Public Health Lessons From the Bhopal Chemical Disaster

THE 1984 CHEMICAL disaster in Bhopal, India, was first and foremost a terrible human tragedy. For those who were there and even for those at considerable distances who read about it, the reality of 2000 or more persons dead and many tens of thousands poisoned by a toxic cloud is horrifying. However, in its particulars and complexities, Bhopal's chemical disaster can also serve as a case example for almost any discipline taught in a school of public health. The disaster has elements of acute and chronic epidemiology, industrial hygiene, toxicology, environmental pollution and planning, disaster preparedness and management, health economics, medical ethics, and environmental protection law, to name a few. Mehta et al[1] review the literature on the Bhopal disaster and its aftermath and focus on the long-term health effects. They recognize the incomplete nature of much of the data and the serious methodologic limitations for study that the circumstances of the event engendered. What conclusions can we draw from this event? What can we learn to better prepare ourselves for similar events that might occur in the future?

See also p 2781.

There is an inherent catch-22 in doing a health evaluation of a disaster. The time period just following the event—when there remains considerable chaos, confusion, and inaccessibility of means of transport, communication, and data collection—is the very best time to try to establish information that will become invaluable in determining the health effects. This feature is common to natural disasters such as the Mount Saint Helens volcano eruption or man-mediated ones such as Bhopal or the nuclear contamination at Chernobyl. This immediate postdisaster time period is also when it is most difficult to organize systematic and valid epidemiologic studies.[2]

The information that is usually of most interest relates to mortality and morbidity (ie, the public health impact), exposure, and environmental damage. Depending on the setting, epidemiologic studies following environmental disasters may focus on some or all of the following: (1) accurate estimates of exposure; (2) correlation of environmental and human exposure data; (3) relationship of exposure (or dose) to observed health effects; (4) the potential interaction of other risk factors with exposure in producing health effects; (5) the natural history of the disaster-related illness (especially if, as with methyl isocyanate [MIC], such illness has not been well documented in the past); (6) impact of therapy or progression of disease (particularly in situations where the therapeutic approach is uncertain—in Bhopal this arose because of questions concerning possible toxic effects of cyanide); (7) effectiveness of screening and diagnostic tests (in determining who was affected and to what extent); (8) identification of markers of prognosis (in Bhopal a critical issue was who among the many individuals with acute respiratory problems would ultimately develop chronic pulmonary toxic effects), (9) evaluation of the effectiveness of disaster plans (including the implementation of warning systems, evacuation procedures, and the provision of emergency medical services); and (10) the psychosocial impact of the disaster on the affected population.[3]

These data are needed for several purposes: (1) to identify exposed and clinically ill persons to provide long-term care and monitoring for their own well-being; (2) to improve contingency planning for future disasters; (3) to determine the short- and long-term health effects; and (4) to link exposure and health consequences for litigation and reimbursement. The acquisition of scientific knowledge is not an intellectual exercise. Rather, it provides information that can help prevent or better control a similar disaster in the future.[4]

A rough estimate of deaths can sometimes be obtained in a disaster setting in a developing country by conducting a survey at the site soon after the event.[5] In Bhopal, this meant that in the first 5 days after the event, sample surveys might have been conducted in selected areas of the city. While there was some disruption of families, much of the local population was still present up to 10 days after the event. Available interviewers with appropriate supervision could have been given brief training and a data collection form and sent out to obtain rough rates of death and illness, along with other variables. In disaster situations there are often many practical impediments to collecting what would otherwise seem to be readily available information. For instance, in Bhopal on the night of the disaster, so many patients were seen at the major hospitals that even rudimentary medical records were not available for most patients; this would complicate unbiased sample selection for clinical epidemiologic studies of hospitalized patients. Such practical constraints ranged from the unavailability of death certificates or medical records to the lack of prior census data, very limited numbers of on-the-scene epidemiologists or investigators, and insufficient envi-

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ronmental data (or even the equipment to collect such data). The constraints to the conduct of health studies were especially severe in Bhopal because of the enormous scope of this environmental disaster.

Determining health effects, particularly long-term ones, requires a knowledge of the amount of exposure. Without such information, diseases and conditions that develop over time in a population tend to be more readily noticed, added together, and ascribed to the presumed exposure. Comparing such a newly measured incidence of an adverse health event with a neighboring nonexposed community or with the same community at a time prior to the disaster is problematic. Even neighboring communities often may have characteristics that are different from the case community, such as differing customs, different environmental exposures (the case community may have other toxic hazards in addition to those associated with the disaster), and different food or water sources. A comparison with an earlier time period is often not possible due to the lack of carefully collected data on the health condition in question prior to the disaster and the problem of recall bias. Measuring exposure is made considerably easier when a biomarker of exposure, such as a blood chemistry level or determination of the level of radioactivity, can be obtained

For the exposure to MIC at Bhopal, such a marker had not been identified. An alternative approach is to establish a dose-response relationship between a measure of environmental exposure and a health event. In the aftermath of the disaster at Bhopal, this was not possible, because wide-scale environmental measurements of MIC (or breakdown products) could not be obtained in time. Approximations were based on less precise measures of exposure such as how close an individual lived to the plant. Actual exposures would be affected by many other factors, such as the height of the patient from the ground, the degree of ventilation of the house, and the shielding of the patient from the MIC vapors. It was also noted that degrees of damage to local vegetation could serve as an approximate, albeit imprecise, indicator of environmental exposure. Indeed, several investigators of the Bhopal disaster used a simplified dose-response approach in looking at late health events. They chose a community within 2 km of the plant and a farther one (approximately 8 km from the plant) and found higher rates of decreased pulmonary function,[6] increased acute ocular symptoms,[7] and increased pulmonary symptoms in children[8] for the individuals living closer to the plant. However, these studies were conducted 3 to 4 months after the disaster, and we have no longer-term follow-up data.

What might have been done epidemiologically, especially in ideal circumstances, is therefore a moot point for Bhopal. The immediate medical response to the disaster appeared to be swift, appropriate, and effective. The epidemiologic response could not be a priority at the time.

Thus the information we have today, 6 years after the event, is not profoundly different from that available in the first weeks after the gas leak; there were considerable acute pulmonary toxic effects with bronchospasm and pulmonary edema, severe irritation of exposed mucous membranes and the cornea, and little evidence of residual ocular effects. However, careful study would be needed to determine the long-term pulmonary damage and damage to other organs.

The article by Mehta et al confirms these early observations, suggests that long-term pulmonary damage has occurred, and raises the issue of teratogenic and fetal damage from MIC, although not proving it. Their statement "none of the data on morbidity and mortality are firm" is disappointing for their desire to present (and the readers to receive) a data-rich scientific review. But more important, this lack of firm data extends the tragedy by denying some damaged individuals proper restitution, confounding follow-up and care for exposed individuals, and minimizing the new information available to better prevent and control future MIC exposures. Health authorities in industrial and chemical disasters must first focus on provision of care for the ill and injured but also must see as an urgent priority the establishment of a surveillance and epidemiologic study system that will address the aftermath of the acute exposure.

We readily perceive disaster planning and preparedness to encompass chemical plant operating conditions and safety systems (the cause of the disaster), and procedures to warn, evacuate, and protect nearby populations. The provision of emergency medical services is obvious. But the ability to conduct effective and valid postdisaster epidemiologic and health evaluations also depends on prior planning and available infrastructure. In Bhopal, support came promptly from a variety of local and national resources, including the Indian Council for Medical Research. The article by Mehta et al highlights the importance of the public health response, particularly epidemiology and health surveillance, in disaster planning.

Finally, it is impossible to close a discussion of the Bhopal disaster without reemphasizing the importance of prevention. While there are many lessons to be learned from a careful and thorough investigation of the health effects resulting from the Bhopal disaster, what a terrible price was paid for these lessons. Many difficult issues remain to be addressed to assure that similar disasters do not occur. Among these are how to prevent such potentially dangerous plants from being located in heavily populated areas, how to ensure the safe operation and maintenance of technologically complex facilities, and how to develop effective disaster plans to better protect workers and nearby residents.[9]

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9. Bhopal Working Group. The public health implications of the Bhopal disaster. *Am J Public Health*. 1987;77:230-236.

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