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Psychosocial sequelae of the 1989 Newcastle earthquake: II. Exposure and morbidity profiles during the first 2 years post-disaster

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ABSTRACT

Background. A sample of 1089 Australian adults was selected for the longitudinal component of the Quake Impact Study, a 2-year, four-phase investigation of the psychosocial effects of the 1989 Newcastle earthquake. Of these, 845 (78%) completed a survey 6 months post-disaster as well as one or more of the three follow-up surveys.

Methods. The phase 1 survey was used to construct dimensional indices of self-reported exposure to threat the disruption and also to classify subjects by their membership of five 'at risk' groups (the injured; the displaced; owners of damaged small businesses; helpers in threat and non-threat situations). Psychological morbidity was assessed at each phase using the 12-item General Health Questionnaire (GHQ-12) and the Impact of Event Scale (IES).

Results. Psychological morbidity declined over time but tended to stabilize at about 12 months post-disaster for general morbidity (GHQ-12) and at about 18 months for trauma-related (IES) morbidity. Initial exposure to threat and/or disruption were significant predictors of psychological morbidity throughout the study and had superior predictive power to membership of the targeted 'at risk' groups. The degree of ongoing disruption and other life events since the earthquake were also significant predictors of morbidity. The injured reported the highest levels of distress, but there was a relative absence of morbidity among the helpers.

Conclusions. Future disaster research should carefully assess the threat and disruption experiences of the survivors at the time of the event and monitor ongoing disruptions in the aftermath in order to target interventions more effectively.

INTRODUCTION

Survivors of disasters have disparate experiences, varying in nature, severity and duration, often depending on the individual's role in the disaster. Such variations in personal experiences may lead to different psychological effects (Bromet *et al.* 1990; Dooley & Gunn, 1995). To date, findings on the impact of differing disaster experiences have been equivocal. Whereas experiences of injury have not been clearly linked to psychological morbidity (Hoiberg & McCaughey, 1984; Madakashira & O'Brien, 1987; Curran *et al.* 1990), displacement, property loss and financial stress have been associated with such morbidity (Powell & Penick, 1983; Lima *et al.* 1989; Murphy, 1989; Norris & Uhl, 1993) perhaps with one exception (Madakashira & O'Brien, 1987). However, there has been little clarification of the relative effects of loss of livelihood *versus* loss of home. Helpers in disasters may be at risk for psychological ill effects (Taylor & Frazer, 1982; Raphael, 1983–4; Lima *et al.* 1989; Bartone *et al.* 1989; Lundin & Bodegard, 1993), but there is little evidence of that risk being related to the severity of the trauma (see Bartone *et al.* 1989), either in terms

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of threat or property loss (McFarlane, 1988*a*). There is also some indication that ongoing disruptions are related to poorer outcome (Green *et al.* 1985; McFarlane, 1988*b*). Finally, data from cross-sectional studies indicate that disaster experiences are associated with a wide range of outcomes, whereas longitudinal studies suggest a more consistent pattern of high initial levels of distress reducing over time (Taylor & Frazer, 1982; Raphael, 1983–4).

It is difficult to draw conclusions from the range of findings in the literature. This is due to the varying outcome measures, the lack of specification of experiences that might mediate the effects of the disaster (i.e. injury *v.* displacement) and the heterogeneity of research methods. Therefore, we examined the long-term outcomes of differing disaster experiences in specifically identified subgroups on standardized measures of psychological morbidity. Furthermore, we attempted to quantify the contribution of ongoing disruptions to longer-term psychological morbidity.

The 1989 Newcastle earthquake

The major features of this earthquake have been described previously (Carr *et al.* 1995). It was a continental earthquake of moderate intensity (Richter magnitude = 5·6) that caused 13 deaths and over $A900 million in property damage. To set the scene for the subgroup comparisons reported later, the impact of the earthquake on four groups is briefly described.

The injured

There were 105 injured persons treated in four public medical centres in the region, of whom 30 were admitted to hospital (Miles, 1991). The main injuries were contusion of soft tissues with haemorrhage (40%) and bone fracture of upper and lower extremities (20%). It is not known how many people consulted practitioners outside the public health services for injuries sustained.

The displaced

Over 3000 people were assisted by disaster relief services during the first week, about 800 requiring emergency accommodation. During the first month, City Council approved 78 full and 173 partial demolitions; 1161 buildings were considered a danger to the public and a further 3812 were damaged but habitable. The number of people displaced could not be determined accurately. For many it was immediate relocation, while others were displaced some time later when repairs to their homes were undertaken.

Impact on businesses

The largest concentrated areas of damage were a suburban shopping centre, which was barricaded for 6 weeks, and the Central Business District (CBD). Costs to the business sector included damage to property as well as profits foregone, the latter being largely proportional to the extent of damage sustained.

The helpers

Agencies involved were: professional and voluntary emergency/rescue and welfare/counselling services; armed services; and public utilities. There were 73 State Emergency Service units from divisions throughout the state and they provided over 80000 volunteer hours of assistance.

The Quake Impact Study (QIS)

The previous paper in this series described the objectives of this four phase study, the methods used to assess earthquake exposure and the patterns of psychological morbidity in the community 6 months after the disaster (Carr *et al.* 1995). Data collected during phase 1 enabled each individual's experience of the earthquake to be characterized in four ways: area of residence; location at the time of the earthquake; self-reported earthquake exposure; and membership of special interest groups. Self-reported earthquake exposure proved to be the best of the first three methods of predicting distress. The present paper examines the psychosocial sequelae of differing earthquake experiences defined by membership of 'at risk' groups. It also contrasts the utility of this approach with earthquake exposure classifications based on self-reported earthquake experiences. The injured and the helpers were expected to have had predominantly threat-related experiences, while owners of damaged businesses and the displaced were expected to have had primarily loss-related experiences. Thus, we assessed longitudinally the differential impact of disruption/loss and threat experiences on trauma-related *versus* general psychological distress. In addition, we assessed relationships between the pattern of ongoing disruptions and psychological morbidity during the first 2 years following the diaster. It was hypothesized that ongoing disruptions, which were earthquake-related, would lead to both general and specific post-traumatic psychological distress, while recent life events unrelated to the earthquake would lead to general psychological distress only.

METHOD

Subjects

A total of 1089 subjects was selected for the longitudinal component of the QIS, comprising 688 (63%) drawn from community respondents to the phase 1 survey and 401 (37%) drawn from specifically targeted agencies.

Community sample

A stratified random sample of 5000 electors was mailed the phase 1 survey 6 months post-earthquake, of whom 3007 responded (see Carr *et al.* 1995). Phase 1 community respondents were allocated to four exposure subgroups: Low Exposure ($N = 2480$); Disruption Only ($N = 161$); Threat Only ($N = 250$); and Disruption and Threat ($N = 86$). All members of the last three subgroups were selected for the ongoing study, together with a one-twelfth random sample of the Low Exposure subgroup (total $N = 688$).

Supplementary samples

An additional 1061 people were contacted through various agencies at the same time as the phase 1 community survey. A list of all confirmed injured adults ($N = 96$) was obtained through health authorities and relevant hospitals in conjunction with another study (Miles, 1991). Names and addresses of potentially displaced persons ($N = 300$) were obtained from a government community service agency and from City Council's records of damaged premises. Owners of small businesses ($N = 326$) were selected from lists of commercial premises, comprising a random sample of 40% of businesses in the CBD and 100% of businesses in the suburb of highest damage. Helpers ($N = 339$) were contacted through approaches made to professional and volunteer emergency/rescue and welfare services, the armed services and public utilities. Some helpers were in predominantly threat situations (e.g. emergency service personnel) while others were in predominantly non-threat situations (e.g. counsellors). There was a 50% adjusted response rate at phase 1 from the supplementary samples ($N = 464$). All respondents whose answers to the phase 1 survey confirmed that they fulfilled criteria for membership in the special interest groups were invited to participate in the longitudinal component of the QIS ($N = 388$).

Instruments and procedure

The phase 1 survey included background information, detailed questions about earthquake experiences, the 12-item General Health Questionnaire (GHQ-12; Goldberg, 1972), the Impact of Event Scale (IES; Horowitz *et al.* 1979) and measures of social support, coping strategies and service utilization (Carr *et al.* 1995). Weighted threat and disruption exposure scores were calculated for all phase 1 respondents using the method described previously (Carr *et al.* 1995). All respondents were also classified as members or non-members of each of five groups: injured; displaced; owners of damaged small businesses; and helpers in threat and non-threat situations.

The follow-up surveys (phases 2–4) included the GHQ-12, the IES, the Revised Symptom Checklist 90 (SCL-90-R; Derogatis, 1977), the short Beck Depression Inventory (BDI; Beck *et al.* 1974) and a 6-item recent life event scale (Singh *et al.* 1987). They also included questions designed to elicit details of ongoing disruptions experienced as a result of the earthquake. These were subsequently grouped under five domains: displacement from home; problems with household repairs (e.g. problems with builders or insurance companies); business disruptions; employment changes; and other disruptions (e.g. financial problems, use of shopping centres further from home). An index of ongoing disruptions due to the earthquake was calculated for phases 2, 3 and 4 by summation of the number of domains (range 0–5) in which disruption continued to be reported. A recent general life events index was similarly calculated (range 0–6) for events not specifically related to the earthquake at each of phases 2 to 4 (domains: relationship difficulties; financial problems; bereavement; separation; illness, accident or injury; and other distressing events). Several dispositional measures and items assessing interpersonal relationships, lifestyle factors and psychiatric history were also included in the phase 2–4 surveys and these are described in the third paper of this series (Carr *et al.* 1997). The follow-up surveys were distributed by mail and were completed on average at 50, 86 and 114 weeks post-earthquake.

Data analyses

Data analyses were undertaken using BMDP statistical software (Dixon *et al.* 1988). Where appropriate, Bonferroni-adjusted error rates were used to control for the number of statistical tests. IES total scores (range 0–75) were used in all analyses as the intrusion and avoidance subscales of this instrument were highly correlated ($r = 0{\cdot}78$, $P < 0{\cdot}001$). Scores on the two weighted exposure indices and the Likert method of scoring the GHQ-12 (range 0–36) were used in all correlational analyses and those examining mean differences between selected special interest groups. Cut-off points were also applied to the exposure indices (see Carr *et al.* 1995) to enable all respondents to the follow-up surveys ($N = 845$) to be allocated to one of four earthquake exposure subgroups: Low Exposure ($N = 264$; 31·2%); Disruption Only ($N = 182$; 22·5%); Threat Only ($N = 293$; 34·7%); and Disruption and Threat ($N = 106$; 12·5%). These subgroups were used in defining the between-group factors in the repeated measures analyses of variance (ANOVAs) that were conducted (see Table 3), namely threat exposure (Low *v.* High) and disruption exposure (Low *v.* High). In these analyses, within-subject trend contrasts, which took account of the unequal intervals between phases, were used to assess change over time.

Estimating missing morbidity data

Preliminary regression analyses were conducted using data from subjects who had completed all phases ($N = 535$), in which morbidity scores at phases 2, 3 and 4 were regressed separately onto morbidity scores from the remaining three phases. Equations from these analyses were then used to estimate missing morbidity values for subjects who had completed three of the four phases of the study. Approximately 7% of morbidity scores in the longitudinal database were estimated in this manner (i.e. 742 scores out of 10604, for $N = 845$).

Rationalization of outcome measures

Similar analyses to those in Table 3 were conducted using SCL-90-R (GSI) and BDI data for the three occasions on which these instruments were completed. These analyses have not been reported here (but are available from the authors) as they do not add substantially to the conclusions drawn from the GHQ-12 and IES analyses. Based on the findings from the analyses used to assess changes in morbidity, particularly the relative strength of the linear component of trend (Table 3), and the pattern of correlations between the morbidity measures, it was decided to restrict the major analyses to four outcome measures: average GHQ-12 and average IES across phases 1 to 4 and the rate of decline of GHQ-12 and IES scores over time (i.e. slopes of GHQ-12 and IES scores). The overall correlation between GHQ-12 and IES was 0·5 ($P < 0{\cdot}001$).

RESULTS

Patterns of participation and sample characteristics

The 845 subjects who completed the phase 1 survey and at least one of the follow-ups comprised 78% of those selected for the ongoing study (sample sizes across phases: 845, 753, 721 and 619). There were no significant differences between respondents ($N = 845$) and non-respondents ($N = 244$) with respect to gender, primary language, social support, occupational prestige, initial disruption exposure and phase 1 IES. However, respondents tended to be older (42·70 *v.* 38·64 years; $t = 3{\cdot}51$, $P < 0{\cdot}001$), to have experienced higher threat exposure (1·30 *v.* 1·16; $t = 2{\cdot}34$, $P < 0{\cdot}05$), and to have reported lower phase 1 GHQ-12 scores (13·51 *v.* 14·53; $t = -2{\cdot}05$, $P < 0{\cdot}05$).

Table 1 shows the seven sources of recruitment to the study and the corresponding membership of the special interest groups. There was considerable cross-representation, with 21% of respondents meeting criteria for membership of two or more groups. By back-weighting from all phase 1 respondents in the community sample ($N = 2977$), it was estimated that the percentages of the population meeting criteria for membership of the special interest groups were: injured, 1·5%; displaced, 4·5%; owners of

Table 1. *Membership of special interest groups by source of recruitment to study: subjects who completed at least one of the follow-up surveys* ($N = 845$)

Source of recruitment to study	N*	Membership of special interest groups: Owner of small business	Injured	Displaced	Helper in threat situations	Helper in non-threat situations	Number of groups to which subject was allocated: 0	1	2	> 2
Community sample										
Moderate property damage area	393 (76%)	65	22	85	40	64	190	142	51	10
Minor property damage area	146 (86%)	15	4	13	14	19	98	33	14	1
Supplementary samples†										
Lists of commercial premises	92 (68%)	**92**	2	6	8	14	—	70	15	7
Area health service	37 (80%)	—	**37**	2	1	1	—	34	2	1
Government community services agencies and City Council	44 (67%)	4	5	**44**	3	4	—	34	6	4
Professional and volunteer emergency/rescue and welfare services; armed services and public utilities	120 (86%)	6	5	3	**83**	**100**	—	52	61	7
Volunteers‡	13 (100%)	1	—	2	2	2	6	7	—	—
Total	845 (78%)	183	75	155	151	204	294 (35%)	372 (44%)	149 (18%)	30 (4%)

* Participation rates are shown in parentheses (i.e. N as a percentage of those selected for the ongoing phases of the study.)
† Values in bold type identify the intended target group(s) for each of the supplementary samples.
‡ People who were not originally selected for the study but who 'volunteered' to participate (e.g. by completing a survey sent to another member of the household).

damaged small businesses, 5·0%; helpers in threat situations, 4·1%; and helpers in non-threat situations, 5·9%. A total of 17·1% of the adult population of Newcastle (or approximately 16300 people) were thus expected to be potentially at risk of psychological morbidity on the basis of this categorization of earthquake-related experience.

Since the five special interest groups were not mutually exclusive, all analyses involved comparisons between members of a given special interest group and respondents who were not members of any of these groups. The upper portion of Table 2 reports those sample characteristics which differentiated the groups. The injured were demographically similar to non-members of the groups but differed from them, as expected, in terms of exposure and ongoing disruptions. Business owners and helpers, especially those who assisted in threat situations, were more likely to be male and to have higher occupational prestige. Each of the special interest groups reported higher disruption exposure than non-members of these groups, however, only the injured and both helpers groups reported higher threat exposure. Finally, all groups, except the helpers in threat situations, reported higher ongoing disruptions than non-members of the special interest groups.

Ongoing disruptions

A three-way repeated measures ANOVA (threat exposure by initial disruption exposure by time) was conducted, with ongoing disruptions index scores as the outcome variable. There were significant main effects for threat exposure ($F = 6·10$, $P < 0·05$), disruption exposure ($F = 126·17$, $P < 0·001$) and time (linear trend, $F = 141·08$, $P < 0·001$). There were also significant interactions between time and threat exposure (linear trend by exposure, $F = 4·57$, $P < 0·05$; quadratic trend by exposure, $F = 6·72$, $P < 0·01$) and between time and disruption exposure (linear trend by exposure, $F = 29·04$, $P < 0·001$; quadratic trend by exposure, $F = 8·49$, $P < 0·01$). Overall, those people who were more highly exposed initially continued to report higher levels of ongoing disruptions. There was also a tendency for those experiencing high levels of exposure initially to report steeper

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Table 2. *Sample characteristics and average psychological morbidity profiles by membership of special interest groups* (N = 845)

	Membership of special interest groups					
	Owner of small business (*N* = 183)	Injured (*N* = 75)	Displaced (*N* = 155)	Helper in threat situations (*N* = 151)	Helper in non-threat situations (*N* = 204)	Non-member of special interest groups (*N* = 294)
Sample characteristic						
Mean age (years)	43·68	47·79	43·43	39·09*	40·80	43·86
% Female	42·0***	57·3	54·2	14·6***	32·8***	62·9
% Married/*de facto*	75·0*	58·7	55·3	71·5	72·4	62·9
Mean education level (1–13)	7·28	6·45	7·39*	7·53***	8·05	6·93
Mean occupational prestige†	3·34***	4·05	3·85*	3·83**	3·62***	4·13
Mean exposure						
Threat	0·94	2·20***	1·32	1·86***	1·48***	1·12
Disruption	1·71***	1·10***	1·85***	1·31***	1·48***	0·72
Mean score on ongoing disruptions index	0·94***	0·75**	1·15***	0·61	0·63*	0·44
Measure of psychological morbidity (means)						
Average General Health Questionnaire (GHQ-12) score (Likert method)‡	12·76	14·76***	13·79*	11·53	11·84	11·89
Slope of GHQ-12 scores‡	−0·83	−1·28*	−1·38**	−0·14	−0·38	−0·61
Average Impact of Event Scale (IES) total score‡	10·81	19·04***	14·55**	9·82	10·53	10·06
Slope of IES scores‡	−2·33	−3·09	−3·13	−1·74	−2·02	−2·23

The special interest groups are not mutually exclusive (see Table 1) and therefore all analyses involved comparisons between the members of the designated special interest group and participants who were not members of any of these groups; Bonferroni-adjusted error rates were used to control for the $\kappa = 5$ comparisons per variable: * $P < 0·05$; ** $P < 0·01$; *** $P < 0·001$.

† Occupational prestige scores are from Daniel's (1983) scale, on which lower scores indicate higher occupational prestige.

‡ Across all four phases.

Table 3. *Psychological morbidity profiles across the four phases of the Quake Impact Study by gender and initial earthquake exposure (Threat/Disruption subgroups): Mean GHQ*-12 *(Likert) and IES total scores for subjects with complete morbidity data sets* (N = 686)

Measure of psychological morbidity	Exposure: Threat	Exposure: Disruption	Gender	Survey phase: Phase 1	Phase 2	Phase 3	Phase 4	Significant *F*-ratios from four-way ANOVAs†	
General Health Questionnaire (GHQ-12) total score – Likert scoring	Low	Low	F	11·81	11·17	10·97	10·61	G:	16·22***
			M	9·91	9·83	9·67	9·99	T:	49·05***
	Low	High	F	15·55	13·62	11·57	11·45	D:	29·41***
			M	12·36	11·94	11·14	10·78	L:	83·05***
	High	Low	F	15·78	14·85	13·07	13·15	L×G:	11·01**
			M	12·07	11·56	11·52	11·09	L×T:	6·49*
	High	High	F	17·95	16·21	14·12	13·10	L×D:	20·65***
			M	16·91	15·22	13·98	13·18	Q:	8·04*
Impact of Event Scale (IES) total score	Low	Low	F	9·81	9·57	5·50	4·35	G:	15·83***
			M	8·42	6·60	4·24	3·09	T:	66·29***
	Low	High	F	15·31	13·28	7·94	8·21	D:	17·43***
			M	10·49	8·75	6·02	5·51	L:	274·49***
	High	Low	F	19·47	19·52	13·41	12·19	L×T:	6·51*
			M	12·95	12·77	8·53	7·69	C:	27·74***
	High	High	F	23·91	25·65	18·21	15·51		
			M	19·93	19·62	13·20	11·82		

† From 2×2×2×(4) analysis of variance (ANOVA): Gender [G]×Threat exposure [T]×Disruption exposure [D]×time [L: linear, Q: quadratic and C: cubic components of trend across phases]; Bonferroni-adjusted error rates were used to control for the $\kappa = 4$ dependent variables: * $P < 0·05$; ** $P < 0·01$; *** $P < 0·001$.

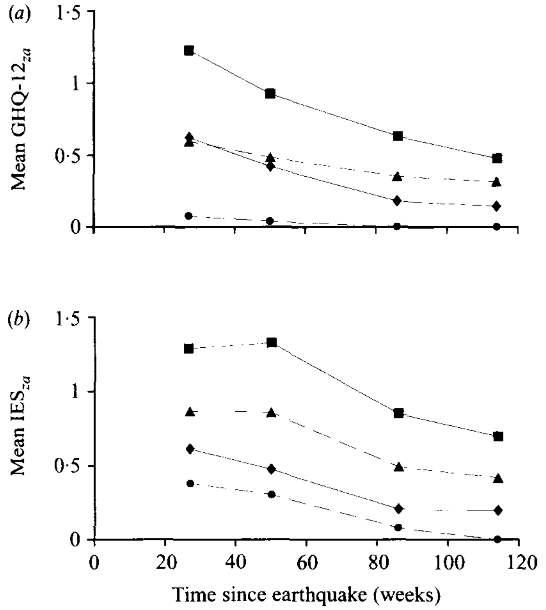

FIG. 1. Post-disaster morbidity profiles for selected exposure subgroups: (*a*) mean standardized General Health Questionnaire (GHQ-12*za*) scores; and (*b*) mean standardized Impact of Event Scale (IES*za*) scores for four exposure subgroups – Low Exposure (●--●), Disruption Only (◆—◆), Threat Only (▲--▲) and Disruption and Threat (■—■).

declines in ongoing disruptions over time, with most of the change occurring between the second and third phases. While there was no significant quadratic component of trend overall, there were significant interactions, signifying that there were non-linear reductions in disruptions for some subgroups. For example, the Disruption and Threat subgroup reported unusually high ongoing disruptions at phase 2 (given their mean phase 1 disruption exposure). An examination of the items in the ongoing disruptions index revealed that 36% of the Disruption and Threat subgroup reported financial problems at phase 2, compared with 24% of the Disruption Only subgroup, 8% of the Threat Only subgroup and 7% of the Low Exposure subgroup ($\chi^2 = 66{\cdot}25$, $P < 0{\cdot}001$).

Self-reported earthquake exposure and psychological morbidity

Table 3 presents a breakdown of mean GHQ-12 and IES scores, together with the corresponding four-way repeated measures ANOVAs: gender by threat exposure by disruption exposure by time. For both the GHQ-12 and IES there were significant effects of gender, exposure and time. Females had higher GHQ-12 and IES scores than males but their GHQ-12 scores tended to converge on those of males over time, an effect not seen on the IES. The significant main effects for threat and disruption exposure, with no interaction between them, suggest that their contribution to morbidity was largely additive. The significant linear trend for both the GHQ-12 and IES reflects the marked decline in morbidity over time. With respect to the GHQ-12, the extent of the linear trend was related to gender, threat exposure and disruption exposure, with steeper declines in morbidity being experienced by females and those with higher earthquake exposure. For the IES, the only similar interaction involved the linear trend across phases by threat exposure, which again reflected the association between exposure to threat and higher initial IES scores leading to a steeper decline over time. There was a significant but small quadratic trend on the GHQ-12, highlighting a sharper decline between phases 1 and 2 relative to the rate of change over the subsequent phases. Finally, there was a significant cubic trend for the IES, reflecting the relative stability in IES scores from phase 1 to 2, followed by a sharp decline, with less change from phase 3 to 4.

Comparisons between standardized GHQ-12 and IES profiles

An additional analysis was conducted to test directly whether threat and disruption were associated with different patterns of psychological morbidity. Adjusted standardized scores (*za*) were calculated for the two main outcome measures, using as (non-disaster) 'reference points' the gender standardized phase 4 means for the Low Exposure group. Thus, $GHQ\text{-}12_{za}$ and IES_{za} scores for phases 1–4 were obtained by subtracting the reference point (GHQ-12, 10·30; IES, 3·72) from each person's morbidity scores and dividing by the grand standard deviation (GHQ-12, 5·89; IES, 14·21). Fig. 1 illustrates, in effect size units, the overall patterns of change in general and trauma-related psychological morbidity.

The adjusted standardized morbidity scores were included in a five-way repeated measures ANOVA (gender by threat exposure by disruption exposure by time by morbidity scale

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Table 4. *Four-step hierarchical regression analyses assessing the contributions of background factors, group membership, earthquake exposure, and recent events and disruptions to post-earthquake morbidity. Outcome variables: average General Health Questionnaire (GHQ-12) score (Likert method) and average Impact of Event Scale (IES) score across phases 1 to 4* (N = 691)

		Outcome measure			
		Average GHQ-12 score		Average IES score	
Step	Predictor variables	ΔR^2	*pr*	ΔR^2	*pr*
1	Set A				
	Background factors ($m = 4$)	0·048***	(0·22)	0·078***	(0·28)
	Age		−0·01		0·17**
	Gender (Male = −1, Female = 1)		0·15*		0·12
	Occupational prestige		−0·03		0·02
	Major life events during 6 months before quake (0–6)		0·15**		0·19***
2	Set B				
	Membership of special interest groups ($m = 5$)	0·039***	(0·20)	0·038***	(0·20)
	Owner of small business (No = 0, Yes = 1)		0·05		0·00
	Injured (No = 0, Yes = 1)		0·16*		0·18***
	Displaced (No = 0, Yes = 1)		0·11		0·11
	Helper in threat situations (No = 0, Yes = 1)		−0·01		0·01
	Helper in non-threat situations (No = 0, Yes = 1)		−0·02		0·02
3	Set C				
	Earthquake exposure ($m = 2$)	0·094***	(0·32)	0·108***	(0·35)
	Threat		0·26***		0·31***
	Disruption		0·18**		0·15***
Alternate order for sets B and C†					
2	Set C				
	Earthquake exposure ($m = 2$)	0·105***	(0·33)	0·130***	(0·38)
	Threat		0·27***		0·34***
	Disruption		0·21***		0·17***
3	Set B				
	Membership of special interest groups ($m = 5$)	0·028**	(0·18)	0·016	(0·14)
4	Set D				
	Recent events and disruptions ($m = 2$)	0·121***	(0·38)	0·073***	(0·31)
	Average life events score since quake (0–6)		0·28***		0·21***
	Ongoing disruptions index score (0–5)		0·23***		0·20***
Squared multiple correlation (R^2)		(0·301)		(0·298)	

Values are the increment in squared multiple correlation at each step (ΔR^2), a measure of variance explained, and the partial correlations (*pr*) between the predictor variables and the outcome measure. m = the number of predictor variables per step. Bonferroni-adjusted error rates were used in assessing the significance of ΔR^2 ($\kappa = 4$ dependent variables), with Scheffé follow-up tests as appropriate for individual predictor variables: * $P < 0·05$; ** $P < 0·01$; *** $P < 0·001$.

† Only significant predictors are listed for this alternate order of entry into the regression equation.

(GHQ-12 *v.* IES)). In this analysis, there were five significant effects involving the morbidity scale factor. Overall, the IES_{za} was a more responsive indicator of earthquake related morbidity ($F = 26·82$, $P < 0·001$), with an average (standardized) difference from the reference point of 0·51, compared with 0·35 for the GHQ-12_{za}. Consistent with the analyses in Table 3, there was a more marked overall linear change (i.e. steeper gradient) in IES_{za} scores ($F = 5·47$, $P < 0·05$), as well as a more marked cubic component of trend ($F = 9·88$, $P < 0·01$), reflecting the plateau effects noted earlier (see Fig. 1). There was also a more pronounced quadratic trend in GHQ-12_{za} scores compared with IES_{za} scores ($F = 3·86$, $P < 0·05$), indicating a sharper decline in GHQ-12_{za} scores between phases 1 and 2 relative to the other phases. There were no significant overall differences between the morbidity scales in the size of the threat or disruption effects: the overall difference ($F = 3·54$, $P = 0·054$) between the Low and High threat exposure groups was 0·49 for the IES_{za} (0·27 *v.* 0·76) and 0·38 for the GHQ-12_{za}

(0·16 *v.* 0·54); the corresponding comparison ($F = 1{\cdot}16$) for overall disruption effects was 0·17 for the IES_{za} (0·45 *v.* 0·62) *versus* 0·27 for the $GHQ\text{-}12_{za}$ (0·25 *v.* 0·52). However, there was a significant triple interaction (disruption exposure by linear trend by morbidity scale, $F = 12{\cdot}10$, $P < 0{\cdot}001$), with the size of the initial disruption effect on the $GHQ\text{-}12_{za}$ declining across phases from 0·48 to 0·10, while the corresponding change on the IES_{za} was from 0·22 to 0·15. In short, the principal morbidity measures tended to be equally responsive to threat effects, with the GHQ-12 being more sensitive to the effects of the initial disruption experiences during the early phases of the study. Perhaps the most striking feature of Fig. 1 is that the trauma-related measure of morbidity (IES) tended to remain high across phases 1 and 2, and showed little convergence of scores in the four exposure groups over time.

Group membership and psychological morbidity

Comparisons were undertaken between the five special interest groups and non-members of these groups in terms of the four selected outcome measures (see the lower portion of Table 2). Only the injured and displaced differed from non-members of the special interest groups, having higher average GHQ-12 and IES scores and steeper rates of decline in GHQ-12 scores. These findings may reflect the fact that these groups had the highest levels of threat and disruption exposure respectively (see the upper portion of Table 2). The slopes of the IES scores did not distinguish any of the groups, which is consistent with the detailed analyses of IES changes reported above.

Other factors and psychological morbidity

Finally, we examined the contributions of background factors (Set A), special interest group membership (Set B), level of earthquake exposure (Set C), ongoing disruptions and other post-disaster life events (Set D) to post-earthquake morbidity. This was undertaken in a series of four-step hierarchical regression analyses, in which we also considered alternate orders of entry for sets B and C, thereby permitting an assessment of the relative merits of classifying exposure either by group membership or self-reported earthquake experiences. The left-hand columns of Table 4 summarize the analyses based on average GHQ-12 scores. Gender and life events prior to the earthquake made a significant but modest contribution to average GHQ-12 scores, with females tending to have higher overall scores. Of the predictor variables defining group membership, only that for injury made a unique contribution, but this effect was also small. Exposure to threat and disruption were clearly stronger predictors of average GHQ-12 scores than group membership. When included at step 2 in the equation, group membership contributed an additional 3·9% to the explained variance, compared with 10·5% for the exposure indices. Life events and ongoing disruptions since the earthquake also made a relatively strong contribution, adding a further 12·1% to the variance. The regression analysis with slope of GHQ-12 scores as the outcome variable revealed that only initial exposure (Set C) made a non-trivial contribution (Step 2: $\Delta R^2 = 0{\cdot}049$, $P < 0{\cdot}001$; overall $R^2 = 0{\cdot}101$). Although this effect was small, it was almost entirely accounted for by exposure to disruption ($pr = -0{\cdot}21$, $P < 0{\cdot}001$), with exposure to threat making a non-significant contribution to the prediction of the rate of change in GHQ-12 scores ($pr = -0{\cdot}08$).

The analysis based on average IES scores revealed a similar pattern, except that there was no gender effect but a modest positive association with age (see the right-hand columns of Table 4). Background factors (7·8% *v.* 4·8%) and exposure factors (13·0% *v.* 10·5%) tended to contribute more to the explained variance in average IES scores, relative to the corresponding GHQ-12 analysis. However, this was offset by the reduced contributions of recent life events and ongoing disruptions to average IES scores (7·3% *v.* 12·1%). In the analyses based on the slope of IES scores, only initial exposure (Set C) was significant (Step 2: $\Delta R^2 = 0{\cdot}038$, $P < 0{\cdot}001$; overall $R^2 = 0{\cdot}068$), with exposure to disruption ($pr = -0{\cdot}15$, $P < 0{\cdot}01$) and threat ($pr = -0{\cdot}13$, $P < 0{\cdot}05$) both being significant predictors of the rate of change in IES scores.

DISCUSSION

As expected, both trauma-related (IES) and general (GHQ-12) psychological morbidity declined following the earthquake, but in some subgroups they remained significantly elevated.

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The lack of convergence in levels of psychological morbidity, which was particularly evident in relation to the IES, is well illustrated in Fig. 1. The IES peak at 12 months may have been due to anniversary effects, the inquest into the fatalities, which took place at that time, and/or the impact of ongoing disruptions. These findings suggest: (1) that initial earthquake experiences have an enduring psychological effect which is only partially ameliorated after an extended time; and (2) that the degree of exposure predicts level of morbidity as much as 2 years after the event. The extent to which morbidity was associated with severity of initial exposure contrasts with the findings of others who were unable to demonstrate such a relationship (Madakashira & O'Brien, 1987; McFarlane, 1988*a*). We believe our findings reflect the fact that our exposure indices were based on detailed assessments of individual experiences and were consequently more accurate.

Although the focus of this paper has not been on clinical diagnosis, to facilitate comparisons with other studies we briefly report threshold morbidity rates. Following McFarlane (1988*a*), GHQ-12 scores above 3 (traditional scoring) were regarded as indicative of significant general psychological distress, while IES scores above 25 identified significant post-traumatic stress. The phase 1 *v*. 4 threshold morbidity rates for the GHQ-12 were: Low Exposure, 15% *v*. 13%; Disruption Only, 40% *v*. 19%; Threat Only, 34% *v*. 21%; Disruption and Threat, 64% *v*. 34%. The corresponding IES rates were: 11% *v*. 3%, 19% *v*. 8%, 23% *v*. 13% and 40% *v*. 19%. Thus, phase 1 morbidity rates among the highly exposed subgroups were approximately twice those at phase 4.

Comparisons between special interest group membership and personal experience of the earthquake revealed the comparatively superior predictive power of the latter in terms of psychological morbidity over 2 years, with the exception of the injured category which was still a significant predictor of morbidity even after controlling for other variables (see Table 4). Group membership accounted for just under 4% of the variance in morbidity scores, whereas individual levels of exposure accounted for an additional 10%. On simple group comparisons (Table 2), the injured and the displaced groups reported higher morbidity levels, but the owners of damaged businesses and the helpers reported morbidity levels which did not differ from non-members of these groups. The problems with such group classifications include the fact that 21% of the sample belonged to more than one group, the groups differed on several characteristics (see Table 2), and there was substantial overlap in individual experiences (as measured by the exposure indices). These findings suggest that *a priori* assumptions about exposure, which are based on simple categorizations representing probable exposure levels, are over-simplifications and likely to be inaccurate in terms of actual exposure and predictions of subsequent morbidity. On the other hand, care also needs to be taken to assess the potential impact of vulnerability factors on the reporting of both exposure and psychological distress. Vulnerable individuals may be more likely to respond to a disaster in ways that expose them to higher danger and/or they may perceive their experiences as more threatening. Some of these issues are addressed in the third paper in this series (Carr *et al.* 1997).

In view of the above, we undertook a series of regression analyses to identify those components within our exposure indices that contributed most to the prediction of morbidity over and above the contributions of group membership. Two broad groups of items were identified: those related to the possibility of injury (e.g. danger of things falling on you, time spent in danger); and those associated with the need to change personal plans and daily activities (e.g. changed holiday plans).

The comparatively low morbidity levels in the helpers was unexpected in light of the literature on this issue (McFarlane, 1988*a*; Bartone *et al.* 1989; Lundin & Bodegard, 1993). One explanation for this finding is the possible protective effects of male gender, higher educational attainment and higher occupational prestige, all of which characterized the helpers as a group. Another explanation is simply that there were minimal traumatic effects associated with the type and degree of exposure experienced by most of the helpers (cf. the dose-response effects noted by Bartone *et al.* 1989).

Whereas exposure to actual threat events was confined largely to the initial impact of the earthquake, the experience of disruption extended for well over 2 years. Ongoing disruptions did decline substantially with time, but subjects who reported high levels of initial disruption continued to report comparatively high levels of ongoing disruptions. Those exposed initially to disruption and threat reported particularly high degrees of ongoing disruption 12 months post-disaster, largely due to added financial burden. These results demonstrate that the Newcastle earthquake, like Hurricane Hugo (Norris & Uhl, 1993), was a disaster which continued to have substantial effects on people's lives, rather than a circumscribed event with a defined endpoint.

Persistent disruptions had a considerable impact and contributed substantially to psychological morbidity on top of the effects of initial exposure (Table 4). This suggests that exclusive reliance on initial exposure to identify persons at risk will exclude a significant number of victims in whom the impact of the disaster is latent, emerging as ongoing disruptions accumulate. A further implication is that prompt attention to repair work, rapid settlement of insurance claims, ready financial assistance, minimization of displacement, sympathetic employment arrangements and other means of reducing disruption may help to prevent or reduce psychological morbidity.

Finally, the 1989 Newcastle earthquake was at least a two-dimensional stressor (i.e. threat and disruption effects) with two sets of psychological consequences. From our analysis of adjusted standardized morbidity scores, there was a trend for the IES to be more responsive than the GHQ-12 to threat experiences. We also confirmed that the GHQ-12 was more sensitive to initial disruption experiences. Thus, disruption or loss experiences were associated more with general morbidity while threat experiences were associated more with post-traumatic stress (cf. Dooley & Gunn, 1995). Similarly, ongoing disruptions had a comparable effect on the GHQ-12 and IES, while life events unrelated to the earthquake had a greater impact on GHQ-12 scores (Table 4).

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