Vulnerability in Volcanic Eruptions

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Although volcanoes cause fewer disasters than floods, earthquakes or hurricanes they nevertheless pose formidable hazards to people living in volcanic areas, as eruptions may unleash some of the most lethal and destructive of natural phenomena. In a small country like Nicaragua the numerous active volcanoes which lie along the length of the country are likely to tax the emergency services at least as frequently as earthquakes, even in this country of high seismic risk

There are various unique ways in which volcanic eruptions can impact on health and safety and although they have not been well studied, they offer much potential scope for mitigation. Proximity to an active volcano is an obvious factor in vulnerability and timely evacuation is a key measure in saving life However, predicting eruptions remains an inexact science and emergency planners must accept that in the future large populations may suffer the destructive impacts of eruptive phenomena, of which pyroclastic flows, lahars and ash falls are the most important. In accordance with the theme of this workshop collaborative studies between health workers, volcanologists and other scientists are needed to study the impacts of these phenomena in detail and in association with the factors giving rise to vulnerability of the populations at risk.

The following is an illustrative list (far from complete) of "vulnerability factors" for volcanic hazards:

TEPHRA FLOWS

Pyroclastic flows and surges have caused the most deaths and injuries in volcanic eruptions. Pyroclastic flows are gravity currents of hot clouds of eruptive material and gases which can travel at 200-300km per hour with temperatures up to hundreds of degrees centigrade Although they may travel many kilometres down valleys and following local topography they rapidly cool and lose their momentum by mixing with air In the famous eruption of Mont Pelee in 1902 the city of Martinique, only 8km from the summit, was totally destroyed and 28,000 people died; only two survivors were left in the town itself Much of the material causing this devastation was fine sized and resulted in a deposit only 10cm deep To date the opportunity to study the deaths and injuries caused by pyroclastic flows has arisen once – at the Mount St Helens eruption in 1980 Sparse photographic evidence from the volcanic literature, including the famous plaster casts at Pompeii destroyed in the eruption of Vesuvius in AD79, show corpses in the flexed limb posture caused by exposure to extreme heat around the time of death Curiously these findings were not present at the eruption of Mount St Helens in 1980, at least on the few corpses which were retrieved from this eruption, but 25 autopsies were performed which showed that in some victims death had been caused by asphyxiation due to the inhalation of fine ash, thermal injury and mechanical trauma Volcanologists tend to assume that preventive measures against pyroclastic flows are futile, but in fact the literature points anecdotally to the opposite Thus at the Mount St Helens eruption a detailed study of the deaths and survivors showed that the mortality rate was actually. 47% in people caught by this pyroclastic flow even in the open and in a wilderness area In a modern urban setting the buildings are likely to be protective, at least in the periphery of a flow, and there could be many survivors albeit with severe burns and inhalational injuries. Appropriate advice on protecting the skin against heat and preventing inhalation of hot fine ash may save many lives in future eruptions, but the devising of such emergency measures requires collaborative studies between the health and science sectors which are only now being developed.

TEPHRA FALL OUT

In the Mount St Helens eruption mentioned above, the authorities were totally unprepared for the heavy ash fall which for almost a week later paralysed activity in much of central Washington State. Whilst this event did show that an ash fall of 10cm had little impact on North American buildings, nevertheless the ash fall and subsequent re-suspension of ash in the dry, central area of Washington State, which lasted a week until the rains came, showed that air pollution by ash may have important implications for those suffering from pre-existing respiratory illnesses. About 90% of the particles were within the respirable range (less than 10 μm) and the condition of asthmatics and patients with chronic lung disease was made worse in the days following the eruption and in many for months afterwards.

The eruption of Mount Pinatubo in the Philippines in 1991 was one of the largest eruptions of the century Although the activity of the volcano gradually scaled up, thereby enabling a successful evacuation of 60,000 people from around the volcano, the impact of the heavy ash fall was again underestimated. A typhoon occurred at around the time of the eruption, blowing much of the ash into the South China Sea but, where the ash fall on land exceeded 10cm in depth many buildings collapsed from the weight of ash which had been added to by the accompanying rainfall About 300 people were killed and an unknown number were injured by collapsing roofs Large buildings such as churches and hospitals, where people were likely to seek sanctuary, seemed to be amongst the most vulnerable structures. In addition, the extent and duration of the clean-up operations showed just how difficult it was to clear ash from roofs of tall buildings and the inadequacy of conventional advice to remove ash from roofs during ash falls Much more research is needed in collaboration with architects and engineers to decide on how the impacts of heavy ash falls can be reduced in the future.

An interesting aspect of vulnerability relating to poverty was demonstrated in the eruption of Cerro Negro, Nicaragua, in 1992. The city of Leon, located about 25km downwind of the volcano, received at most a 5cm accumulation of ash from this eruption, and only one person was killed from a falling roof at the time of the eruption. However, eight people were killed and over 200 seriously injured in the days following in the clean-up operations which ensued when children were sent up on to the flimsy tiled roofs to remove the ash. Many children and adults simply fell through the roofs which were already weakened by chronic decay of timbers Meanwhile, farm dwellings made of thatch in the agricultural area quite close to the volcano survived without damage even though the population had had to be hastily evacuated

LAHARS

Lahars are gravity currents of debris and mud, and are extremely destructive, as in the eruption of Nevado del Ruiz in 1984 when 22,000 people were killed Most of those lives could have been saved by a simple warning system so that the population could have moved to higher ground before the lahar struck Over 1,200 people were admitted to hospital and about 140 of these died, mainly from the effects of various types of trauma and infective sequelae The local health services were unprepared for dealing with casualties of this type – another cause of vulnerability.

GENERAL HEALTH ISSUES

The commonest questions asked by an anxious population after an eruption are whether it is safe to drink the water, to eat the crops (or for their animals, the grass), or to breathe the air? Their concerns are justified. A 1mm layer of fine ash from the Hekla volcano is sufficient to kill thousands of sheep from fluorine poisoning Surface waters can be contaminated by toxic substances in ash, and ground water may be affected by volcanic activity. At the Cerro Negro eruption there was real concern that volcanic gas was being blown into the city of Leon although expert observation of the volcano showed that this was not the case Nevertheless, officials are invariably unable to rapidly provide populations with the necessary advice because pre-planning of simple laboratory tests of the ash and water, as well as air monitoring, is omitted in current emergency planning, if plans exist at all.

LIFELINES

Lifelines and parts of the infrastructure are always likely to be damaged in natural disasters Volcanic eruptions may add to the disruption in unique ways. Thus a heavy ash fall can limit visibility to zero and bring all transport to a halt Telecommunications can black out because of the static electricity on the ash in ash falls which may last for days Municipal water supplies can be disrupted by ash clogging in-flow pipes, and sewerage systems can literally grind to a halt, the abrasive ash damaging machinery Widespread power outages can occur because moist ash is an excellent conductor of electricity and short circuits may occur on conductors in the open if they become covered by a layer of ash

DISASTER PREPAREDNESS

Volcanic hazard maps have been prepared for a few of the world's dangerous volcanoes but one of the goals of the International Decade for Natural Disaster Reduction (IDNDR) is to promote scientific collaborative work in producing hazard maps where they are needed in volcanic areas in developing countries. So far there have been few attempts to use hazard maps in predicting the impacts on populations, to identify vulnerability factors and to devise active preventive measures in collaboration with the health sector

Developed countries may not be much farther ahead: Vesuvius is one of the world's most dangerous volcanoes and is overdue for a major eruption which would produce pyroclastic flows and ash falls, as well as other volcanic phenomena. There has been little if any long term land use planning, with buildings now spreading up the flanks of the volcano. Computer-models of tephra fall out predict that there is a probability of an ash fall as deep as 10cm occurring over a wide built-up area in the Bay of Naples with greater depths closer to the volcano However, building surveys to assess vulnerability for such an eruption have not been undertaken. Apart from limited evacuation planning no emergency preparedness has been put in place The problem here as in most other volcanic areas is that one cannot rely upon predictive measures to allow enough time for evacuation, and there is always the problem of undertaking an evacuation when subsequently no eruption occurs The population should therefore be prepared in civil protection measures for a large scale eruption. Similar considerations apply to the large populations living around active volcanoes elsewhere in the world.

An important current example is Galeras volcano, Columbia Seven volcanoes in developing countries have been designated as Decade Volcanoes for special study in the IDNDR, but in January 1993 the first workshop to be held at any of these volcanoes, at Galeras, ended in tragedy when six scientists working on methods to predict a major eruption were killed in the crater area. Galeras is one of the most active volcanoes in South America yet no emergency planning has yet been devised and it was to rectify this situation that the workshop was held there. Unfortunately the civic leaders did not wish to collaborate with even the local volcanologists for fear of arousing anxiety in the population and causing economic disruption in the area Galeras threatens Pasto, a city with a population of 200,000 people situated only 8km from the summit, with pyroclastic flows Refusing to accept the reality of a potential volcanic disaster must represent one of the most extreme examples of vulnerability imaginable, and overcoming such predicaments must be one of the ultimate goals for us to work towards in the IDNDR.

DISCUSSION

Chair: John Knill

Speaker from audience Sophisticated technological warning systems work extremely well in technological societies such as the US This was recently demonstrated with Hurricane Andrew in Florida (it perhaps did not work as well as it should have) There is the means to respond rapidly by evacuation, but Third World countries do not have the infrastructure, transportation may be primitive or non-existent for mass evacuation. How do we take advantage of technological warning in these circumstances?

Ian Davis: Two or three examples exist of excellent evacuations Hurricane Joan striking Bluefields in Nicaragua – within 48 hours about 48,000 people were evacuated by a very effective military operation In Bangladesh in a cyclone about two years ago about 650,000 people were evacuated in a period of 60 hours, and an important example was the Pinatubo eruption involving 60,000 people. Satellite radar systems are improving. One of the major reductions in casualties from cyclones is due to good evacuation planning. This is admittedly patchy in effectiveness, but examples of successful evacuations exist

Claude de Ville One of the problems with evacuation from around volcanoes is the uncertainty of predictions. The problem with moving people is they don't know how long they will be evacuated, they know they will not get what they have been promised in terms of help after and they are sure to have many of their belongings looted They have to make a decision about costs and benefits I don't know what I would do in their shoes.

Frank Farquharson The same problems occur in Bangladesh with cyclone warnings Many cyclone shelters are being built, but people are reluctant to use them because it is a no-win situation If they do use them a lot of their property is looted and they lose. If they don t, they may lose their lives. It is a real problem. The technology now exists to forecast floods fairly reliably, more reliably than volcanoes or earthquakes, but even so these can happen quickly. In Hong Kong a system is being developing to warn people of flooding The warning is that floods will occur within an hour, or one to two hours. If people are away from their homes at work what can they do about it?

Speaker from audience Fleeing from disasters is a natural response, but it is not the only response. The use of shelter, in whatever forms possible, must never be underestimated in terms of its value (it was the government's recommended response to a nuclear attack to seek shelter at home!). In the case of flooding it might involve going up on to the roof and minimising damage by rolling up carpets This mitigates the effect on the individual householder, especially if he or she is aware of the likely duration of flooding The importance of shelter should not be ignored

John Knill: The distance one has to move may not be far. In the 1957 earthquake in Iran within 12 hours of the event animals refused to go into their stalls and insisted on remaining outside overnight. If humans had done the same thing the loss of life would have been considerably less. Often the distance that has to be moved is small. There were obviously problems with the design of houses which in the mountainous areas of Iran have thick walls and heavy roofs

Speaker from audience: Linking something in the Position Paper about the comment by Ian Davis that more was needed on vulnerability analysis. The paper makes reference to 19th century engineering solutions of improving sanitation and water supply being a technical response to social and economic problems, and the reformers did not try to address the issue of poverty. But the 19th century interventions required a shift of culture allowing state intervention in social and economic events and this fundamental shift allowed the introduction of rights of local authorities to raise taxes, to interfere in the construction and design of buildings, spaces, ventilation, supply of water and sanitation. A political shift from laissez faire to state guidance. What is missing in the understanding of vulnerability to rapid onset disasters is that those affected are already pretty vulnerable Power and political structures as illustrated in the example of the Colombian volcano (Galeras) make it very difficult to address this problem and do anything about it. It would be of interest to find ways of shifting culture to make it easier to discuss vulnerability in social and political terms.

Ian Davis The Colombian example is interesting and I have just returned from there. Discussing the specific situation with the Director of National Disaster Planning, he said he had a lot of sympathy with local authorities who know there is a huge risk. But when there was a warning a few years back it was a body blow to the whole economy Businessmen left the city and there was no credit for buying a car. He said the threat of further warnings could tip the whole city into terminal decline It was a critical trade-off between volcanic warnings and the economic consequences. It could be argued that they have not fulfilled an ethical responsibility to their society and that the political power structures are preventing it But it is very much an economic question in their situation Imagine if I was mayor, I would find it difficult to know how to respond when someone says you must issue further warnings when you know what the effect might be But the point that this political issue be raised is important and has been greatly neglected

Peter Baxter: The health sector has a role to play in this, making the risks in these situations clear and getting the message across to politicians and the community. And as Professor Lechat said the primary health care sector should start to have a role in influencing politicians and communities by understanding what the risks really are and working with scientists on these problems in a local context