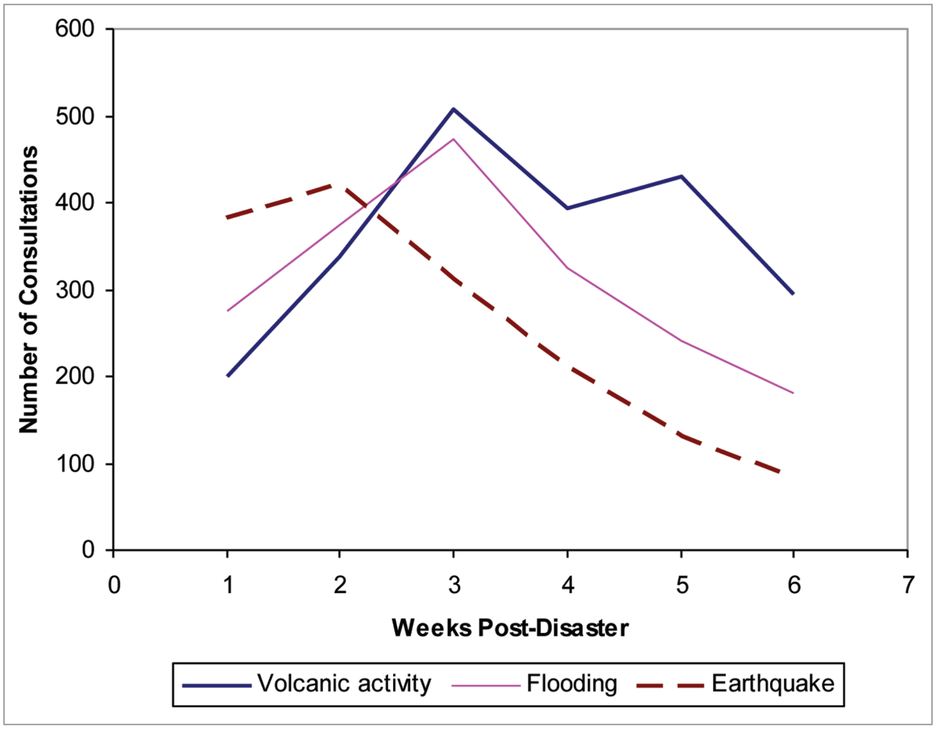

Figure 3. Weekly number of consultations during the first six weeks after each disaster, Peru 2005–2006.

consultations increased continuously throughout the early weeks, peaking in the third week. In all three disasters, consultations decreased substantially by the sixth week. Compared with pre-disaster baselines, the rate of "all-cause" consultations increased following both the earthquake and volcanic activity but decreased after the flooding (**Table 2**). Across the three events, the overall rate of consultations was 59% higher after a natural disaster compared with before the event (95% CI: 52%, 65%, $P < 0.001$).

Discussion

The sporadic occurrence of mega-catastrophes in the developing world such as the Pakistan earthquake[7] and the Asian tsunami[5] highlights the need for better prevention and preparedness in countries where the lack of resources and strong infrastructure usually intensify disaster impact.[15] In contrast, the more frequent, but less dramatic, disasters fail to capture headlines or garner public attention and their victims rarely benefit from international relief actions. For example, while the three disasters described here only caused seven deaths, they affected the lives of more than 20,000 people. The individual and collective impact of such 'small' disasters—as well as the relevance for preparedness—is not well appreciated and is rarely reflected in the scientific literature.

Following two of three low-mortality natural disasters, the earthquake and volcanic activity, the demand for health care increased two- to 3-fold after the onset of the events. For comparison, a similar 2-fold increase was observed in a Mississippi hospital after Hurricane Katrina struck.[2,16] The increased need for healthcare services continued for several weeks after the disasters, consistent with evidence from previous studies.[2] This evidence suggests that extended monitoring of some high-risk populations including the elderly, children, and people with pre-existing conditions, may be needed after natural disasters.

Contrasting with the earthquake and volcanic disasters, fewer consultations were reported after the flooding, potentially due to the relocation of 88% of the population into shelters. Although we lack data to support potential explanations, either evacuation centers may have been unable to provide the same volume of healthcare services or their staff was too overburdened to maintain proper records of medical visits.

Acute respiratory infections (ARI) were clearly the most common indication for consultation. Psychological disorders ranked either second or third, accounting for 8–15% of all consultations. This is comparable to the finding that approximately 10% of participants in post-disaster surveys during the 2004 hurricane season in Florida reported psychological disorders,[17] and mental health conditions accounted for 5% of all patient encounters after Hurricane Katrina.[16] Based on these figures, it appears that mental health problems after natural disasters create an important burden on affected individuals, even in the absence of significant mortality.

Apart from ARI and psychological disorders, there was considerable variability in the frequency of other conditions requiring consultation following each disaster. Moreover, there were important differences among conditions reported in evacuation centers and health facilities. The rate of consultations ranged from 124 to 466 per 100 person-years, and evacuation centers reported more consultations during earthquakes only. Conjunctivitis was reported frequently only during the volcanic

Table 2. Overall number of consultations recorded by the health information system of the areas affected by three natural disasters, Peru, 2005–6.

Event	Overall number of consultations		Rate ratio [95% CI]	p-value
	Before the disaster	After the disaster		
Flooding	2,450	1,871	0.76 [0.72, 0.81]	< 0.001
Volcanic activity	830	2,642	3.18 [2.94, 3.44]	< 0.001
Earthquake	540	1,543	2.86 [2.59, 3.15]	< 0.001
Overall	3,820	6,056	1.59 [1.52, 1.65]*	< 0.001

* Robust estimate, Poisson regression model.

eruption (23%) while injuries were the most common after the earthquake (14%). These results highlight the diverse epidemiological profiles that can result from natural disasters depending on the specific context surrounding each event.

It has been suggested that the risk of disease outbreaks varies with the type of disaster, the size and characteristics of the population, and the eco-epidemiological characteristics of the affected area.[1] Additionally, epidemics could arise if the transmission of endemic pathogens is facilitated by the disruptive secondary effects of the disaster.[18] A careful assessment of baseline threats coupled with the prompt implementation of post-disaster surveillance is crucial to target response interventions and ensure the rapid recovery and rehabilitation of public health services.[19,20]

There is an critical lack of data regarding the impact of disasters and complex emergencies on the burden of non-communicable diseases and even pregnancy outcomes.[21] Peru's national guidelines for post-disaster response direct surveillance efforts to acute, potentially transmissible conditions.[14] A few non-communicable diseases were recognized as important risks for the affected populations, such as post-traumatic stress disorder, injuries and medical trauma in the earthquake and conjunctivitis after the volcanic activity. However, the medium to long-term impact of complex emergencies on the management of chronic conditions is probably substantial but remains poorly described and understudied.

In two of the disasters, 80% or more of the population was relocated to evacuation centers where basic healthcare services were delivered daily. Theoretically, the availability of temporary healthcare providers in shelters, serving as staff extenders, could increase the capacity and utilization of health clinics and potentially improve crisis standards of care.[22] Short-term enhancements in healthcare delivery should be carefully planned, especially regarding integration with long-term services and transfer of capacities to existing facilities and programs.

Our results should be interpreted in light of the limitations of conducting post-disaster surveillance. Underreporting and under-recording of health consultations was probably more frequent than in non-disaster scenarios due to greater demand and limited infrastructure. Also, fewer health conditions were monitored during post-disaster surveillance, so the comparison of the overall number of consultations before and after a disaster probably underestimates the additional demand for healthcare services observed during public health emergencies. Finally, care-seeking attempts were probably prevented by the limited supply of services and frail living conditions, again leading to underreporting. Therefore, it is likely that our estimates of the impact of non-calamitous disasters are conservative, and these events place even a greater burden on healthcare providers than what we have estimated.

According to historical records, volcanic activity causes substantially less mortality than other disasters such as hurricanes, earthquakes, storms and flooding.[23] However, the highest rate of consultations of all three disasters studied and the highest increase in consultations after the event was observed during the volcanic activity. Although the gradual onset of the event provided time to evacuate the area immediately affected, relocation may not have been sufficient to prevent all health consequences. Respiratory problems were the most frequent cause of consultation, but a longer follow-up was not conducted to determine if the inhalation of crystalline silica arising from ash could lead to chronic silicosis as observed during other volcanic eruptions.[24]

As global warming and increased climate variability continues, catastrophic events are likely to become more frequent and severe, and smaller disasters will probably increase exponentially.[25-27] We have shown that disasters with very few deaths can impose a heavy and diverse burden on healthcare facilities, even in the absence of large epidemics. Independent of the magnitude of the event, rapid field deployment and assessments and provision of health and support services are needed after any disaster, fitting closely the epidemiological risk profile determined during the assessments. A timely and carefully executed epidemiological response to all disasters, even non-calamitous events in nature, may reduce their impact and the increased morbidity observed weeks after their initial onset.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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Dr. Blazes is a military service member and Dr. Lescano is an employee of the US. Government. The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, nor the US. Government. This work was prepared as part of their official duties. Title 17 U.S.C. § 105 provides that 'Copyright protection under this title is not available for any work of the United States Government'. Title 17 U.S.C. § 101 defines a US. Government work as a work prepared by a military service member or employee of the US. Government as part of that person's official duties.

Drs. Loayza and Suarez-Ognio designed and created the national guidelines for post-disaster surveillance and Dr. Loayza led response operations for the disasters described in this paper. Dr. Blazes devised the concept of the manuscript and Drs. Loayza and Lescano wrote the first draft. All authors participated in refining the drafts of the manuscript and approved the final version.

References

1. Watson JT, Gayer M, Connolly MA. Epidemics after natural disasters. Emerg Infect Dis 2007; 13:1-5; PMID:17370508; http://dx.doi.org/10.3201/eid1301.060779
2. Jones J. Mother nature's disasters and their health effects: a literature review. Nurs Forum 2006; 41:78-87; PMID:16669985; http://dx.doi.org/10.1111/j.1744-6198.2006.00041.x
3. Bissell RA. Delayed-impact infectious disease after a natural disaster. J Emerg Med 1983; 1:59-66; PMID:6436364; http://dx.doi.org/10.1016/0736-4679(83)90010-0
4. Centre for Research on the Epidemiology of Disasters. 2008. Disasters in numbers. Brussels, Belgium.
5. Doocy S, Gorokhovich Y, Burnham G, Balk D, Robinson C. Tsunami mortality estimates and vulnerability mapping in Aceh, Indonesia. Am J Public Health 2007; 97(Suppl 1):S146-51; PMID:17413062; http://dx.doi.org/10.2105/AJPH.2006.095240
6. Centers for Disease Control and Prevention. Public health response to Hurricanes Katrina and Rita–Louisiana, 2005. MMWR Morb Mortal Wkly Rep 2006; 55:29-30
7. Kerr RA, Bagla P. Pakistan earthquake. A seismic murmur of what's ahead for India. Science 2005; 310:208; PMID:16223988; http://dx.doi.org/10.1126/science.310.5746.208b
8. Naranjo JL, Sigurdsson H, Carey SN, Fritz W. Eruption of the nevado del ruiz volcano, Colombia, on 13 november 1985: tephra fall and lahars. Science 1986; 233:961-3; PMID:17732038; http://dx.doi.org/10.1126/science.233.4767.961
9. International Federation of Red Cross and Red Crescent Societies, 2005. World Disasters Report 2005: Focus on information in disasters. World Disasters Report: 521.
10. World Bank. 2007. Economic Indicators, Atlas Method.
11. McNeely JA, Miller KR, Reid WV, Mittemeier RA, Werner TB. 1990. Conserving the World's Biological Diversity. Gland, Switzerland: IUCN.
12. Rennie D. After the earthquake. Lancet 1970; 2:704-7; PMID:4195941; http://dx.doi.org/10.1016/S0140-6736(70)91971-9
13. Jovel JR, 2000. The impact of the 1997-1998 El Niño on the Andean Community of Nations. ISDR Informs 1.
14. Oficina General de Epidemiología. 2002. Directiva de Vigilancia epidemiológica con Posterioridad a Desastres Naturales y Otras Emergencias Sanitarias. Lima, Peru: Ministerio de Salud del Peru.
15. Davidson JR, McFarlane AC. The extent and impact of mental health problems after disaster. J Clin Psychiatry 2006; 67(Suppl 2):9-14; PMID:16602810
16. Centers for Disease Control and Prevention (CDC). Morbidity surveillance after Hurricane Katrina--Arkansas, Louisiana, Mississippi, and Texas, September 2005. MMWR Morb Mortal Wkly Rep 2006; 55:727-31; PMID:16826160
17. Centers for Disease Control and Prevention (CDC). Epidemiologic assessment of the impact of four hurricanes--Florida, 2004. MMWR Morb Mortal Wkly Rep 2005; 54:693-7; PMID:16034314
18. Toole MJ. Communicable disease epidemiology following disasters. Ann Emerg Med 1992; 21:418-20; PMID:1554181; http://dx.doi.org/10.1016/S0196-0644(05)82662-9
19. Lillibridge SR, Noji EK, Burkle FM Jr. Disaster assessment: the emergency health evaluation of a population affected by a disaster. Ann Emerg Med 1993; 22:1715-20; PMID:8214862; http://dx.doi.org/10.1016/S0196-0644(05)81311-3
20. Glass RI, Noji EK. 1992. Epidemiologic surveillance following disasters. Halperin W, Baker EL, eds. Public Health Surveillance. New York, NY: Van Nostrand Reinhoid, 195-205.
21. Demaio A, Jamieson J, Horn R, de Courten M, Tellier S. Non-communicable diseases in emergencies: a call to action. PLoS Curr 2013; 5:5; PMID:24056956
22. Mosier W, Orthner W. Military Medical support for Humanitarian Assistancce and Disaster Relief: Lessons Learned From the Pakistan Earthquake Relief Effort. Joint Center for Operational Analysis Journal 2007; 9:1-10
23. Noji EK. 1997. The Public Health Consequences of Disasters. New York, NY: Oxford University Press.
24. Searl A, Nicholl A, Baxter PJ. Assessment of the exposure of islanders to ash from the Soufriere Hills volcano, Montserrat, British West Indies. Occup Environ Med 2002; 59:523-31; PMID:12151608; http://dx.doi.org/10.1136/oem.59.8.523
25. Huppert HE, Sparks RS. Extreme natural hazards: population growth, globalization and environmental change. Philos Transact A Math Phys. Eng Sci 2006; 364:1875-88
26. McMichael AJ, Woodruff RE, Hales S. Climate change and human health: present and future risks. Lancet 2006; 367:859-69; PMID:16530580; http://dx.doi.org/10.1016/S0140-6736(06)68079-3
27. van Aalst MK. The impacts of climate change on the risk of natural disasters. Disasters 2006; 30:5-18; PMID:16512858; http://dx.doi.org/10.1111/j.1467-9523.2006.00303.x