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Preparing for Disaster

The cataclysmic eruption of Mount St. Helens on May 18, 1980 resulted in displacement of one and one-half cubic kilometers of mountain covering over 100 square miles of the "blast zone" with volcanic debris destroying all in its path and claiming the lives of at least 63 people who were voluntarily or mistakenly caught within the "blast zone." For several reasons, the relatively few individuals killed in this disaster must be considered fortunate:

- The timing of the eruption coming at 8:00 AM on a Sunday morning reduced not only the number of hikers in the area who might have ignored warnings to the public, but also the number of loggers who had been working in certain restricted areas under permit.
- The direction of the primary blast to the more sparsely populated north and northeast rather than the more populous Columbia River Valley was clearly a factor.
- And the role of the National Geological Survey in forecasting the approximate time and the area likely to be affected by the eruption was an important factor.

The Mount St. Helens eruption also provided a major test for federal, state, and community disaster plans. For those of us involved in the immediate public health response, Mount St. Helens provided some important lessons in organizing a disaster team, in documenting the impact on the public's health, and in preparing for future disasters. The Biological Effects of Volcanic Ash (BEVA) monograph that is the subject of the supplement to this issue of the Journal[1] provides a planning model for future volcanic eruptions and other major disasters. It should be viewed in its broadest context.

Within the past year, three other major public health disasters have occurred, serving to emphasize the point that there will be future catastrophic events which must be anticipated in order to reduce their public health impact. In December 1984, a lethal cloud of methyl isocyanate was released from the Union Carbide plant in Bhopal, India—killing over 1,700 community residents and leaving thousands more severely injured. While it was maintained that this could not occur in the United States, late in the summer of 1985 "pressure build-up" in a 500-gallon storage tank resulted in the release of a toxic cloud of aldicarb oxime, a less toxic chemical derivative of methyl isocyanate, from a Union Carbide plant in Institute, West Virginia, sending 125 residents to area hospitals for treatment and confining thousands more to their homes without clear immediate warning or understanding of the toxicity of this chemical plant emission.[2] More recently, a major earthquake shocked Mexico City, Mexico, resulting in over 7,000 deaths, thousands more injured, and millions of dollars in property damage associated with disruption of public services and commerce for hundreds of thousands, and destruction of the major tertiary care hospitals of the country. Clean-up and rebuilding are expected to take several years. And as this is written, we have received news of the eruption of the Nevada del Ruiz volcano in Colombia, South America; the eruption covered four towns in an Andes mountain valley and claimed an estimated 25,000 lives.

Unlike the Mount St. Helens eruption, several factors in these major disasters probably contributed to the extensive loss of life:

- In Bhopal, there were apparent system failures in the plant for reasons that are not yet completely clear. In addition, there were no zoning restrictions, so that housing was occupied right up to the plant gates. A delay occurred in community recognition of the release of methyl isocyanate, to which darkness probably contributed. There was little public knowledge of the potential toxicity of plant emissions. And finally, there was only one small community hospital, unable to cope with the thousands of injured residents seeking medical care.

- In Mexico City, several factors contributed to the number of casualties: a densely populated area, structures including hospitals which were not designed to withstand a major earthquake, a particularly vulnerable subsoil, inadequate public education, lack of rescue and debris removal equipment, and limited functioning medical facilities.
- In the case of the Nevada del Ruiz eruption, news accounts indicate that contingency plans had been made but had not yet been implemented. Several of the key factors in disaster planning may be difficult if not impossible to control, especially in developing countries. Yet some of them could be mitigated under circumstances which provided the resources of adequate technology, early hazard recognition, and organized disaster planning.

Planning for disaster may be considered under five major headings: 1) the use of *technology* to forecast events; 2) the use of *engineering* to reduce risks; 3) *public education* on potential hazards; 4) a coordinated *emergency response;* and 5) a *systematic assessment of the effects* of a disaster in order to better prepare for the future. Many man-made disasters can be prevented through use of modern technology and engineering, whereas "acts of God" require attention in all five headings in order to reduce their impact on a given community and limit casualties.

Technological Forecasting—Citing geological technology, Newhall and Fruchter in Chapter 2 of the BEVA monograph[1] summarize long-range forecasting of volcanic eruptions over a variable period of years based on geological history and records, and short-range eruption forecasting over months, weeks, days or hours based on "seismicity", ground deformation, gas emissions, or thermal manifestations. A long-range eruption forecast was made for Mount St. Helens in 1975 and again in 1978.[3,4] Short-range forecasts predicted the Mount St. Helens eruption to occur in April or early May of 1980, thus allowing evacuation and restricted entry to the areas likely to be affected. The four smaller subsequent eruptions of Mount St. Helens were all accurately forecast through monitoring seismic activity. Just as long-range forecasts have told us that the Cascade Range has entered an active phase, similar methods indicate that earthquake activity along the San Andreas Fault in Southern California is now more likely. Monitoring seismic activity along the Fault will allow geologists to increase the probability of accurate short-range forecasts.

The industrial correlate used to forecast major chemical spills or mine explosions is the use of technology to detect defective pipes or valves, and on-line gas or vapor detectors to monitor and signal chemical leaks or a dangerous concentration of methane gas which could trigger a mine fire or explosion. Understanding of chemical reactions and the toxicology of chemicals provide further examples of the use of technology to forecast probable events. Utilizing this knowledge, US Representatives Timothy Wirth, Henry Waxman, and James Florio have recently introduced H.R. 2576, the "Toxic Release Control Act of 1985"; among its other provisions, it calls for vigorous maintenance schedules, minimal requirements for monitoring leaks, and a special permit requirement for "extremely hazardous substances" such as methyl isocyanate or phosgene. In June 1985, the US Environmental Protection Agency (EPA) announced "A Strategy to Reduce Risks to Public Health from Air Toxics".[5] Part of this strategy dealt with sudden, accidental releases. While citing sophisticated safety systems in major firms in the chemical industry, EPA acknowledged that "not all firms share the safety consciousness of the industry leaders", and announced its intention to issue an "Acute-Hazards List" that would include substances known for their toxicity and potential for release. Hence, modern technology is being applied in many instances to help us forecast the likelihood of natural or man-made disasters, and predict the extent of the hazard and type of expected health effect.

Engineering Technology—Just as technology may be used to forecast events, engineering technology provides the means to prevent undesirable chemical reactions through proper component and plant design. Attention to properly engineered systems and adequate maintenance and up-dating of such systems provide the best assurance that major chemical spills will not occur. Section 301 of H.R. 2576 would require the EPA Administrator to "promulgate leak control requirements, monitoring requirements, vapor recovery requirements and other design, equipment, work practice, and operational requirements which shall be applicable to all such devices and systems which are owned or operated by a covered manufacturer or processor." Similarly, proper seismic design and construction of public buildings allow them to withstand major structural damage from earthquakes, such as that which struck Mexico City. While modern buildings have been so designed, many older buildings are not seismically safe. Such information about public buildings is obviously important in disaster planning in areas where significant seismic activity is predicted.

Public Education—A third principal in disaster prevention is public education. Again, Mount St. Helens, as described by Bernstein, Baxter, and Buist, *et al,* in Chapters 3 and 10 of the BEVA monograph, provides a prominent example of how federal, state, and community agencies used available information to provide adequate public education and warnings to alert the public to probable imminent danger, and then kept them informed as to probable risks and measures to take to reduce exposure following the eruption. Similarly, transmission of earthquake information to a population at risk would permit timely evacuation of seismically unsound structures and evacuation of the danger zone. Section 203 of H.R. 2576 delineates provisions of the "Community Right-to-Know," what potentially hazardous substances may arise from a local manufacturing or chemical processing plant, the concentrations of those substances, and their potential adverse health effects. Public education in the face of a major disaster has proven to be effective in reducing risk and is increasingly being regarded as a community "right"—with industry, community, state, and federal officials increasingly held responsible to provide appropriate information to the public. EPA has embraced the concept of the "Community Right-to-Know" in its aforementioned "Strategy to Reduce Risks to Public Health from Air Toxics," and plans to provide "Site-Specific Community Awareness Guidance," a list of questions designed to assist community work groups to gather information for public education and contingency planning.[5] The chemical industry also has recently taken steps through the Chemical Manufacturers Association and its Community Awareness and Emergency Response program to provide information to the chemical plant community through establishing communication networks. These actions are the direct result of the Bhopal tragedy, but are expressed within a background of growing state and community right-to-know legislation together with increasing liability and insurability issues which now face the chemical industry and others who may process or discharge toxic chemicals.

Emergency Response—Clearly, a coordinated emergency response may further reduce loss of life through rescue and rapid medical treatment. While the number of injured survivors who might benefit from such an emergency response may be relatively small, as was the case with the Mount St. Helens eruption, plans must be made to anticipate an approximate number of casualties, how they may be evacuated to medical facilities, the type of injuries, and the most efficient and appropriate medical treatments. Contingency plans must also be made for much larger numbers of displaced persons who may need shelter, food, and clothing for an indefinite period. The emergency response to the Mount St. Helens eruption, in both planning and execution, was generally effective in saving those that could be saved and in dealing responsibly with the events that followed.

The specter of Bhopal has stimulated the US Congress, EPA, and the chemical industry to come forward with new or revised emergency response proposals. Section 601 of H.R. 2576 contains several reasonable provisions for assuring an adequate emergency response to a major chemical spill. Among them are requirements that each covered major manufacturer develop a comprehensive evacuation and emergency response plan to include designation of state and local officials to be notified with emergency information, a detailed description of the health effects of any hazardous substance, the specific measures to be taken to mitigate and minimize risks to human health and the environment, specification of an emergency evacuation plan, specification of an emergency notification plan for hospitals and the public, an evaluation of available medical, police and, fire-fighting resources and, if appropriate, recommendations for additional resources. The bill also calls for the formation of "Emergency Response Districts" and "Emergency Response Committees" to be designated by the Governor of each State for the purpose of developing a comprehensive emergency response plan for the designated districts. Similarly, EPA's National Strategy for Toxic Air Pollutants[5] has stressed contingency planning through development of a document entitled "Evidence for Developing a Community Contingency Plan" and through its leadership role under the National Contingency Plan. Under the National Contingency Plan, the National Response Team carries out national planning and response coordination for a twelve-agency, federal emergency response network. Within each of the ten federal regions, there is a Regional Response Team comprised of representatives of the member agencies. EPA and the US Coast Guard maintain trained staffs in their respective Regional and District Offices to serve as federal coordinators and provide, as necessary, expertise and resources from other federal agencies and private contractors and for interface with state response teams.

In the case of a major chemical spill, however, the earliest and most crucial response must come from the manufacturing plant itself. Many firms already have in place emergency response plans similar to that outlined in H.R. 2576. The Chemical Manufacturers Association has established the Chemical Response and Information Center to organize information, train non-industry local personnel on the local level, and coordinate industry responses. Clearly, the Bhopal disaster has galvanized the chemical industry and underscored the need for a coordinated response to such a disaster.

Systematic Assessment—A fifth principal in planning for disaster is evaluation of the effectiveness of the response to the disaster and systematic investigation of the impact of the disaster on affected communities. In this respect, the evaluation of the Mount St. Helens disaster provides a superb model, as documented in the BEVA monograph. This evaluation was made possible by a coordinated and collaborative effort involving state and federal agencies, industry, organized labor, and academia.

It was initiated by a request from the Washington State Health Department of the Center for Disease Control's (CDC) Center for Environmental Health (CEH) and National Institute for Occupational Safety and Health (NIOSH). Together with state agencies in Washington and Oregon and the Federal Emergency Management Agency, CEH and NIOSH helped assess immediate and probable short-term health effects among those exposed to volcanic ash. Within days after the initial eruption, information was available on the concentrations and characteristics of volcanic ash. Within a few weeks, data from a hospital emergency room surveillance study revealed only slight excesses in respiratory disease morbidity.[6] Within a month following the eruptions, high-risk occupational groups involved in clean-up and logging were under investigation.[7] Within three months, information was available on the mineralogy of volcanic ash samples, on an array of vitro tests of ash toxicity, and the earliest experimental animal studies—all suggesting that volcanic ash was not likely to cause significant adverse effects unless inhaled in high concentrations over a relatively long period of time.[8,9] The CDC also made funds available to support the long-term collaborative research coordinated by the Biological Effects of Volcanic Ash Study Center which, for the first time, provided definitive data on the long-term effects of volcanic ash inhalation.

Mount St. Helens has given us an exemplary model of how to plan for disaster—through the proper use of technology, public education, a coordinated emergency response, and a thorough evaluation of the health effects arising from exposure. We have the benefit of this experience and, in the United States, the necessary resources to deal with future man-made and natural disasters. The challenge is to use them wisely and effectively.

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