Public health aspects of volcanic hazards; Evaluation and prevention of excessive morbidity and mortality due to natural disasters

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INTRODUCTION

Until we develop reliable and precise methods for predicting the location and time of onset; the nature, magnitude, and extent; and the frequency and duration of such natural phenomena as severe weather, earthquakes and volcanic eruptions, *primary* prevention of hazardous exposures may not be technically feasible (Macdonald, 1977; Walker 1982).

When primary prevention is not technically feasible, then public health officials must develop *secondary* preventive measures to recognize, evaluate and prevent excessive morbidity and mortality due to natural disasters such as explosive volcanic eruptions (Baxter *et al.*, 1982; Bernstein *et al.*, 1982, Green *et al.*, 1982; Merchant *et al.*, 1982). The proximity, size and vulnerability (e.g. the predisaster health status, public health resources and prior disaster experience) of populations at risk for natural disasters must be considered in predisaster planning and in response efforts. In addition, the various types of potentially hazardous physical (traumatic), biological (infectious), and chemical (toxic) exposures which may result directly or indirectly from a disaster may require medical surveillance and environmental monitoring of high-risk groups (Bernstein *et al.*, 1982; Buist *et al.*, 1983; Fraunfelder *et al.*, 1983; Olenchock *et al.*, 1983). The biological plausibility and public health importance of both delayed and acute effects should be considered, since more sophisticated methods of recognition, evaluation and secondary prevention may be needed for health effects which may become manifest after a period of prolonged latency (Buist, 1982).

THE HONOLULU SYMPOSIUM

The goals of the Symposium's technical and panel sessions and the subsequent WHO workshop were to: (1) characterize the hazards of explosive volcanic eruptions, including an introduction to the state of the art of monitoring and predicting explosive volcanic activity; (2) discuss the previous multidisciplinary efforts of geologists, social scientists, toxicologists, physicians and public health officials in providing assistance to affected populations; and (3) describe the state of knowledge, the problems, and the research needs in each of these groups regarding the public health aspects of explosive volcanic eruptions.

A major disaster may be quite complex in terms of its potential impact on safety, health, and well-being — the three components of WHO's definition of "health."

The general classes of volcanic hazards and some of the biologically plausible adverse effects on safety, health and well-being within each class are outlined in Table 1. Volcanic hazards may be characterized by their impact on health as *direct or indirect* and by their time of onset as *immediate or delayed.*

The central theme of *secondary* preventive approaches in natural disasters is that, although *primary* prevention of the exposure may not be technically feasible (the source being an unpreventable and relatively unpredictable volcanic eruption), it may be possible to reduce the short- and long-term adverse impact of such a disaster through appropriate multidisciplinary planning and response and relief measures.

In the technical session, **the acute hazard potential** and distribution of active volcanoes in the circum-Pacific region were described. The area includes 238 (87%) of the 275 most active and dangerous volcanoes that have erupted during historic times. Of these 39 (18%) are on the Japanese and Mariana Islands and 37 (17%) are in Indonesia. About 30 to 40 explosive eruptions occur each year around the rim of the Pacific (the "Ring of Fire"). Although most of these are small and occur in uninhabited areas, several each year are large enough to destroy nearby settlements.

In the past 20 years, fatalities and considerable socio-economic disruption have resulted from ten eruptions at nine Indonesian volcanoes. Five of the eruptions were on Java, a crowded island about the size of California but inhabited by 90 million people with high levels of malnutrition and endemic diseases (especially tuberculosis and other respiratory diseases).

In the period 1600—1980, about 160,000 deaths (67% of those for which data exist) have resulted from volcanic eruptions in Indonesia; 32,000 (13%) in the Caribbean Region; 19,000 (8%) in Japan; and only 30,000 (12%) in all other areas of the world. Pyroclastic flows (high speed blasts of hot gases and ash), volcanic mudflows and ashfalls are the most frequent causes of mortality. However, in a few eruptions, enormous numbers of deaths occurred because of starvation and disease or tsunamis. It is of interest to compare the magnitude of fatalities caused by volcanic eruptions with the overall impact of natural disasters:

Table 1. Hazards to human safety, health and well-being from *explosive* volcanic activity

General class of hazards	Specific examples of plausible effects
1. Direct and immediate	(a) Safety hazards from the effects of blasts, pyroclastic or lava flows and earthquakes
	(b) Health hazards from inhalation exposure to intense air-borne concentrations of ash and gases (e.g. irritation of the respiratory tract; exacerbation of pre-existing asthma, chronic bronchitis, or cardiopulmonary diseases; and suffocation) or from ingestion of water contaminated with toxic amounts of volcanic minerals (e.g. fluoride or mercury)
	(c) Psychosocial, environmental and economic hazards from rumors or uncertainties about current or future hazards; from disruption of routine services; by displacement of large numbers of people into refugee camps; and from destruction of property
2. Direct and delayed	New onset, exacerbation or acceleration of chronic respiratory diseases from frequent, intense, or prolonged exposures to toxic gases and/or respirable-size ash
3. Indirect and immediate	(a) Safety hazards from mud flows, flash floods, lightning-induced fires and tsunamis
	(b) Health hazards from epidemic outbreaks of previously well-controlled or endemic diseases due to disruption of routine environmental, public health and medical services
4. Indirect and delayed	(a) Health hazards from increases in the pathogenic potential of infectious and pulmonary pathogens due to the irritant and toxic effects of volcanic gases and ash on the lung's defense mechanisms
	(b) Psychosocial, economic and public health problems resulting from intense or prolonged disruption of society and the environment

The *effusive* type of volcanic activity, characteristic of Hawaiian-type volcanoes, results in three types of potential hazards: (1) Safety hazards from lava fountains, lava flows or earthquakes; (2) Health hazards from emissions of volcanic gases or from the combustion products of forest fires caused by lava and hot gases; and (3) Psychosocial and economic hazards from the effects of volcanic activity on property, agriculture, horticulture and air quality.

during the same period, earthquakes alone caused about 20 times this number of deaths.

The reported mortality data are deficient in many ways, and caveats abound when interpreting them for the purpose of reducing excessive morbidity and mortality. Thus, we are only beginning to develop valid and reliable criteria that will enable us to provide public health advice to populations near a volcano undergoing premonitory activity, let alone to populations in the vicinity of an active volcano in an apparently dormant or "repose" period. If no evacuation warning can be given, secondary prevention may depend on epidemiologic surveillance in refugee settlements; on clearing ash from roofs to prevent them from collapsing and from streets to reduce resuspension and poor visibility (a factor in traffic accidents) or inhalation (a factor in respiratory problems); on preventing flooding due to volcanic mud or diverted water from swollen streams and damaged dams; and on environmental measures such as monitoring air and water quality (Baxter *et al.*, 1982).

The delayed-onset hazard potential of volcanic ashes, gases and aerosols was also discussed in Symposium sessions. The results of *in vitro* and *in vivo* laboratory studies at several different federal (Green *et al.*, 1982; Vallyathan *et al.*, in press) and other (Martin *et al.*, 1983) institutions consistently support the conclusion that prolonged, intense exposures to airborne volcanic ash (a highly respirable mixture of varying amounts of toxic free silica and irritating silicates) may result in "pneumo(vol)coniosis" or chronic bronchitis (Bernstein *et al.*, 1982; Buist, 1982).

For the general population with low-level, transient exposures, the risk for chronic lung injury is extremely low (Craighead *et al.*, 1983; Merchant *et al.*, 1982). However, changes in pulmonary function, consistent with new onset of obstructive airways disease, have been observed in preliminary analyses of a longitudinal epidemiologic study of loggers after only two years of intermittent and occasionally intense exposures to ash from Mount St. Helens' eruptions. Cross-sectional and short-term followup evaluations of this cohort of loggers had revealed no evidence for acute ash-related abnormalities (Bernstein *et al.*, 1982).

In the Symposium panel and WHO workshop sessions, public health professionals described their experiences after eruptions of Mount Usu, Soufriere, Mount St. Helens and Galunggung. Use of epidemiologic methods enabled investigators to identify and manage acute respiratory problems, acute psychosocial reactions and indirect safety hazards (Baxter *et al.*, 1981, 1982). Indonesian epidemiologists were able to rule out a reported epidemic of malaria in the wake of Galunggung's eruptions by comparison of post-eruption rates with routine surveillance data, while epidemiologists in the U.S.A. identified an outbreak of waterborne giardiasis which was caused (indirectly and in a delayed fashion) by Mount St Helens' volcanic activity (Weninger *et al.*, 1983).

Workshop participants identified three goals for further discussion at the Second International Symposium on Public Health in Asia and the Pacific Basin: (1) to assess the vulnerability, needs and capacities of WHO member countries in relation to the public health aspects of natural disaster preparedness and relief activities; (2) to develop technical assistance materials (e.g. training manuals and guidelines for preparedness and relief); and (3) to identify international human and technical resources for evaluation and prevention of excessive morbidity and mortality due to natural disasters — such as severe weather, earthquakes and volcanic eruptions.

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REFERENCES

Baxter P.J., Ing R., Falk *et al.*, Mount St. Helens Eruptions, May 18 to June 12, 1980; An overview of the acute health impact, *J. Am. Med. Assoc.* **246**, 2585—2589 (1981).

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Baxter P.J., Bernstein R.S., Falk H., French J. and Ing R., Medical aspects of volcanic disasters: An outline of the hazards and emergency response measures, *Disasters* **6**, 268—276 (1982).

Bernstein R.S., McCawley M.A., Attfield M.D. *et al.*, Epidemiologic assessment of the risk for adverse pulmonary effects from persistent occupational exposures to Mount St. Helens' volcanic ash (tephra), in: *Mount St. Helens: One Year Later* (Edited by S.A.C. Keller). Eastern Washington University Press, Cheney, Washington (1982).

Buist A.S., Are volcanoes hazardous to your health? *West J Med* **137**, 294—301 (1982).

Buist A.S., Johnson L.R., Vollmer W.M., Sexton G.J. and Kanarek P.H., Acute effects of volcanic ash from Mount St. Helens on lung function in children, *Am. Rev. Resp. Dis.* **127**, 714—719 (1983).

Craighead J.E., Adler K.B., Butler G.B. *et al.*, Health effects of Mount St. Helens volcanic dust, *Lab. Invest.* **48**, 5—12 (1983).

Fraunfelder F.T., Kalina R.E., Buist A.S., Bernstein R.S. and Johnson D.S., Ocular effects following the volcanic eruptions of Mount St. Helens, *Arch. Ophthalmol.* **101**, 376—378 (1983).

Green F.H.Y., Vallyathan V., Mentnech M.S. *et al.*, Is volcanic ash a pneumoconiosis risk? *Nature* 293, 216—217 (1981).

Green F.H.Y., Bowman L., Castranova V. *et al.*, Health implications of the Mount St. Helens' eruption: Laboratory investigations, *Ann. occup. Hyg.* **26**, 921—933 (1982).

Macdonald G.A., Volcanological aspects, Volume 1 in: *Disaster Prevention and Mitigation: A Compendium of Current Knowledge.* Office of the United Nations Disaster Relief Co-ordinator, New York, NY (1977).

Martin T.R., Wehner A.P. and Butler J., Pulmonary toxicity of Mount St. Helens volcanic ash: A review of experimental studies, *Am. Rev. Resp. Dis.* **127**, 158—162 (1983).

Merchant J.A., Baxter P.J., Bernstein R.S. *et al.*, Health implications of the Mount St. Helens' eruption: Epidemiological considerations, *Ann. occup. Hyg.* **26**, 911—919 (1982).

Olenchock S.A., Mull J.C., Mentnech M.S., Lewis D.M. and Bernstein R.S., Changes in humoral immunological parameters after exposure to volcanic ash, *J. Tox. Environ. Health* **11**, 395—404 (1983).

Vallyathan V., Reasor M., Settler L., Robinson V. and Bernstein R.S., Comparative *in vitro* cytotoxity of volcanic ashes from Mount St. Helens, El Chichon and Galunggung, *Lab. Invest.* (in press).

Walker G.P.L., Volcanic hazards, *Interdiscip. Sci. Rev.* **7**, 148—157 (1982).

Weniger B.C., Blaser M.J., Gedrose J., Lippy E.C. and Juranek D.D., An outbreak of waterborne giardiasis associated with heavy water runoff due to warm weather and volcanic ashfall, *Am. J. Pub. Hlth* **73**, 868—872 (1983).