Some Indications of the Long-Term Health Effects of a Natural Disaster

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LITTLE IS KNOWN ABOUT THE LONG-TERM EFFECTS on health of natural disasters. This significant area of research has recently been brought to the attention of the epidemiologic and medical communities (*1–3*), but in few empirical studies have epidemiologic methods been used. Investigators have usually focused upon the health effects of a disaster during the immediate period of recovery from it. Concentrating on infectious diseases and other short-term health effects, they have failed to study chronic disease or the general health status of the affected population during the longer postrecovery period following a disaster. Kinston and Rosser (*4*) have referred to disaster as a "situation of massive collective stress." However, stress can be viewed as a risk factor not only in the brief period right after the disaster's

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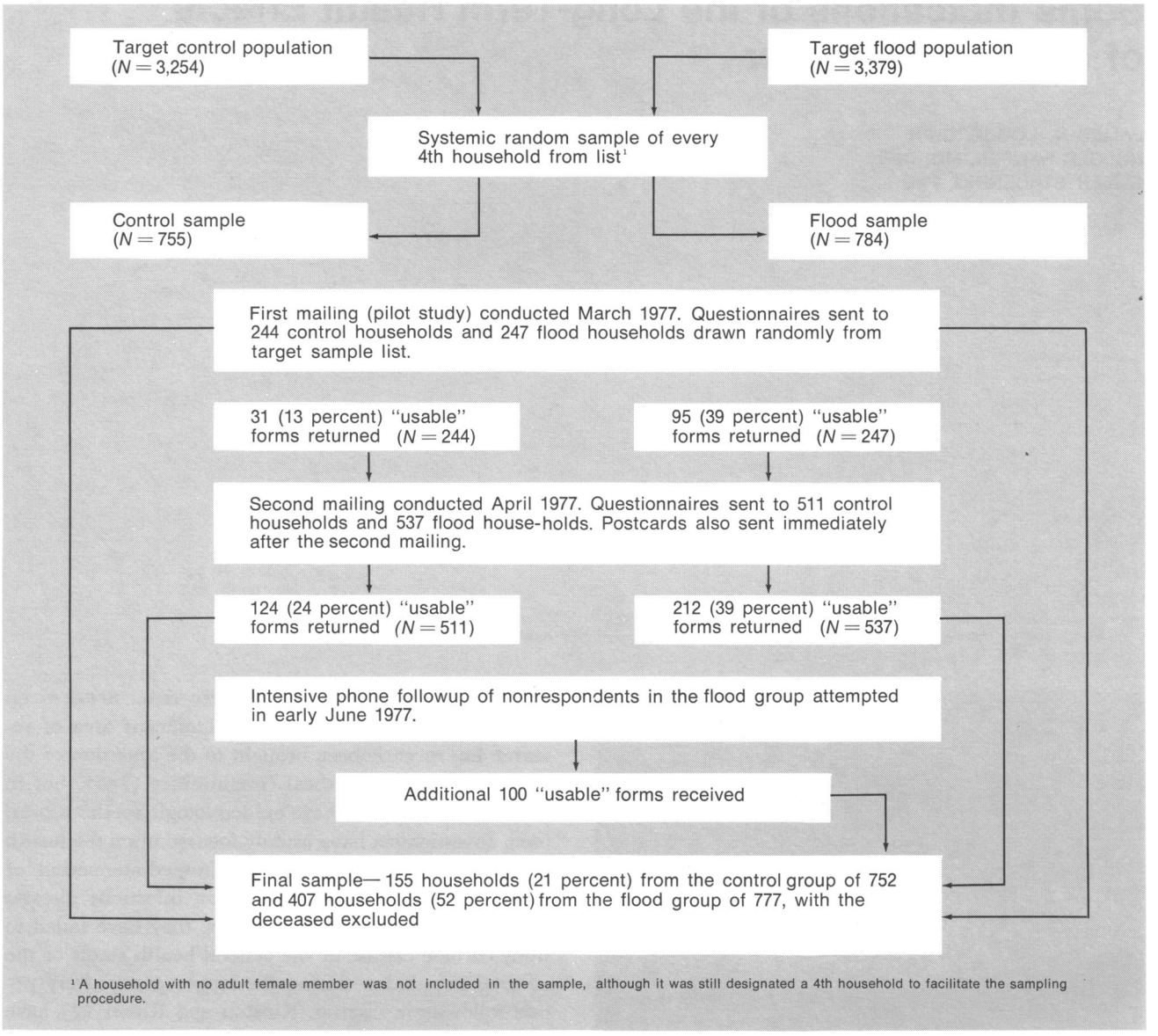
Sample selection and return rate for questionnaire



[1] A household with no adult female member was not included in the sample, although it was still designated a 4th household to facilitate the sampling procedure.

impact, but also over many months, and possibly years, thereafter.

Previous investigations of the long-range effects of major disasters have included a followup study of the effects of Hurricane Audrey, which struck Cameron Parish, Louisiana, in 1957 (*5*), and a study by Beach and Lucas (*6*) of a Canadian coal mine disaster. An epidemiologic study by Bennet (*7*) of the 1968 floods in Bristol, England, concentrated on mortality and morbidity in the subsequent 1-year period. Long-range mental health problems in the 2-year period following the Buffalo Creek flood in West Virginia have recently been documented (*8–11*). Probably the most systematic study of the long-range health effects of a disaster was conducted by Melick (*12*), who surveyed working class males 21 to 65 years of age approximately 3 years after the Hurricane Agnes flood.

In June 1972 Hurricane Agnes moved north from the Gulf of Mexico and caused extensive flood damage to a large portion of the eastern and northeastern United States. It was described as "the worst natural disaster in the history of the Republic" (*13*), and seven States were declared major disaster areas as a result of the floods that followed. In the Wyoming Valley of northeastern Pennsylvania, the flooding on June 23 and 24 caused the Susquehanna River to ex-

pand to a width of 1½ miles in the greater Wilkes-Barre area. Nearly one-third of the homes in the city of Wilkes-Barre (about 7,000) and all but 20 of the 6,000 homes in the adjoining city of Kingston were flooded.

The purpose of the study described here was to identify the long-range health effects of the disaster on a cross section of female residents of the Wyoming Valley. In contrast to earlier reports that had focused on the emotional and physical distress during the extended recovery period (*14*) and the risk factors specifically related to hypertension following the flood (*15*), the special focus of this study was on the post-recovery period, and therefore we reviewed the broad spectrum of physical and mental health sequelae over a postdisaster period spanning 5 years

The study was conducted during the early part of 1977, about 5 years after the actual flooding occurred. As pointed out by Melick (*12*), areas of disaster research that have met with little systematic attention include (*a*) measurement of the incidence and prevalence of secondary health problems after a disaster, (*b*) determination of the types of disaster-related health problems as well as assessment of the severity and duration of these problems, and (*c*) delineation of high-risk groups. Potential high-risk groups that deserve special attention in disaster studies include children, the elderly, and the disadvantaged (*16*). By using a much larger sample than Melick used in her project, we sought to obtain a good cross section of the various subgroups.

Methods

The chart on page 68 shows the steps that were involved in obtaining the final samples for the study. The 1972 and the 1976 Greater Wilkes-Barre city directories (*17,18*) were used to identify families residing in the selected geographic areas before the June 1972 flood that had at least one adult female member and had not left the area since the flood. From a list, which consisted of 3,254 households in the control population and 3,379 households in the flood population, samples to receive the survey questionnaire were drawn. Based on this list of area residents, a new list was made of every fourth household (784 of whom resided in Kingston, the flood town, and 755 in the surrounding control towns). This restricted selection obviously limits the inferences that one can draw from our study to those women and their families who elected to remain at the same residence after the disaster.

Two separate mailings were carried out in March and April 1977, and an intensive telephone followup was conducted of members of the flood group who did not respond to these mailings. Overall, 407 questionnaires were returned by Kingston residents (52 percent of the recipients) and 155 questionnaires by residents of the control towns (21 percent of the recipients). The final flood group consisted of 392 Kingston residents and 4 residents of adjoining towns whose homes had also been flooded—a total of 396 respondents. The final nonflood group consisted of 151 residents of towns adjoining Kingston and 15 Kingston residents whose homes had not been flooded—a total of 166 respondents.

The information sought on the 105-item questionnaire included demographic characteristics, personal experiences in the recovery period, information on

Table 1. Comparisons of selected characteristics of flood group and nonflood group

Characteristics	Flood group	Nonflood group	P
Age (years)			< 0.05
Number of respondents	386	165	....
Mean ± S.E.	57.1 ± 0.6	54.6 ± 1.0	....
Range	23–86	21–88	....
Respondent's education (years)			< 0.001
Number of respondents	383	161	....
Mean ± S.E.	12.1 ± 0.1	11.0 ± 0.2	....
Range	3–19	3–17	....
Level of social status (1–5)			< 0.001
Number of respondents	286	117	....
Mean ± S.E.	3.26 ± 0.06	3.92 ± 0.08	....
Range	1–5	1–5	....
Marital status			< 0.50
Number of respondents	385	162	....
Married	293 (76%)	117 (72%)	....
Widowed	61 (16%)	32 (20%)	....
Separated or divorced	9 (2%)	1 (1%)	....
Single	22 (6%)	12 (7%)	....
Religion			< 0.001
Number of respondents	388	158	....
Catholic	179 (46%)	110 (70%)	....
Protestant	146 (38%)	43 (27%)	....
Jewish	59 (15%)	3 (2%)	....
Other	4 (1%)	2 (1%)	....
Income level [1]			< 0.001
Number of respondents	355	152	....
Mean ± S.E.	6.63 ± 0.19	5.47 ± 0.23	....
Range	1–13	1–13	....
Number of persons in family in 1972			< 0.05
Number of respondents	386	152	....
Mean ± S.E.	3.25 ± 0.08	3.61 ± 0.15	....
Range	1–9	1–9	....

[1] 1 = under $3,000, 2 = $3,000–$5,000, 3 = $5,000–$7,000, 4 = $7,000–$9,000, 5 = $9,000–$11,000, 6 = $11,000–$13,000, 7 = $13,000–$15,000, 8 = $15,000–$17,000, 9 = $17,000–$19,000, 10 = $19,000–$21,000, 11 = $21,000–$25,000, 12 = $25,000–$30,000, and 13 = over $30,000.

Table 2. Comparison of the development in the flood group and the nonflood group of selected conditions from the

Condition and group	Immediate family				Respondent			
	Number with condition	Relative risk	X^2	P	Number with condition	Relative risk	X^2	P
Hypertension		1.52	2.36	> 0.10		1.16	0.13	> 0.50
Flood group	65 (N = 1,264)				35 (N = 396)			
Nonflood group	19 (N = 562)				17 (N = 166)			
Gastritis		> 5.79	4.46	< 0.05		> 3.77	2.53	> 0.10
Flood group	13 (N = 1,264)				9 (N = 396)			
Nonflood group	0 (N = 562)				0 (N = 166)			
Frequent constipation		> 5.79	4.46	< 0.05		> 4.20	2.95	< 0.10
Flood group	13 (N = 1,264)				10 (N = 396)			
Nonflood group	0 (N = 562)				0 (N = 166)			
Severe headaches		6.66	8.06	< 0.005		4.82	4.80	< 0.05
Flood group	30 (N = 1,264)				23 (N = 396)			
Nonflood group	2 (N = 562)				2 (N = 166)			
Bladder trouble		5.11	5.14	< 0.025		7.55	4.43	< 0.05
Flood group	23 (N = 1,264)				18 (N = 396)			
Nonflood group	2 (N = 562)				1 (N = 166)			
Disease of the bone or cartilage		> 5.34	4.02	< 0.05		> 2.52	1.31	> 0.25
Flood group	12 (N = 1,264)				6 (N = 396)			
Nonflood group	0 (N = 562)				0 (N = 166)			
Conditions of the cardiovascular system		1.54	5.15	< 0.025		1.36	1.47	> 0.10
Flood group	121 (N = 1,264)				68 (N = 396)			
Nonflood group	35 (N = 562)				21 (N = 166)			
Conditions of the gastrointestinal system		2.07	5.09	< 0.025		1.63	1.45	> 0.10
Flood group	56 (N = 1,264)				35 (N = 396)			
Nonflood group	12 (N = 562)				9 (N = 166)			
1 or more of conditions on checklist (see box)		1.57	14.31	< 0.005		1.55	13.14	.005
Flood group	262 (N = 1,264)				189 (N = 396)			
Nonflood group	74 (N = 562)				51 (N = 166)			

[1] Not calculated because of small sample size.

health, the respondent's perception of the amount of stress attributable to major life events (such as retirement, death in the family, a broken marriage), and the respondent's perception of the degree of social support available at various points in the postdisaster period.

Information on long-term physical health was obtained by means of an open-ended question about the respondent's and her family's major illnesses since the flood, as well as by a checklist of 50 specific health problems relating to the major body systems (see box). The checklist was derived from questions in the Public Health Service's Health Interview Survey (*19*). In addition, information was sought about the treatment, duration, and severity of the conditions as perceived by the respondent, who rated the conditions on a scale of 1 (very mild) to 6 (very severe).

The respondent used the Zung self-rating depression scale (*20*) and Langner's 22-item screening instrument (*21*) to assess aspects of her and her family's mental health at the time of the survey. As noted by Gersten and associates (*22*), the Langner scale relates principally to an anxiety dimension. Also, those items that constitute factors 1 through 5 of the SCL-90 —self-report symptom inventory (*23–25*) were included on the questionnaire. These five factors pertained to the following dimensions of mental health: factor 1—somatization, factor 2—obsessive-compulsive, factor 3 —interpersonal sensitivity, factor 4—depression, and factor 5—anxiety.

With respect to general long-term physical health, a few questions were judged to be probable indicators of health status. The respondent was asked to indicate how much, in her opinion, the flood was responsible for the health problems she and her family had encountered over the past 5 years since the flood by using a 4-point scale of 1 (not at all) to 4 (very much) to rate these problems. The respondent was also asked to rate her own health at the time of the survey and that of every other person in her immediate family on a 6-point scale of 1 (excellent) to 6 (very poor). Other

50-item checklist during the postflood period

Husband			
Number with condition	Relative risk	X^2	P
.....	5.39	6.07	< 0.025
27 (N = 293)	.....		
2 (N = 117)	.....		
.....	> 1.19	(1)	(1)
3 (N = 293)	.....		
0 (N = 117)	.....		
.....	> 1.26	(1)	(1)
2 (N = 293)	.....		
0 (N = 117)	.....		
.....	> 1.60	(1)	(1)
4 (N = 293)	.....		
0 (N = 117)	.....		
.....	1.26	(1)	(1)
2 (N = 293)	.....		
1 (N = 117)	.....		
.....	> 0.160	(1)	(1)
4 (N = 293)	.....		
0 (N = 117)	.....		
.....	1.75	3.54	< 0.10
57 (N = 293)	.....		
13 (N = 117)	.....		
.....	2.80	1.36	> 0.10
14 (N = 293)	.....		
2 (N = 117)	.....		
.....	1.26	2.34	> 0.10
126 (N = 293)	.....		
40 (N = 117)	.....		

details regarding sample selection and the study questionnaires are provided elsewhere (*26*).

Results

The basic strategy followed in this project was to compare the flood group with the nonflood group in respect to demographic characteristics, the checklist of 50 problems, and 10 selected global variables representing both mental and physical health.

Because of the low response rates for both the flood and the nonflood groups, two additional strategies were used. First, historical controls relative to the mental health self-rating scales were compared for both study groups. Second, the Kingston flood respondents alone were divided into subgroups based upon their differential experiences in the recovery period following the flood. This strategy corresponds to the method of "internal comparisons" discussed by MacMahon and Pugh (*27*), an approach that has been used successfully in other cohort studies.

Demographic characteristics. The results of the statistical between-group comparisons for important characteristics of the flood group and nonflood group respondents are displayed in table 1. The two study groups proved to be somewhat dissimilar with respect to a number of demographic variables. The women in the flood group tended to be slightly older and better educated than those in the nonflood group. The nonflood respondents were primarily Catholic; the respondents in the flood group demonstrated a greater variety of religious preferences. Finally, the women in the flood group, in general, were of higher income and social class, as measured by the Hollingshead two-factor index of social position (*28*), and their families were smaller than those of women in the control group.

50-item problem checklist. Long-term health status was measured in part by the responses on the checklist of 50 specific health problems shown in the box. The respondent was asked to indicate both for herself and for any member of her immediate family whether any of the 50 conditions on the list had developed since the 1972 Hurricane Agnes flood, and if so, to state the date of onset, duration, and perceived severity of the condition. However, many respondents simply indicated the presence of a condition with no further details.

The responses to the checklist as reported (*a*) for any member of the immediate family (including the respondent), (*b*) for the respondent, and (*c*) for the respondent's husband (if applicable) are summarized in table 2. Only those conditions, or groups of conditions, that showed statistically significant differences between the flood and nonflood group for either the respondent, her family, or her husband are presented. Note that the analysis by the 2 x 2 chi-square test (with correction) does not control for the possible confounding effects of other variables such as age, level of education, or income.

The immediate families of the flood group respondents and the nonflood group respondents differed significantly in respect to whether or not the following developed in the postdisaster period: at least 1 of the 50 conditions on the checklist, conditions pertaining to the cardiovascular system, conditions pertaining to the gastrointestinal system, gastritis, frequent constipation, severe headaches, bladder trouble, and disease of the bone or cartilage. The flood group and the nonflood group respondents themselves differed significantly in respect to whether at least 1 of the 50 conditions on the checklist, severe headaches, or bladder trouble developed. The husbands of the flood and nonflood respondents differed significantly only in re-

50-item problem checklist

1. Cancer
2. Hypertension
3. Stroke
4. Heart attack
5. Arteriosclerosis
6. Coronary heart disease
7. Angina pectoris
8. Tachycardia
9. Gangrene
10. Varicose veins
11. Phlebitis or thrombophlebitis
12. Other conditions of cardiovascular system
13. Cirrhosis of liver
14. Hepatitis
15. Other liver trouble
16. Diabetes
17. Disease of pancreas
18. Hernia or rupture
19. Ulcers
20. Gastritis
21. Enteritis
22. Colitis
23. Frequent constipation
24. Other conditions of digestive system
25. Tuberculosis
26. Pneumonia
27. Work-related respiratory conditions
28. Asthma
29. Hay fever
30. Emphysema
31. Other conditions of respiratory system
32. Severe headaches
33. Epilepsy
34. Neuralgia or neuritis
35. Thyroid trouble
36. Anemia
37. Nephritis
38. Kidney stones
39. Other kidney trouble
40. Bladder trouble
41. Prostrate trouble
42. Disease of uterus or ovary
43. Paralysis of any kind
44. Arthritis or rheumatism
45. Slipped or ruptured disc
46. Disease of bone or cartilage
47. Eczema or psoriasis
48. Any kind of skin allergy
49. Dermatitis or any other skin trouble
50. Any serious injury or accident

NOTE: Respondents were instructed to check for themselves and members of their immediate families those conditions that had developed since the 1972 Agnes Flood. Respondents were further instructed not to check those conditions that had been present before the flood occurred.

spect to the development of hypertension. However, the results of the analyses also approached statistical significance ($P < 0.10$) in two additional instances: for the respondents, frequent constipation, and for their husbands, conditions of the cardiovascular system.

In all of these group comparisons, the flood group consistently showed higher incidence rates than the nonflood group. Because of the low incidence rates for each of the 50 conditions, we considered it desirable to measure the frequency of any reported physical condition—in addition to the conditions affecting the cardiovascular system, the digestive system, and the respiratory system. The reason was that these indices represent a composite of conditions which tap various dimensions of a common system. The excess of 1 or more reported conditions in the flood group was highly significant ($P < 0.005$) for both the respondent's immediate family and the respondent.

Intercorrelations among health variables. For analysis of the relationships among significant long-term health variables pertaining to flood victims, 10 dependent variables were selected, whose intercorrelations are presented in table 3. Seven of the 10 variables were considered relevant to long-term mental health status, namely, total Langner, total Zung, and factors 1 through 5 of the SCL-90. Three variables were thought to reflect long-term physical health status, namely, the perceived health of the respondent, the perceived health of her immediate family, and the perceived effect of the flood on the health of the respondent and her family.

The high correlation between factor 5 and total Langner (0.782) is of interest. Gersten and associates (22) had indicated that the Langner scale contained many items dealing with anxiety, and since factor 5 specifically relates to this dimension, the association between total Langner and the measurement of anxiety appears to be consistent in our study.

The correlation between total Zung and factor 4 (0.652), both of which pertain to depression, was not as strong as might have been expected in view of the

relationship of these scales to the same dimension. It is interesting to note, however, that factors 4 and 5 correlate very closely (0.859), even though different dimensions are being assessed. All intercorrelations among factors 1 through 5 are close (above 0.600). This result seems to indicate that there was considerable overlap of the dimensions corresponding to factors 1 through 5 in this study.

The correlations between the effect of the flood on the health of the respondent (and her immediate family) and all the other dependent health variables were, in general, low (all under 0.500). Perhaps the respondents considered both mental health status and physical health status in making their overall judgment concerning the effect of the flood on health. Correlations of about 0.400 were found for both the mental health variables and the physical health variables.

When all 10 dependent health variables were subjected to a principal components analysis with varimax rotation, 2 factors were identified. The first factor, corresponding to the overall mental health dimension, consisted of the following 7 variables: total Langner, total Zung, and factors 1 through 5 of the SCL–90; all 7 variables showed loadings above 0.640. The second factor, corresponding to the physical health dimension, related to the perceived health of the respondent and her family and the effect of the flood on their overall health status; all these variables showed loadings above 0.630.

Covariance of global health variables. Since the flood group and the nonflood group differed significantly in a number of demographic characteristics, analysis of covariance was carried out for the 10 selected dependent health variables in order to adjust for these group discrepancies. A three-way model was chosen in which the main effects were represented by age (60 years or less and 60 years or more), religion (Catholic versus other), and flood experience (home flooded, Yes or No), or a $2 \times 2 \times 2$ factorial.

The respondent's education and income level were introduced into the model as covariates because of the highly significant ($P < 0.001$) difference between the two groups. The flood and nonflood groups also differed significantly with respect to social status, but lack of information about this variable for a large group of the women prevented introduction of this variable into the model. The groups differed significantly ($P < 0.05$) in family size, as shown in table 1, but when they were stratified by age and religion into four subgroups, the between-group difference in family size was no longer significant. Finally, a preflood variable pertaining to the respondent's dependence upon the family of her origin showed a statistically significant between-group difference, which was still present when the groups were stratified by age and religion. Therefore, this variable was introduced into the model as the third and last covariate. Hence, a three-way analysis of covariance with three covariates was the approach adopted for the statistical analyses of the long-term health variables.

The covariance procedures were based upon the method of fitting constants (*29*), which can be applied to a three-way fixed model when interaction

Table 3. Intercorrelations among 10 selected dependent health variables

Variables	Variables								
	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Total Langner [1]									
2. Total Zung [2]	.632								
3. Total factor 1 (somatization)	.676	.471							
4. Total factor 2 (obsessive-compulsive)	.676	.572	.654						
5. Total factor 3 (interpersonal sensitivity)	.693	.529	.624	.720					
6. Total factor 4 (depression)	.751	.652	.703	.760	.791				
7. Total factor 5 (anxiety)	.782	.569	.751	.769	.782	.859			
8. Effect of flood on health [3]	.449	.331	.424	.340	.338	.493	.454		
9. Perceived health of respondent [4]	.390	.391	.410	.236	.279	.346	.317	.416	
10. Perceived health of immediate family [4]	.325	.359	.353	.237	.256	.311	.248	.451	.807

[1] Total symptoms reported as "present" from total of 22 Items.
[2] Total raw score reported.
[3] Based on the scale: 1—not at all, 2—somewhat, 3—moderately, and 4—very much.
[4] Based on the scale: 1—excellent, 2—better than most, 3—average, 4—below average, 5—poor, and 6—very poor.
NOTE: Only those items in the SCL–90 that comprise the first 5 factors in this instrument were used in the current study.

Table 4. Results of 3-way analysis of covariance for indicators of long-term mental and physical health

Indices of health	Mean square error for flood's effect	Residual error	F	d.f.	Test of flood's effect (P)	Adjusted means: Flood group	Adjusted means: Nonflood group
				Mental health			
Total Zung	177.22	74.05	2.39	1,389	0.1227	37.02	35.36
Total Langner	40.15	11.78	3.41	1,426	0.0656	3.93	3.28
Total factor 1	36.39	47.41	0.77	1,393	0.3815	20.29	19.77
Total factor 2	136.99	45.56	3.01	1,393	0.0837	17.65	16.34
Total factor 3	34.22	30.64	1.12	1,405	0.2912	14.60	14.08
Total factor 4	151.80	78.08	1.94	1,392	0.1640	23.72	22.44
Total factor 5	48.54	39.17	1.24	1,393	0.2663	16.62	16.08
				Physical health			
Effect of flood on health	69.15	0.89	77.95	1,405	< 0.0001	2.18	1.28
Perceived health of respondent	3.86	1.03	3.77	1,418	0.0529	2.81	2.63
Perceived health of immediate family	4.87	0.74	6.55	1,420	0.0108	2.73	2.48

is not a problem. This method of analysis is available in the routine of the Statistical Analysis System "PROC REGR" (*30,31*) and may be used when a design is unbalanced and subclass frequencies are unequal. Since the main effect that is of primary interest was the flooding of a housing unit (Yes or No), the results of the three-way analyses are presented in an abbreviated analysis of covariance. Table 4 shows the results for the main effect due to flooding and the residual error term, in addition to the results of the F test and the associated two-tailed probability for the test of this main effect. The appropriate adjusted means for both the flood group and the nonflood group are also presented.

Table 4 demonstrates a trend ($P < 0.10$) for total Langner and factor 2 (obsessive-compulsive) of the SCL–90. In both instances, the flood group demonstrated more symptoms than the nonflood group. Although a trend was not observed for the variables measuring depression, the flood group again demonstrated more symptoms, and the probability levels were fairly small for total Zung ($P = 0.12$) and factor 4 (depression) of the SCL–90 ($P = 0.16$). Thus, for all seven variables related to mental health, the results consistently showed the flood group as having more symptoms than the nonflood group, although none of the contrasts were significant, and only two showed a trend. The three variables pertaining to physical health status showed statistically significant group differences. The flood group also demonstrated significantly more physical health problems than the nonflood group. The actual differences between the groups for all 10 variables displayed in table 4 can be determined from the adjusted means, which are weighted and correspond to the ordered responses for these variables.

Historical comparisons. Zung (*32*) investigated depression in a large group of normal persons 65 years of age or older ($N = 169$) and in another group of normal persons between the ages of 20 and 64 years ($N = 363$). The mean self-rating depression score (SDS) for the geriatric group was 48 with a standard deviation of 10; for the younger group, it was 39 with a standard deviation of 9. This investigation by Zung of the presence of depression among normal people afforded us the opportunity to use a historical control in our study. A two-way analysis of covariance was applied to our entire data set, with one factor being the flooding of the dwelling in 1972 (Yes or No) and the other factor being age (less than 65 years or 65 years or more). Both income and education served as covariates in the analysis.

For the flood group, the adjusted mean SDS for the younger group ($N = 229$) was 45.6 and for the geriatric group ($N = 86$), 48.1. For the nonflood group, the adjusted mean SDS for the younger group ($N = 103$) was 44.2 and for the geriatric group ($N = 32$), 46.4. The standard deviation associated with all four adjusted means was 10.8. It is noteworthy that the geriatric subgroups in this study did not differ significantly in respect to the mean SDS from the geriatric group described by Zung. However, both of the younger subgroups in our study demon-

strated significantly higher SDS indices than the younger group that Zung reported. Both the geriatric subgroup and the younger subgroup of the flood group consistently had higher SDS indices than the corresponding subgroups of the nonflood group, but the differences were not statistically significant.

Like Melick's subjects (*12*), the nonflood group as well as the flood group was subjected to stress because the flood affected their families. It would, therefore, be reasonable to expect some long-term health problems attributable to the flood even among respondents in the nonflood group. The results reported here seem to suggest that women under the age of 65 years were at greater risk than older women of experiencing depression even though 5 years had passed since the disaster. The results also seem to suggest that younger women living in this postdisaster community were at risk, whether or not they personally experienced the flooding.

Langner's results (*21*) for 1,438 normal persons afforded another historical control for comparison with the flood group and the nonflood group in respect to the Langner scale. The mean score of the historical group was 2.60 with a standard deviation of 2.67. In contrast, the mean score for our flood group ($N = 312$) was 3.93 with a standard deviation of 3.43, and for our nonflood group ($N = 125$), 3.28 with a standard deviation of 3.43. The mean Langner scores both for the flood group and the nonflood group were significantly higher than for the historical group.

Finally, comparisons were made with a group of 735 normal persons tested with the Hopkins Symptom Checklist (*25*), a precursor of the SCL–90. To carry out these comparisons, the results obtained for factors 1 through 5 of the SCL–90 had to be transformed, since the HSCL is a four-point scale and the SCL–90 is a five-point scale. The two scales relate to the same dimensions of mental health (factors 1 through 5 of both scales are described in the same fashion), but the items that constitute factors 1 through 5 of the SCL–90 are not completely identical to the items that consitute factors 1 through 5 of the HSCL. The comparisons of the groups in our study with the 735 normal persons tested with the HSCL may therefore be subject to some bias that cannot be accurately measured.

If these reservations are kept in mind, the results for both groups in our study were basically comparable with those for the historical group for all five factors, except that the flood group had significantly higher scores than the historical group for factor 2 (obsessive-compulsive) and factor 4 (depression). The results for factor 4 may be viewed as supportive of the results based upon the historical control in Zung's study of normal people under 65 years of age.

Internal comparisons of the flood group. Kingston residents who were victims of the flood were assigned to various subgroups based upon their perception of stress during the recovery period. Fourteen variables pertaining to the recovery period were selected and subjected to multivariate factor analysis in order to condense the total number of independent variables (see table 5). Factor 1 resulting from the analysis was composed of seven of these variables (variables with loadings of 0.50 or higher). This factor was a general one relating to overall distress and was considered the most important independent variable because it accounted for 42 percent of the variance among the 14 variables.

Variable 15, which had the highest loading (0.764) for factor 1, concerned the amount of distress experienced by the respondent and her family during the recovery period. Factor 2, consisting of variables 70 and 71, related to medical care in the recovery period. Other factors identified by factor analysis were not strong; therefore, the five variables not included in factors 1 and 2 were treated as independent variables in our subsequent analyses. The dependent variables were total Langner and total Zung (mental health) and the perceived health of both the respondent and her family (physical health).

A total score for factor 1 was calculated by summing the actual values of variables 10, 15, 17, 20, 21, 36, and 100. However, since variables 10, 36, and 100 demonstrated negative loadings, the scales for these variables were inverted before the summing was performed. Similarly, a total score for factor 2 was obtained by summing the actual values of variables 70 and 71.

Because factors 1 and 2 pertained to more than one variable, the total scores for these two factors were trichotomized by using the two "cut points" of mean total score $\pm$ 0.5 standard deviation. Scores for the variables 8c, 11, 16, 27, and 50 were dichotomized into low stress or high stress, and the mean scores were used as the appropriate points for separating the two groups.

To test the hypothesis that stress associated with the recovery period was responsible for long-term health problems, a two-way analysis of covariances under a fixed model was used. The main effects were stress associated with the flood experience and age. Age was stratified into three levels (less than 55 years, 55 to 64

years, and more than 64 years), while stress associated with the flood experience was stratified into either two or three levels (low or high or low, medium, or high). Age was used as a main effect rather than as a covariate, since investigation of the relationship between the three age categories and the dependent health variables was judged to be desirable. Income and education were used as covariates in the model, because earlier analyses had shown these variables to be significantly associated with the dependent variables. The adjusted means relative to the main effect, stress, are presented in table 6. Complete results of the two-way analysis of covariance are provided elsewhere (*26*).

Results of the analyses of the seven independent variables by the covariance procedure are summarized at the bottom of table 6. A review of the adjusted means in table 6 clearly shows that stress arising from the flood experience is significantly associated with both mental and physical health problems measured 5 years after the flood. This association was particularly brought out by the analysis of factor 1 (the overall distress dimension) and factor 2 (the lack of medical care).

Table 5. Questions specifically relating to the recovery period from the disaster, scales used for rating responses to questionnaire, and definitions used for high, medium, and low stress

Questions	*Scales*
Factor 1 [1]	
10. Tranquilizers or other medications used in the recovery period?	1 = not at all, 2 = some of the time, 3 = quite a bit of the time, 4 = most of the time.
15. State of mind after the flood	1 = so discouraged felt like giving up completely, 2 = very discouraged, 3 = moderately discouraged, 4 = somewhat discouraged, 5 = not at all discouraged.
17. Financial problems because of the flood.	1 = severe financial problems, 2 = moderate problems, 3 = some problems, 4 = no financial problems.
20. Feelings about people trying to cheat the respondent during the recovery period.	1 = all of the time, 2 = practically all of the time, 3 = very often, 4= fairly often, 5 = sometimes, 6 = just a few times, 7 = not at all.
21. Feelings about physical work done in the recovery period.	1 = work was so hard someone in the family became sick, 2 = very hard work (really wore us out), 3 = hard work (proceeded without many problems), 4 = worked consistently (very few problems), 5 = worked at own pace (things went along smoothly), 6 = did not work that hard, 7 = someone else did most of work.
36. Amount of distress, in general, experienced in the recovery period.	1 = none, 2 = slight, 3 = moderate, 4 = severe, 5 = very severe.
100. Length of the recovery period (months).	1 = 1–6, 2 = 7–12, 3 = 13–18, 4 = 19–24, 5 = more than 24.
Factor 2 [2]	
70. Obtaining regular medical checkups hindered by the flood?	1 = not at all, 2 = somewhat, 3 = moderately, 4 = very much.
71. Treatment of specific medical problems hindered because of the flood?	1 = not at all, 2 = somewhat, 3 = moderately, 4 = very much.
Other questions	
8c. Perceived damage to home and possessions.	1 = everything totally destroyed, 2 = extremely severe damage, 3 = very severe damage, 4 = severe damage, 5 = moderate damage, 6 = some damage. (Scores < 3 = high stress and ≥ 3 = low stress.)
11. How helpful were alcoholic beverages in the recovery period?	1 = I don't drink *or* not at all helpful, 2 = somewhat helpful, 3 = moderately helpful, 4 = very helpful. (Scores 2, 3, or 4 = high stress, and scores equal to 1 = low stress.)
16. Estimate of monetary loss with respect to property damage.	1 = none, 2 = under $10,000, 3 = $10,000 to $20,000, 4 = $20,000 to $30,000, 5 = $30,000 to $40,000, 6 = $40,000 to $50,000, 7 = over $50,000. (Scores > 3 = high stress and ≤ 3 = low stress.)
27. Stress because of unemployment ..	1 = not at all stressful, 2 = somewhat stressful, 3 = moderately stressful, 4 = very stressful. (Scores > 1 = high stress, and scores 1 or 0 (if not applicable) = low stress.)
50. Temporary living quarters during the recovery period—rating of how stressful the experience was for the respondent.	1 = not too stressful, 2 = somewhat stressful, 3 = moderately stressful, 4 = very stressful, 5 = extremely stressful. (Scores > 2 = high stress and ≤ 2 = low stress.)

[1] Total scores < 18 = high stress, 18–24 = medium stress, and > 24 = low stress.

[2] Total scores < 3 = low stress, 3 or 4 = medium stress, and > 4 = high stress.

For both factors, each of the two-way analyses relating to the four dependent health measures demonstrated that stress had a statistically significant main effect (for factor 2, the analysis relating to the health of the respondent's immediate family demonstrated a significant main effect for stress at the level of $P < 0.10$ rather than at $P < 0.05$). For variables 8c, 11, 16, 27, and 50, an inspection of the adjusted means for total Langner and total Zung revealed that the low stress group consistently had fewer health problems than the high stress group. With respect to total Langner, a significant main effect for stress was observed for variables 11, 16 ($P < 0.10$), 27, and 50. With respect to total Zung, a significant main effect for stress was observed only for variables 11 and 27 ($P < 0.10$). Finally, the results pertaining to physical health status for variables 8c, 11, 16, 27, and 50 showed no significant main effect for stress with the exception of the analysis of the respondent's health for variable 50.

A statistically significant main effect for age was demonstrated in all of the two-way analyses based on total Zung and total Langner, but in none of the two-way analyses based on the respondent's average health or the average health of her immediate family. It is interesting to note that respondents 65 years of age or older demonstrated the least mental health problems based upon total Langer, whereas respondents less than 55 years of age demonstrated the least mental health problems based upon total Zung. For both total Langner and total Zung, respondents between the ages of 55 and 64 had the most mental health problems. The results of the analyses of the respondent's health and the health of her immediate family also appeared to show that the 55 to 64 age subgroups experienced the most physical health problems compared with those younger than 55 or 65 and older. The significance, if any, of this result, is not clear. We may speculate, however, that the 55-year to 64-year subgroup was at greatest risk because of impending retirement.

Discussion

Caution is needed in drawing conclusions from this study on the long-term health effects of disasters. The low response rates for both the flood and the nonflood groups may have biased the study. Based upon a nearly complete telephone followup of nonrespondents in the flood group, we believe that the nonrespondents were characteristically an older group with many health problems, and that therefore the health problems of the final sample of flood respondents may have been underestimated. But this information is of limited value since it is only based upon impressions. Some nonflood subjects who did not fill out the questionnaire offered such reasons for not responding as not being

Table 6. Adjusted mean health scores for various dimensions of the flood experience by associated levels of stress

Dimension of flood experience	Total Langner			Total Zung			Respondent's health			Health of immediate family		
	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
Factor 1 [1]	2.55	3.70	6.42	34.5	35.3	42.4	2.32	2.61	3.20	2.33	2.61	3.04
Number of persons	75	119	70	75	119	70	76	120	71	76	120	71
Factor 2 [2]	2.98	4.96	5.95	34.9	38.6	40.3	2.52	2.74	3.08	2.55	2.70	2.84
Number of persons	140	76	48	140	76	48	140	77	50	140	77	50
Other questions: [3]												
8c.	3.78	.....	4.34	36.6	.....	37.2	2.67	.....	2.70	2.63	.....	2.66
Number of persons	119	.....	145	119	.....	145	120	.....	147	120	.....	147
11. [4]	3.66	.....	5.26	36.1	.....	39.2	2.73	.....	2.58	2.69	.....	2.54
Number of persons	193	.....	71	193	.....	71	195	.....	71	196	.....	71
16. [5]	3.50	.....	4.45	36.3	.....	37.3	2.63	.....	2.72	2.56	.....	2.70
Number of persons	100	.....	164	100	.....	164	102	.....	165	102	.....	165
27. [6]	3.72	.....	5.27	36.5	.....	38.4	2.66	.....	2.76	2.61	.....	2.75
Number of persons	201	.....	63	201	.....	63	204	.....	63	204	.....	63
50. [7]	3.55	.....	4.92	36.6	.....	37.5	2.58	.....	2.84	2.60	.....	2.72
Number of persons	160	.....	104	160	.....	104	162	.....	105	162	.....	105

[1] Statistically significant ($P < 0.05$) main effect for stress for all 4 dependent variables—total Langner, total Zung, respondent's health, and health of immediate family.

[2] Statistically significant ($P < 0.10$) main effect for stress for all 4 dependent variables except health of immediate family.

[3] For wording of "Other questions," see table 5.

[4] Statistically significant main effect for stress for total Langner and total Zung.

[5] Statistical trend ($P < 0.10$) for total Langner.

[6] Statistically significant stress main effect for total Langner and statistical trend for total Zung.

[7] Statistically significant stress main effect for total Langner and respondent's health.

an "appropriate" target for study. The health of these women did not appear to be a major reason for their not responding.

When long-term physical health problems were assessed, primarily by the 50-item checklist, husbands of the flood respondents were shown to have experienced a significantly higher ($P < 0.025$) incidence of hypertension than husbands of the nonflood respondents, as reported 5 years after the disaster. A trend ($P < 0.10$) was noted for husbands of the flood respondents to experience more long-term cardiovascular problems, in general, than husbands of the nonflood respondents. The flood respondents and their families also reported more long-term physical health problems, in general, than did the husbands of the nonflood respondents and their families ($P < 0.005$). The difficulty, however, with all of the analyses based on the 50-item checklist is that the influence of other intervening factors such as age and income were not controlled, and consequently the overall effect of these factors on the dependent variables remains unknown. For this reason, these results also must be viewed as tentative.

The mental health scales used in our study were principally designed to assess both short-term prevalence (Zung scale and SCL–90) and long-term prevalance (Langner scale). Comparisons of the flood group and the nonflood group revealed statistical trends ($P < 0.10$) for total Langner and factor 2 of the SCL–90 (obsessive-compulsive) as well as possible trends ($P < 0.15$) for total Zung and factor 4 of the SCL–90, both of which measure depression.

Factor 2 of the SCL–90 is an important dimension of mental health status since it appears to correspond to what Lifton and Olson (*11*) have described as "psychic numbing," which, they point out, is the very essence of the "disaster syndrome." Lifton and Olson observed victims of the Buffalo Creek flood approximately 2 years after it took place and noted that this psychic numbing was probably the "most universal response to the disaster" and a condition that appeared to last a long time after the actual disaster. The condition, as described by these authors, appears to be characterized by difficulties with memory and the ability to concentrate, in addition to tendencies to overwork, presumably in an unconscious effort to forget what has happened.

We must caution, however, that since the scales we used (Langner, Zung, and SCL–90) were for the most part designed to measure mental health dimensions of a short-term nature, any positive associations of the 1972 Agnes disaster or the ensuing recovery period with subsequent health problems could be contaminated by intervening factors, some of which were not ascertained in the current study.

In addition to comparisons of the flood group with the nonflood group, we divided the respondents in the flood group into various internal comparison groups based upon their experiences in the recovery period, and we also compared the dependent mental health variables for both study groups with those for historical controls. The results of these additional analyses, which we viewed as complimentary to the flood versus nonflood analyses, appear to support the hypothesis that stress associated with the flooding has long-term health effects. However, since the information about people's experience in the recovery period was obtained retrospectively, the memory of the experience itself may have been associated with the health items measured at the time of the survey. Also, if the historical controls and our flood and nonflood groups were not comparable, the validity of the contrasts of the dependent mental health variables would have been directly affected.

Conclusion

The current study was primarily designed to explore the issue of "stress as enduring," as described by Wilson (*33*) in a discussion of the relationship of stress to disasters. Long-term health effects that respondents in our study described 5 years after the 1972 Agnes flood suggest that stress associated with disasters may endure for many years and be responsible for excess long-term morbidity. Wilson pointed out that the character of the specific community affected by disaster will have a strong bearing on the way persons in the community react to stress. Erickson (*34*) described the Buffalo Creek community in West Virginia as having been subjected, even before the Buffalo Creek disaster, to great external pressure because of the modernization that had taken place in this century. In some ways, the Wyoming Valley was subjected to similar pressures before the 1972 flood. Although on the fringe of Appalachia, this valley experienced relatively favorable economic conditions early in this century because of the coal mining industry. More recently, however, it had been subjected to high unemployment, the migration of young people to other areas offering better opportunities, and the aging of its population. It is likely that the Wyoming Valley population was less able to adapt to the flood and the changes that it caused because of the social problems the population had experienced before the flood.

Recently, the medical community has come to realize that disasters pose major threats to public health far

beyond the early recovery period and that these events can be fruitfully investigated with an epidemiologic approach. It is necessary to emphasize, however, that health problems of a noninfectious nature are the critical dependent variables that need to be investigated following a disaster in a developed nation.

Because the results reported in this paper are tentative, we encourage other investigators in the disaster research field to study the long-term health effects of major natural disasters, both during the recovery and the postrecovery period. Establishment of true cause-and-effect relationships will depend upon replication of the results from many studies with a variety of study designs. The suggestion that some adverse health effects are associated not only with the actual flooding of one's dwelling, but also with various negative experiences in the recovery period may inspire study hypotheses for these future investigations.

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