Journal of Hazardous Materials, 22 (1989) 1-11
Elsevier Science Publishers B.V., Amsterdam — Printed in The Netherlands

COMMUNITY EVACUATION FOLLOWING THE SPENCER METAL PROCESSING PLANT FIRE, NANTICOKE, PENNSYLVANIA

P. DUCLOS[1], S. BINDER[1] and R. RIESTER[2]

[1]*Acute and Natural Hazards Studies Section, Division of Environmental Hazards and Health Effects, Center for Environmental Health and Injury Control, Centers for Disease Control, Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA 30333 (U.S.A.)*
[2]*Pennsylvania Department of Health, Northeastern District Office, 383 Wyoming Avenue, Kingston, PA 18704 (U.S.A.)*

(Received November 19, 1988; accepted February 6, 1989)

Summary

On Tuesday, March 24, 1987, 15,000 persons were evacuated from communities surrounding a fire at the Spencer Metal Company in Nanticoke, Pennsylvania. To evaluate the evacuation process, we conducted a phone survey and interviewed representatives of 504 households. Ninety-eight percent of all households complied with the order to evacuate. Factors that might have been responsible for the high compliance rate are the proximity of a nuclear power plant; the warning of most persons by officials; the social structure of the community; previous knowledge of evacuation plans by part of the population; the ability of many residents to see the fire; and the time of day. In 30% of interviewed households, at least one member reported mild symptoms that are consistent with an acute exposure. For future evacuations, we recommend the following: (1) improve advertising of evacuation plans; (2) make plans more flexible; (3) improve the warning message and address people's concerns; and (4) develop research on the risks of indoor versus outdoor exposure from chemical accidents to improve guidelines for decision-making.

Background

As a strategy for prevention of exposure to natural or toxicologic hazards, each year hundreds of thousands of persons are evacuated in the United States from areas at risk. In 1986, over 111 hazardous material accidental releases resulted in evacuations [1]. Surprisingly, the efficiency of these evacuations and the problems they generate have seldom been the focus of epidemiologic studies. Most of the published literature about evacuations relates to specific populations, such as those in hospitals, or evaluates only psychological or sociological impact. This paper presents a household survey conducted to evaluate the evacuation process in a community with a preexisting evacuation plan.

On Tuesday, March 24, 1987, at 0:15 a.m., a fire erupted at the Spencer Metal

0304-3894/89/$03.50

Processing Company in Nanticoke City, Luzerne County, Pennsylvania. This plant, in which aluminum is electroplated, was located at the corner of Alden Road and Union Street at the Sheatown-Nanticoke border (see Fig. 1). The plant contained a variety of chemicals used in the electroplating process, mostly

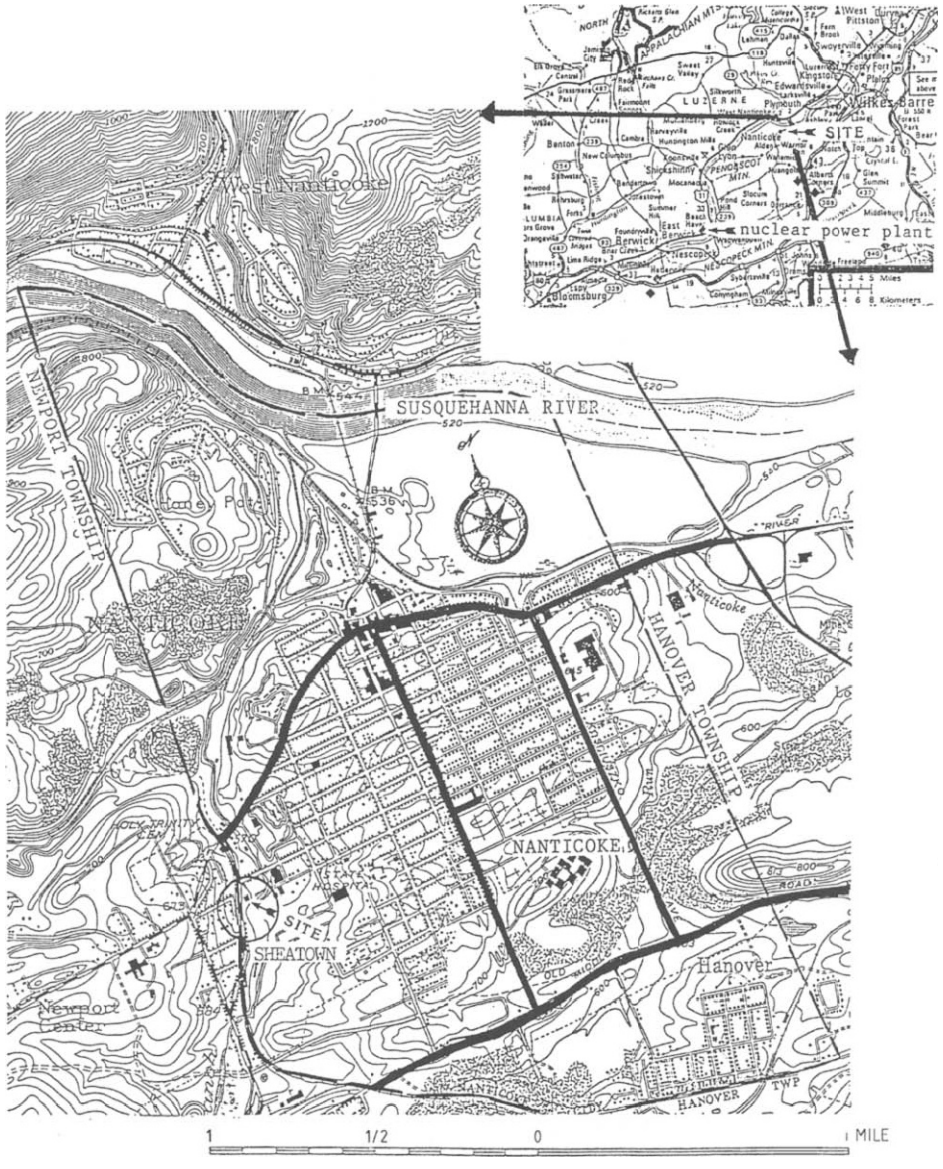

Fig. 1. Map of Nanticoke City, location of Spencer Processing Company and Susquehanna Nuclear Power Plant, and major evacuation routes. - - - Border of Nanticoke Township, ——— major evacuation routes.

a variety of acids but also several bases, dyes, and other products used in smaller amount. Chemicals were stored in drums, vats, and plastic containers. The fire was contained in the electroplating part of the building. The storage area did not catch on fire. A cloud formed as a result of boiling acid plating baths which contained nitric, sulfuric, and phosphoric acid. This cloud was believed to be releasing acid aerosols. Wind direction was variable but generally from the northwest at five miles per hour (8 km/h).

Because of the potential danger from toxic fumes, evacuation was ordered by the fire chief and endorsed by the Nanticoke City Mayor. As a result, the entire city of Nanticoke and parts of nearby Newport Township were evacuated. According to officials, 15,000 people were directed to leave their homes in four successive evacuations during the night. Nanticoke State General Hospital and four nursing homes were also evacuated. Evacuation was coordinated by the director of the Nanticoke Emergency Management Agency. It proceeded according to the Radiological Emergency Response Plan established for incidents at the nearby nuclear power plant, the Pennsylvania Power & Light Co.'s Susquehanna Steam Electric Station. This document included plans for warning the public, transporting persons in medical or extended care facilities and individuals without transportation, and utilizing traffic control and evacuation routes to move residents away from the power plant. It covered all the evacuated areas.

Several firemen complained of the following: skin irritation at wrists and neck, sore throat, hoarseness, coughing, burning around lips, and eye irritation. These symptoms are typical of acid mist exposure. In addition, firemen's bunker gear started to disintegrate and this is also typical of acid mist exposure. Exact composition of the toxic cloud remained unknown, as air monitoring was not performed before 9 a.m. when the fire was out. Since air levels of CO, SO_2, NO_2, and acid aerosols remained within normal range, the Nanticoke City Mayor officially ended the evacuation at 4:45 p.m. on Tuesday 24, 1987.

Methods

We conducted a cross-sectional household survey to evaluate the community evacuation process and potential associated health effects. This study focused on Nanticoke City, which had been ordered entirely evacuated and contained most of the evacuated residents. A systematic sample of 788 residential phone numbers was selected from the 5516 residential phone numbers listed in the 1986 cross directory for Nanticoke Area. Approximately 84% of all households have telephone service. Each household was contacted by telephone and, if the household was in an area officially under evacuation directives, a 17-page questionnaire was administered to an adult who responded for the entire household.

Since almost all people in Nanticoke were evacuated, it was difficult to study directly the impact of various factors upon evacuation effectiveness. There-

fore, delay between receipt of the first warning to evacuate and the actual evacuation was used as a surrogate measure of evacuation effectiveness. For the purpose of our analyses, delay (less than 30 minutes versus 30 minutes or more) was treated as a dichotomous variable.

Fisher's exact test was used for comparisons. Odds ratios (OR) were used to measure of the strength of the association between two variables. Mantel–Haenszel summarized OR (ORMH) were used when controlling for a third variable. Ninety-five percent confidence intervals (CI) for proportions were computed by using the normal approximation for proportions greater than 0.1 and lower than 0.9 and by using the angular transformation method for extreme proportions [2].

Results

Overall, 504 of the 788 households selected were interviewed. Six and seven-tenths percent ($n=52$) of telephone numbers were disconnected, 13.5% ($n=106$) were noneligible because their dwelling was located outside of the area officially evacuated, and 6.5% ($n=51$) numbers were not answered after five attempts at different times of the day. The refusal rate was 12.8%. The overall compliance rate was 79.6%. Demographics of the interviewees are compared with those of the entire Nanticoke population in Table 1.

Description of the evacuation warnings

According to the interviewees, most directives to evacuate were issued between 2 and 4 a.m. on Tuesday (see Fig. 2). Sources of first and subsequent directives to evacuate reported by interviewees are shown in Table 2. Three households stated that they did not receive any warning at all. When considering all warnings received, although there was no difference in the frequency with which they remembered officials coming to the door or hearing the warning on the radio or the television, persons 65 and older were more often warned

TABLE 1

Demographics of interviewees and of all Nanticoke residents*, Nanticoke, Pennsylvania, 1987

Parameter	Interviewees	1980 Census
Age (y) median	58.9	42.3
mean	55.5	40.2
Sex (% male)	28.5	44.0
Average number of persons per household	2.53	2.46

*Based on 1980 Census data.

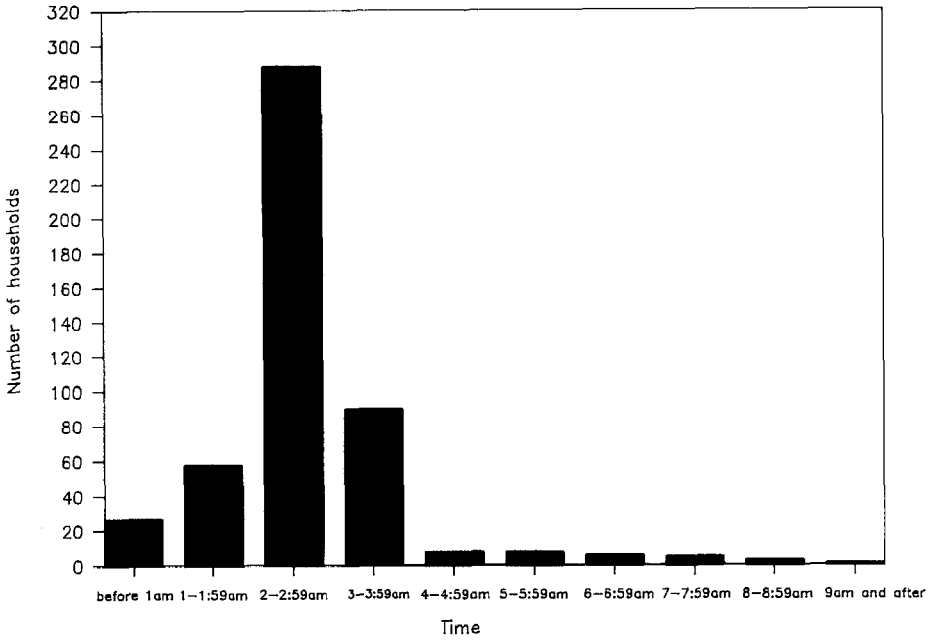

Fig. 2. Time of first directive to evacuate Nanticoke, 1987.

TABLE 2

Sources of first and subsequent directives to evacuate, 504 households, Nanticoke, Pennsylvania, 1987

Sources of directives	% of households reporting	
	First warning	Subsequent warning
Sirens	31.8	39.2
Phone	20.4	6.0
Neighbor came to house	17.3	14.4
Fire department loudspeakers	14.9	26.4
Officials came to house	4.6	9.2
Radio	4.2	17.6
Television	0.8	2.6
Other sources (including citizen band radio)	5.4	7.6
None	0.6	–

by neighbors coming to the door (21.7% versus 16.4%) or being called (29.0% versus 20.1%) than those younger than 65. They were less likely to have heard the sirens (24.6% versus 29.9%) or the fireman loudspeakers (10.1% versus 16.7%).

When asked an open-ended question about their recollection of the warning

TABLE 3

Recollection of the content of evacuation message received by interviewees, Nanticoke, Pennsylvania, 1987

Information about the	% of interviewees reporting
Need to evacuate	73.4
Fire	41.1
Chemical release	25.4
Danger	10.3
Spencer Metal Company was on fire	11.7
Nature of the fumes	10.1
Evacuation centers	9.9

messages they received, people recalled different patterns in the directives (see Table 3). Nobody remembered being told the limits of the area under evacuation.

Description of evacuation behavior

Of all interviewed households, 98.0% (CI 96.5–99.0%) complied with the order to evacuate: 31.8% evacuated because of the perception of danger, 26.2% because they were requested to do so, 38.0% for both of these reasons, and 4.0% for other reasons. Those who did not evacuate were more likely to think that there was no danger ($OR=5, p=0.06$) and to have family members away from home ($OR=3.9, p=0.06$). Those who were first warned by watching television were less likely to evacuate ($OR=69.0, p=0.001$).

Mean delay between receipt of the first directive to evacuate and evacuation (Fig. 3) was 35 minutes, median was 18.4 minutes, with a range from almost 0 to 390 minutes. Forty-nine interviewees departed immediately after hearing directives to evacuate. People were more likely to evacuate before 30 minutes if their dwelling was in the path of the fumes ($OR=1.8, p=0.001$) or if all members of the household were at home when first warned ($OR=1.5, p=0.08$). Content of the remembered warning message or the presence of pets (40.7% of households owned pets) did not affect the delay. Those who departed within 30 minutes of their first warning were more likely to have heard official loudspeakers (20.0% versus 9.3%, $OR=3.8, p=0.000003$) or had officials come to the door (6.7% versus 1.9%, $OR=4.8, p=0.002$).

Transportation used by households to evacuate and places where they sought shelter are presented in Table 4. Nanticoke had a list of persons who were likely to need special notification of evacuations (like the hearing impaired) or had transportation needs. The hearing impaired were contacted by officials going to their doors or by telephoning their neighbors. City transportation was offered to the elderly and other without private transportation and ambulances were used to evacuate some hospital and nursing home patients. A private

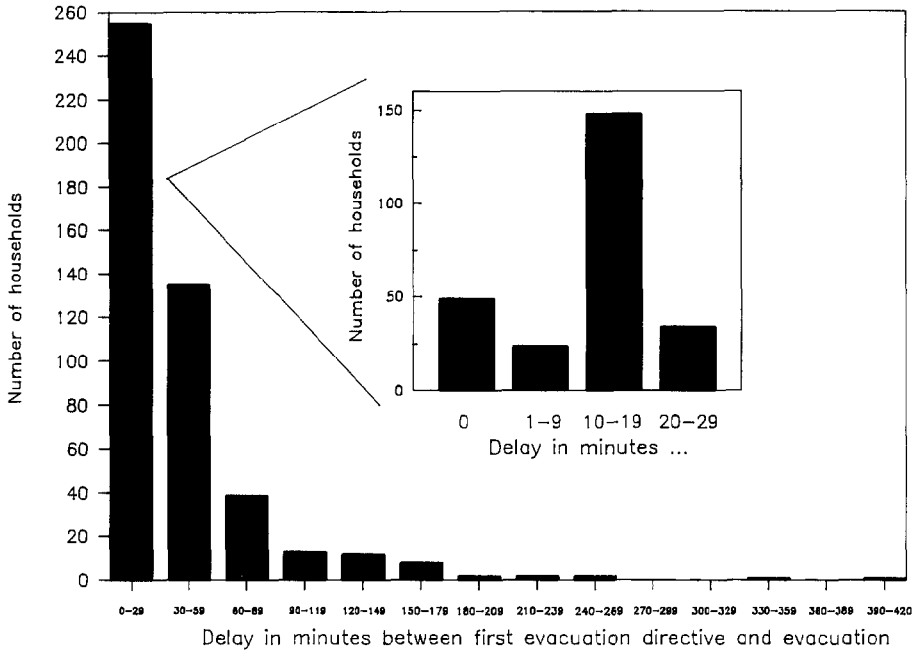

Fig. 3. Delay until evacuation of Nanticoke, 1987.

TABLE 4

Transportation used by households during the evacuation process and places where they sought shelter, Nanticoke, Pennsylvania, 1987

Evacuation	% of household reporting
Transportation mode	
Private automobile	95.9 (CI 94.1-97.6)
State or city provided transportation	1.0 (CI 0.3-2.1)
Other transportation including ambulance	2.9 (CI 1.6-4.6)
Place where sought shelter	
In a public shelter	43.2 (CI 39.0-47.4)
At friend's house	8.7 (CI 6.3-11.1)
At a relative's house	37.4 (CI 33.3-41.5)
At a motel	1.2 (CI 0.4-2.4)
In another place	11.3 (CI 8.7-13.9)

automobile was the most commonly used means of transportation and 24.7% (CI 21.1–28.3%) of all households were involved in a traffic jam for more than 5 minutes during the evacuation process. Only 77.2% (CI 72.9–81.1%) of all households reached the city limits in less than 30 minutes after leaving their

home. Normally, the city limits are accessible from anywhere in the city within 30 minutes. Among interviewees, 48.5% (CI 44.1–52.9%) were exposed to the fumes while in transit or getting into a car. Among those households that owned pets 49.0% (CI 42.2–55.8%) evacuated with all of their pets and 7.6% (CI 4–11.2%) with only some of their pets.

Concerns about evacuation at the time people were asked to evacuate were numerous and included fear of looting for 111 interviewees, care of pets for 39, difficulties moving with children or elderly for 21, feelings of panic for 21, the lack of a place to go for 13, separation of the family for 11, and the lack of transportation for eight. Interviewees also mentioned other concerns like what to take with them during the evacuation, how long they were going to be out of home, family's safety, missing work, and a possible remaining air contamination when they returned. Among interviewees, 91.4% (CI 88.2–93.4%) thought that the evacuation was necessary. Although, 53.8% (CI 49.6–58.0%) had heard of the nuclear power plant evacuation plan before the incident, only 4.3% (CI 2.6–6.3%) had practiced evacuating prior to this fire. Those who were aware of emergency plans were more likely to depart within 30 minutes of the receipt of the first directives to evacuate ($OR=1.5, p=0.02$).

Health impact

Among the interviewees 19.8% (CI 16.3–23.3%) reported personally developing symptoms on or after March 24, that may have been related to the chemical fire. Only one (11.1%) of the nine interviewees who did not evacuate reported symptoms, compared with 20.0% of individuals who evacuated. However, due to small numbers and large confidence intervals, these two proportions are not significantly different. Overall, 30.3% (CI 26.4–34.9%) of households reported at least one member affected by the fumes. Frequency of symptoms reported are listed in Table 5. Among people developing symptoms, 19% sought medical care and 38.7% were still experiencing symptoms at the time of the interview. Type of dwelling (single family home versus apartment), being stopped by a traffic jam for more than 5 minutes, or failure to evacuate did not affect the likelihood of developing symptoms. Persons who evacuated more than 30 minutes after the first warning were not more likely to report symptoms. Among the interviewees, when controlled for age by 10 year age groups, males were less likely to report that they experienced symptoms ($ORMH=0.5$, $p=0.03$). After controlling for exposure to fumes while in transit or getting into a car and for sex, people tended to be more likely to develop symptoms if their house was in the fumes ($ORMH=1.9, p=0.05$). When controlled for the dwelling being in the fumes and for sex, people were more likely to develop symptoms if they were exposed to the plume while in transit or getting into a car ($ORMH=5.8$, $p<0.001$). In addition to symptoms from the fumes, one person reported that he sustained a back injury during the evacuation, when the driver behind his car had a heart attack and bumped his car from behind.

TABLE 5

Frequency of reported symptoms, 1275 persons, Nanticoke, Pennsylvania, 1987

Symptoms	Frequency reported*
Burning throat	82
Burning eyes	52
Cough	38
Chest pain	25
Headache	23
Shortness of breath	19
Burning skin	12
Vomiting	9
Dizziness	6
Blurry vision	3
Fainting	1
Muscle cramps	1

*Includes symptoms experienced by interviewers or other household members.

Discussion

Evacuation is a commonly used strategy for preventing mortality and morbidity during potential public health disasters. Every nuclear power plant is required to plan for evacuation of a 10 mile radius (16 km) around the plant, and it was this plan that was used in this evacuation. The majority of evacuations to prevent public health consequences of unintentional environmental releases is a result of chemical, not radiation leaks, and may occur in areas without detailed evacuation plans. This was an opportunity to evaluate an evacuation resulting from a chemical release in an area with a detailed and publicized plan.

The compliance rate with the evacuation directives was very high and the evacuation was very successful in this regard. The proximity of the nuclear power plant may have been an important factor in this high compliance rate, both because of community awareness of the potential for a radioactive release and because of awareness with both the concept and the content of evacuation plans by part of the population. Other factors may have included warning of most persons by officials (sirens, loudspeakers, or direct contact); the social structure of the community (many persons took care of neighbors, either by warning them or providing transportation – although only 76.1% of households had one or more vehicle available according to the 1980 Census, 95.9% of them evacuated with a private automobile); the ability of many residents to see the fire; and the time of the day. The fact that a large part of the population evacuated so promptly may have increased the probability that the rest of the population followed the crowd. From our survey, it is impossible to determine the role of each of these factors. Since all evacuated areas were covered by the

Radiological Emergency Response Plan, it was impossible to compare evacuation performance of areas with and without a plan.

Although the evacuation was effective in removing people from the area, many difficulties can be identified which might have caused severe problems under other circumstances. One major consideration was that the roads were used according to the evacuation plan for the nuclear facility, which is several miles away from the town; this plan may not have been optimal for evacuation from a release source within the town. Also, the evacuation plan did not take into account the closure of one of the bridges. Exposures of persons in transit could have been increased by factors that slowed traffic, such as the bridge closure and the regular operation of traffic lights.

Symptoms people reported were relatively mild, generally of short duration, and consistent with an acute caustic exposure to acid aerosols. However, due to the lack of air monitoring, the hilliness of the city (which makes modelling of exposures extremely difficult), lack of precise data on location of individuals, and the variation in exposure duration and escape paths, it is impossible to evaluate causality according to a dose–response effect.

Mass evacuation may generate more problems than the original threat, since it may disrupt health care and other services and disrupt social networks. The larger the population, the greater the probability of adverse effects from the evacuation. Unfortunately, the decision to evacuate is often made very quickly and does not always result from objective reasoning and pre-established guidelines. In addition to injuries and deaths that might occur from evacuations, people may suffer a traumatic psychological experience. Was this evacuation necessary? Would the exposure and health impact have been less if people had not been evacuated and had stayed inside? It is impossible to answer these questions with our survey. Further study is needed to determine whether evacuations are the best strategy for protecting public health during chemical releases that are likely to be relatively short in duration and leave little residual environmental contamination (unlike some scenarios for nuclear power plant incidents).

We identified several factors that might account for a delayed departure or non compliance with the evacuation directives. Among these are the source of warning and lack of awareness of evacuation plans.

Recommendations

In anticipation of future evacuations, following our findings and observations, we recommend to:

1. Improve advertising of evacuation plans, when such plans exist. Information should be repeated frequently, since populations change.

2. Make plans more flexible. They should be adjusted according to circumstances (the nature of the incident, traffic obstacles, etc.).

3. Improve the warning message – make clear what is happening, provide directions, and address people's concerns, such as fear of looting and care of pets. Sirens should be used according to a code indicating specific meanings, and people should be aware of the code. Special attention is needed for the elderly, who are more frequently alone, without phones, with no transportation, and are more likely to be hearing impaired.

4. Develop research on evaluating risks of remaining indoors versus evacuating (and potentially being exposed outdoors) following chemical releases. This research is necessary to improve guidelines for decision-making during chemical emergencies.

Acknowledgements

We would like to express our gratitude for their help to all the staff of the Northeastern Health District of Pennsylvania.

We also would like to thank Drs. Brian Redmond and Michael Case, Earth and Environmental Science Department, Wilkes Barre College, and John Wilkes, Department of Environmental Resources, Bureau of Air Quality, Pennsylvania Department of Health Services who provided us with air monitoring data.

The work was supported by funds from the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Trust Fund, provided via an interagency agreement with the Agency for Toxic Substance and Disease Registry, U.S. Public Health Service.

References

1 S. Binder, Deaths, injuries and evacuations from acute hazardous materials releases, Am. J. Public Health, 1989, in press.

2 P. Dagnelie, Théorie et méthodes statistiques, Vol. 2, 2th ed. Les Presses Agronomiques de Gembloux, Gembloux, 1975, pp. 463.