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## FLASH FLOOD DISASTER-NÎMES, FRANCE, 1988

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**Key words:** Flood - France - Disaster - Epidemiology - Health effects - Planning

On October 3, 1988, at 7:45 a.m. a flash flood occurred in the region of Nîmes, France. Though the homes of 45,000 people were damaged and more than 1,100 vehicles were destroyed, only 3 severe injuries and 9 deaths were reported. A community survey was conducted to study (1) what factors might have contributed to the limited number of deaths, (2) the reactions of the population to the disaster, and (3) the health effects associated with the impact and postimpact phases of the disaster. Overall, 108 questionnaires were completed from a systematic sample of 187 households living in ground-level dwellings in two of the most seriously affected areas of the city. Only 17% of all interviewees knew that they lived in an area subject to flood. When they realized they were in danger, 93% of all persons were in their houses or other buildings, 4% were in the streets, and 3% were in cars. Fifty-six percent of the interviewees tried to get to safety. Thirty percent of the interviewees reported that they were rescued; 20% of these persons reported being saved from a direct life threat.

Neighbors (40%), family members (20%), firefighters (12%), the Red Cross (10%), and military personnel (8%) conducted rescue operations. Six percent of all members of interviewed households were reportedly suffering mild injuries that, in 70% of these cases, had been sustained during the impact phase. Health problems and injuries during the postimpact phase may have been limited by the response of trained military personnel and by the distribution of boots and gloves to other responders. The limited death toll might be attributed to: (1) the disaster occurred early in the morning when people were still home (2) traffic heading into the city was stopped by flood water on some access roads, (3) the rescue operations were set up within the framework of the French disaster plan, and (4) the civilian response. No outbreaks of infectious disease were detected after the disaster.

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### INTRODUCTION

Nîmes, a city of 130,000 inhabitants, is located in the south of France in the region of Gard, and for the past 30 years has had an average annual rainfall of

between 600 and 700 mm. On October 2, 1988 the National Weather Service issued a warning for very heavy rains of approximately 100 mm on October 3. On Monday, October 3, 263 mm of rain fell at the Nîmes-Courbesac meteorological station between 3 a.m. and noon. This resulted in a flash flood which occurred at around 8 a.m. Pouring rains sent water flowing from the mountains onto saturated ground with a low infiltration capability. The two natural

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creeks (cadereaux) that serve to drain water from the city, and which are usually dry, were suddenly filled and overflowed. The water ran through the city to the Vistre, a small river located downstream (see Figure 1).

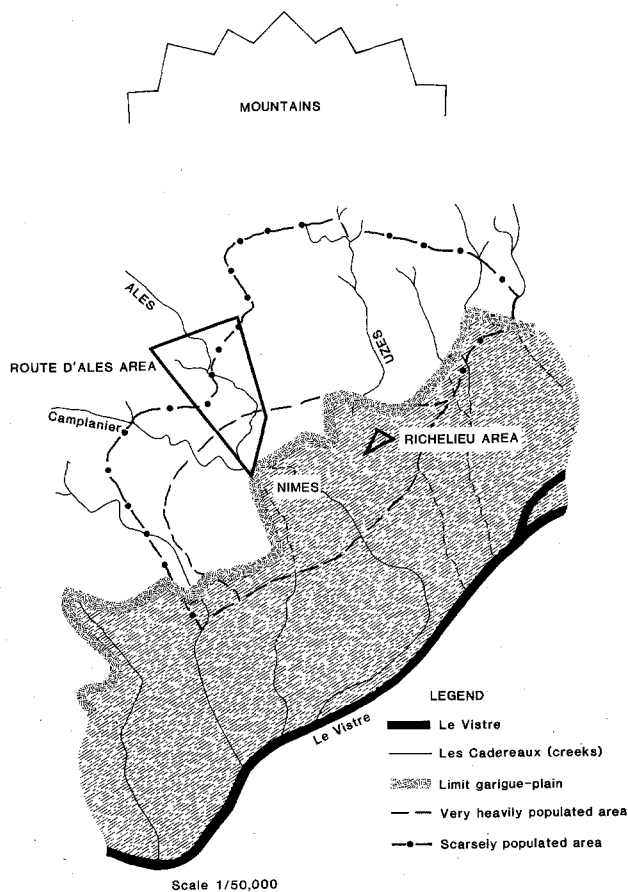


Figure 1. - Nîmes and its region.

All areas below Nîmes were also flooded. The flooding was exacerbated by the facts that the creeks, which were located within the city, were filled with debris, and dams in the plains around the Vistre prevented water from flowing rapidly toward the sea.

In terms of damage and economic loss, this was one of the worst disasters that France has experienced in recent decades. It caused tremendous destruction to the city, including damage to the homes of 45,000 persons. Over 1,100 motor vehicles were destroyed.

The ORSEC plan (rescue plan) was put into action by the governor of the Gard region, and a state of natural disaster was declared for 70 cities (including Nîmes, by far the largest) located in 10 counties. At 1 p.m. on October 3, after the rain had stopped, 17 civil defense and army helicopters began rescue operations. Military amphibian vehicles and tanks were used for access and cleanup operations.

Three epidemiologic activities were defined and initiated:

1. An assessment of the overall health impact of the disaster through review of medical care delivery sources.

2. The surveillance of infectious diseases.

3. A community survey of affected non-institutionalized populations to describe (1) the factors contributing to the limited mortality, (2) the reaction of the population to the disaster, and (3) the health effects associated with the impact and post-impact phases of the disaster.

## METHODS

### 1. Assessment of the health impact of the disaster

To obtain a complete picture of the health effects of the flood, contacts were made with the Service d'Aide Médicale Urgente (SAMU), the hospitals, the Red Cross, the army medical services, the firefighters' medical services, the physician of the electricity and gas company, the civil defense medical team, the "médecin de santé scolaire" and twenty general practitioners in Nîmes. The SAMU log books from September 26 through October 5 were reviewed. Death certificates computerized at the Direction Régionale des Affaires Sanitaires et Sociales (DRASS) were reviewed for the city of Nîmes and for all 10 affected counties for the period January 1987 through December 1988 for the following causes of deaths: all causes, ischemic cardiopathies (ICD9 code 410-414), cerebrovascular accidents (ICD9 codes 431-436), drownings (ICD9 code E910), and deaths related to natural disasters (ICD9 code E908).

### 2. Surveillance of infectious diseases

The DRASS established a specific surveillance system for diarrheal diseases, typhoid fever, leptospirosis, and hepatitis A based on a systematic sample of 20 general practitioners (13%) and 4 medical laboratories (20%) in Nîmes. In addition, four other general practitioners from other affected cities were enrolled in the surveillance. Two other general practitioners from non-affected cities nearby were also enrolled to serve as a control group. Surveillance was difficult as the background of cases was not very accurately defined. Surveillance was initiated on October 10 with calls placed to all selected practitioners and laboratories. Second calls were placed 3 days later. All participants were called again at the end of each week (for a 6-week period). They were asked to immediately notify the DRASS by telephone in case of an outbreak.

### 3. Community survey

Because of limited resources, focus was placed on

two areas of Nîmes particularly affected by the flood (see Figure 1): (1) the neighborhood along the Route d'Ales, a residential area that was exposed to strong water flow because it is near the creeks that overflowed during the flood; and (2) the Richelieu neighborhood, which has a large elderly population and is located in the middle of the city where the water level was very high.

A questionnaire was field-tested, revised, and administered to a systematic sample of families whose dwellings were located at least partly on the ground level and who were selected on the basis of the address number. The questionnaire was administered to a family representative over 16 years of age who was present in Nîmes at the time of the flood and who responded for the entire family. For those families who had relocated, new addresses were obtained from neighbors or from the Direction Départementale des Services Sociaux (DDSS) or the city hall. The questionnaire contained information pertaining to the interviewee and his family (demographics, severity of damage to the dwelling, injuries, reactions, rescue operations, assistance received). The questionnaire was administered in person or, if the household members had been relocated to a remote area, by telephone. The surveys were conducted between October 24 and December 10, 1988. For data analysis and data management, the 3.0 version of Epi Info was used.

## RESULTS

### 1. Assessment of the health effect of the flood

The health effect of the disaster during the impact phase amounted to 9 deaths by drowning (including two persons who tried to rescue others) and only three severe injuries (one with arm and face burns, one with a leg fracture, and one with broken arms). The SAMU files also listed two hypothermia cases, three instances of near drowning, and approximately ten minor injuries.

Death certificates did not reveal any increased mortality from the flood other than those above mentioned deaths which were coded as natural disaster related (see Figure 2).

Among rescue and cleanup workers, twelve cases of carbon monoxide poisoning were reported involving firefighters, civilians, and members of the military who were pumping water and effluents from basements. Three instances of exposure to chlorinated derivatives were also reported and a few sprains were treated by the civil defense infirmary.

Although we were not able to quantify this finding, interviewed physicians reported an increase in visits for mental problems among Nîmes residents with or without preexisting conditions. They did not report any increases in other conditions.

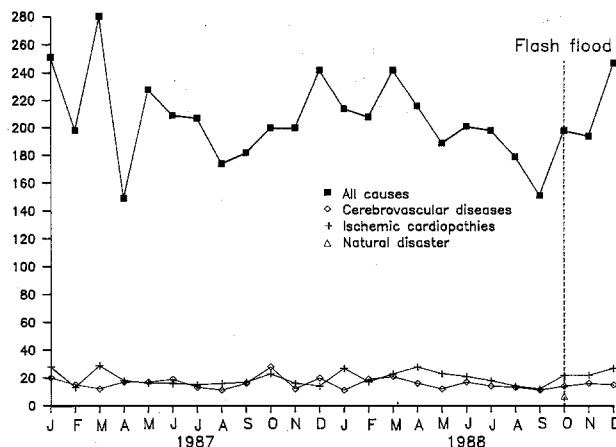


Figure 2. - Monthly number of deaths in the ten flooded counties, 1987-1988.

### 2. Surveillance of infectious diseases

No specific increase was observed in infectious outbreaks. In October 1988, after the flood, only two cases of typhoid fever were confirmed by culture of *Salmonella typhi*. Because both victims had drunk water that bacteriologic analysis revealed unsuitable for consumption, these cases, in the absence of other clearly identified sources, were thought to be related to water. One of the victims was a Nîmes resident and the second lived in another flooded city. No relationship could be established between the two cases. There is normally an average of 5 typhoid cases a year in the Gard region.

### 3. Community survey

Though many results are presented for all members of interviewed households, some information concerns only the household representative-interviewees. More detailed results, therefore, are presented for the interviewees.

From a sample of 181 households, 108 (58%) questionnaires were completed (54 in the Richelieu area, and 54 in the Route d'Ales area). The 108 participating families included 228 persons. Demographic characteristics of interviewed households are presented in Table 1.

Two percent of all dwelling units were completely destroyed. The level reached by the water on the first floor of dwelling units was over one meter in 38% of cases.

Six percent of all persons reported mild injuries (contusions, cuts, and sprains) related to the flood. Seventy percent of these injuries were sustained during the impact phase. In 66% of the cases, medical care was obtained from a health care facility or from a member of the household. The mean age of the

TABLE 1. - Demographic data for interviewed families, Nîmes flood, October 1988.

	Both areas	Richelieu area	Route d'Ales area
Age (yrs)			
Range	2-92	2-92	2-91
Median	52	53	51
Average	48	48	48
% of males	47	44	50
% of interviewees partially dependant	6	8	4
Type of housing (%)			
Appartment building	44	74	13
Private house	56	26	87
% of dwelling units with only one floor	26	17	35

injured persons was 46.4 years. Thirty-two percent of the interviewees reported medical problems that they believed to be related to the flood. Fifty-nine percent of these mentioned stress-related problems, such as insomnia or anxiety. Other reported medical problems included influenza, bronchitis, rhinitis, sinusitis, and rheumatism. Only 2% of the interviewees who had routine scheduled medical treatments or drug prescriptions reported that the flood had made it difficult for them to obtain this medical care.

Seventeen percent of all interviewees knew that they were living in an area subject to flooding.

The time at which interviewees realized the danger of the situation is presented in Table 2. At the time of the flood, 87% of all persons were in their homes, 6% were in another building, 4% were in the street, and 3% were in a vehicle. Major concerns

TABLE 2. - Time on October 3 when interviewees realized the danger of the situation, Nîmes flood, October 1988.

Time	% of all interviewees both areas
6	2
7	26
8	42
9	18
10	10
11	1
13	1

reported by interviewees when they realized the danger are reported in Table 3.

Sixty-one percent of the interviewees went to another location; 92% of these to seek safety, 8% to see family, 5% to seek people, and 4% to return to their houses. To evacuate their homes, 37% of interviewees needed some assistance.

Among those interviewees who did not try to move to another location, 58% thought it was not necessary, 45% felt safe, 25% had no way to escape, 3% reached a dead end, 3% were handicapped, 10% stayed to protect their property, and 8% were in a stalled vehicle.

Of all interviewees, 18% found refuge at their homes, 58% went to a higher level in the building or to the roof, 4% climbed onto furniture, 1% went into the street, 15% went into another house, and 5% sought other shelter.

Forty-one percent of interviewees tried to warn others: family members, 59%; a neighbor, 15%; a friend, 5%; and another person, 32%. Thirty percent listened to the radio for information.

TABLE 3. - Principal concerns of interviewees when they realized the severity of the situation, Nîmes flood, October 1988.

Concerns	% of all interviewees
Go to safety	27
Save own life or those of family members	15
Save personal belongings	8
Prevent water from entering the house or remove water	7
Panic, anxiety	6
Save persons other than family members	4
Go back home	4
Worry about family members	4
Other	6

Sixty-three percent of the interviewees tried to take pets or personal belongings to safety. Of those who tried to save personal belongings or pets 27% took care of pets; 26%, important papers; 21%, furniture; 11%, clothes; and 5%, other objects. Of the 15 family members who were not at home, three (20%) could not reach their house before the following day. Major concerns mentioned by interviewees on the day they completed the questionnaire are presented in Table 4.

Fifty percent tried to telephone for help and 50% shouted. Overall, 23% of all persons were rescued.

TABLE 4. - Major concern reported by interviewees the day of the survey, Nîmes flood, October 1988.

Concerns the day of the survey	% of interviewees
Repair and put everything back in order	29
Insurance and indemnities	26
Go back home	5
Find another dwelling unit	3
Concern about flood reoccurring	2
Try to forget	1
Wish to go back to work	1
Deal with humidity in house	1
Care for family	1

TABLE 5. - Source of rescue operations, Nîmes flood, October 1988.

Sources	% of all rescue operations (number)	
	All persons rescued	Persons rescued from imminent risk of death
Neighbors	40 (20)	80 ( 8)
Family	20 (10)	10 ( 1)
Firefighters	12 ( 6)	10 ( 1)
Red Cross	10 ( 5)	0 ( 0)
Army	8 ( 4)	0 ( 0)
Unknown civilian	8 ( 4)	0 ( 0)
Other	2 ( 1)	0 ( 0)
Total	100 (51)	100 (10)

Eighty percent of all rescue operations were from a non direct life threat. Sources of rescue operations are presented in Table 5, which shows the very important role of neighbors.

Locations where interviewees spent the night of October 3 and where they were relocated are presented in Table 6.

Thirty-three percent of all households were relocated locally. Of those who spent the night of October 3 outside their houses and were relocated, 77% were relocated in the same type of place that they were in on October 3.

TABLE 6. - Location where interviewees spent the night of October 3 and where relocated, Nîmes flood, October 1988.

Location	% of interviewees	
	spending the night of October 3 in	being relocated (after October 3) in (among those relocated, n = 36)
Own dwelling unit	59	53
Relatives' home	17	11
Neighbors' home	13	28
Friend's home	6	0
Hotel	1	0
Working overnight	1	0
Low rent housing	0	3
Nursing home	0	3
Unspecified	3	3

## DISCUSSION

### 1. Health effects

According to estimations, floods account for 40% of all the world's natural disasters, and they produce the greatest amount of damage (2). The way people respond is a key factor in the morbidity and mortality associated with such events.

Compared with previous floods (3) and because of (1) the suddenness and magnitude of the flood, (2) the huge amount of damage (particularly the destruction of more than 1,100 vehicles), and (3) the lack of awareness of the civilian population, one would have expected a greater number of deaths and injuries. However, the limited death toll can be attributed to the fact that the disaster occurred early in the morning when most people were still home, and to the fact that, before the sudden peak of the flood, water was already blocking traffic on some roads giving access to the center of the city. The limited mortality and morbidity can also be attributed to (1) the mild temperature (minimal recorded temperature at the Nîmes-Courbesac meteorologic station was 13.4°C the day of the flood), (2) the rescue operations that were set up within the framework of the ORSEC plan, and (3) most of all, rescue operations conducted by civilians.

During the post-impact phase, very few health problems occurred in Nîmes. In contrast, in many other disaster situations, many injuries occurred during cleanup operations. The limited number of injuries in this disaster might be partly explained by the large participation of the military (healthy, trained, and well-equipped), and by the distribution of boots

and gloves to other workers at the request of the Service Communal d'Hygiène.

Some difficulty in obtaining data from medical sources was related to lack of attention to and failure to flag those injuries related to this flood. Easy access to such data is important for the investigation of the health impact of disasters. Therefore, health professionals should be informed of the importance of collecting such data.

Floods may cause disruption of water purification and sewage disposal systems, rupture of underground pipelines and storage tanks, overflowing of toxic waste sites, enhancement of vector-breeding conditions, and dislodgement of chemicals stored above ground. These events can contribute to increased exposure to biological and chemical agents.

No epidemic was detected in the aftermath of this disaster and this may be related to the fact that potential pathogens were diluted by flood waters or to active sanitation measures undertaken by the City Department of Health Services and the DDASS, which provided potable water, enforced destruction of all contaminated food, chlorinated city water and monitored water chlorination, organized replacement of sewerage systems, and organized disinfection and water removal from basements.

The release of chemicals during previous floods has been documented, but information on adverse health effects associated with such exposures is limited (4). The lack of documentation of adverse health effects from flood-associated toxic exposures may be attributed to the facts that very few, if any, studies have been done to identify such associations and that the symptoms associated with toxic exposures are often non-specific and may have a latency period. At the time of this report, no toxic effect has been detected in the Nîmes population. Indeed, no facility containing important amounts of pesticides or toxic substances was reported as flooded.

The large number of nervous or mental problems reported by interviewees, although most people did not seek medical care, suggests a large community emotional problem commonly described after such a large-scale disasters and the need for follow-up of populations and increased mental counseling. The other medical conditions reported as disaster-related medical conditions, such as respiratory problems, cannot be attributed with certainty to the flood. Such problems, however, have been reported previously in the aftermath of other floods (3).

## 2. Reaction of the populations and assistance provided

Only a very low percentage of interviewees knew that the area in which they lived could be flooded, although the area was evidently prone to at least minor floods.

There has been a very important community effort to try to warn and help others. Overall, most efficient rescue operations seem to have been

performed by neighbors and family members with little equipment. This is often the case in large-scale disaster because organized response is often initiated after the critical first 4-6 hours.

The fact that 30% of the people tried to get information from the radio indicates that the radio is an important, but insufficient, way to disseminate official information. This should be considered in further planning. Despite the limited death toll, rumors of 200 deaths were spreading. This can be explained by a lack of communication and the media seeking information outside single official channels and by the fact that a substantial portion of the population that was not at home at the time of the flood could not return before the following day.

When people were relocated, an important role was played by family, friends, and neighbors. As time goes on, the role of family and friends become proportionally more important.

As the results of media coverage, different types of help were sent to Nîmes. Many medical supplies, such as insulin, were sent by communities or organizations. Because these volunteer shipments were not coordinated with local health authorities, they were more trouble than help, particularly those shipments of out-of-date medications.

Several other type of humanitarian assistance were sent which diverted resources and did not cover real needs.

It is important to remember that, unless otherwise requested by authorities, the most useful disaster help is money.

Concerns about insurance and indemnities were still numerous after the flood. This seems to indicate that many people did not receive expeditious help or assurance that their losses would be covered. Insurances companies need to be organized to cope with such disaster situations.

## 3. Prevention and Control Measures

The principal steps to follow for preventing death and injury associated with floods such as the one which occurred in Nîmes are:

- To identify flood-prone areas and take appropriate preventive action, including the following: the institution of engineering controls, such as construction of reservoirs, flood walls (as recommended and projected by the City Hall), and the diversion of rivers; forestation of watersheds; land-use management that would prevent new construction in flood-prone areas and deforestation of watersheds; and increased regulation of flash-flood-prone areas and posting of flash-flood warnings in recreational areas subject to flash floods such as some camping areas along the Ardèche river.

- To identify meteorological conditions that will contribute to heavy precipitation and runoff and issue forecasts and flood warnings for a specific geographic area. In addition to the National Weather Service,

local observers can be used in flash-flood-prone areas to monitor precipitation and take periodic measurements of creeks and rivers during periods of heavy rainfall. These observers have been very effective in the USA in the diffusion of adequate flash-flood warnings.

- To ensure that the public is made aware of flood and flash-flood-prone areas and of the appropriate action to take when faced with potential exposure to such flooding.

The scope of health and social services during disasters should include: (1) monitoring of potential outbreaks of infectious disease, (2) monitoring of the occupational health risk to disaster relief workers, (3) monitoring of sanitation (particularly disinfection and water potability), (4) providing mass care (food, water, shelters, clothes), and drug supplies, (5) mental health counseling, (6) ensuring continuity of medical and social care by supporting local medical and social service personnel and facilities, and (7) describing the health impact of the catastrophe to establish a health profile for each disaster, which would then help in appropriate planning for the future. In this respect,

providers of medical care during the disaster should clearly identify disaster-related cases in order to report them to the DDASS.

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