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Persistent mental health disturbances during the 10 years after a disaster: Four-wave longitudinal comparative study

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Aim: Although some studies have examined the long-term effects of disasters, very little is known about severe persistent symptoms following disasters. The aim of the present study was to examine persistent mental health problems and to what extent disaster exposure predicts long-term persistent disturbances.

Methods: Following a major disaster, a four-wave study was conducted (surveys 2–3 weeks, 18 months, 4 years and 10 years after the event) that examined severe post-traumatic stress disorder (PTSD) symptomatology (Impact of Event Scale), anxiety and depression symptoms and sleeping problems (Symptom Check List-90-R), and use of physician-prescribed tranquilizers. Participants were affected adult Dutch native residents ($n = 1083$). At wave 2 and 3, a control group participated ($n = 694$). At wave 1, severity of disaster exposure was examined. Multiple imputation was used to target the problem of missing data across surveys due to non-response such as in the fourth wave (61%).

Results: In total, 6.7% (95% confidence interval [CI]: 5.1–8.2) developed persistent PTSD symptoms during the 10 years after the event. For anxiety, depression, sleeping problems these prevalences were 3.8% (95%CI: 2.7–5.0), 6.2% (95%CI: 4.7–7.6) and 4.8% (95%CI: 3.5–6.1) respectively. In total 1.3% (95%CI: 0.6–2.0) used tranquilizers at all waves. Approximately one out of 10 with severe symptoms 2–3 weeks after the event, developed persistent symptoms. Even in the long term, affected residents compared to controls had more often chronic anxiety symptoms and sleeping problems. High disaster exposure independently predicted persistent PTSD symptoms (adjusted odds ratio [adj. OR], 4.20; 95%CI: 2.02–8.74, $P < 0.001$), anxiety (adj. OR, 3.43; 95%CI: 1.28–9.20, $P < 0.01$), depression symptoms (adj. OR, 2.95; 95%CI: 1.26–6.93, $P < 0.01$), and sleeping problems (adj. OR, 3.74; 95%CI: 1.56–8.95, $P < 0.001$).

Conclusion: Post-disaster mental health care should (also) target persistent mental health disturbances in the long term, especially PTSD, anxiety, depression symptoms, and sleeping problems. High disaster exposure may be an early marker for risk of persistent symptoms.

Key words: anxiety, depression, disaster, persistent symptoms, post-traumatic stress disorder.

THE ADVERSE EFFECTS of large-scale disasters on the health of affected adults are well documented,[1–3] showing that victims may suffer from a wide range of health disturbances in especially the short term, but also in the middle and long term. These include, but are not limited to, symptoms of anxiety and depression, sleeping problems, re-experiencing of the event, somatic problems, and bereavement.[4] In general, a minority will develop a mental disorder, such as the most-often examined post-traumatic stress disorder (PTSD).[1] On a population level, the prevalences of post-disaster health

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problems decrease as time passes.[1] The exact course will be dependent on for instance the nature of the disaster, the affected population, disaster recovery response, and provided support and care. Individual patterns of post-disaster health disturbances, however, do not necessarily reflect this general course and may vary. More recent studies suggest that this variability can be captured by approximately six prototypical trajectories such as resilience; recovery; delayed (chronic) dysfunction; resistance; relapsing/remitting; and chronic dysfunction.[5–8]

Of special interest and importance is the presence of the chronic dysfunction trajectory, which encompasses all affected adults who do not recover from initial severe symptoms during a substantial period of time. Longitudinal multi-wave studies (three or more waves) over a longer period starting soon after the disaster, are best suited to provide insight into this trajectory.[9–11] Retrospectively collected data on lifetime severe (chronic) symptoms since the event,[9] are sensitive to recall bias. A relatively small number of studies included multi-wave assessments over a few years, allowing an evaluation of this chronic trajectory.[1] In addition, they mainly focused on PTSD (symptomatology).[6–8,12] Exceptions are one five-wave study 6–39 months after the event that assessed persistent heavy alcohol use,[13] and one two-wave study 3–4 years and 5–6 years after the event that examined asthma, depression and PTSD,[11] after the 9/11 terrorists attacks.

Longitudinal multiwave studies starting a few days or weeks after the disaster covering a substantial post-disaster period of ≥10 years are, however, to the best of our knowledge, absent.[1] Moreover, there is a serious lack of long term disaster-studies.[1,2,4] Therefore, the prevalences of persistent mental health disturbances in the long term and the proportion (ratio) of affected adults with initial severe symptoms who develop severe persistent symptoms are unknown.

To fill this gap of knowledge, the aim of the present four-wave longitudinal study was to examine the development of persistent health disturbances in the period from 2–3 weeks to 10 years after a disaster. Data were analyzed from surveys after a major fireworks disaster in the Netherlands (13 May 2000): a devastating explosion in a fireworks storage facility located in a residential area in the city of Enschede, the Netherlands. This disaster severely damaged or destroyed approximately 500 houses, killed 23 people and injured >900 victims.[14]

We focused on the following mental health disturbances: severe PTSD symptoms; anxiety and depression symptoms; sleeping problems; and use of physician-prescribed tranquilizers. To assess whether symptoms and use were more prevalent than normal, we also assessed chronic symptoms and use of tranquilizers in a comparable non-affected group that participated in two waves. In addition, we assessed to what extent persistent symptoms can be explained by the level of disaster experience or exposure.

METHOD

Procedures and samples

The procedures and the characteristics of the participants of the first three waves have been described in previous studies, and comprehensively in one overview study.[14] In brief, a medical ethics committee (TNO, Zeist) approved study protocols and all participants gave their written informed consent at the first three waves, to be contacted in the future. Affected adults (AR) in the present study were all Dutch natives, and participated in surveys conducted 2–3 weeks (T1, May 2000–June 2000, $n = 1083$; estimated response, 33%), 18 months (T2, November 2001–January 2002, $n = 861$; response, 80%) and nearly 4 years (T3, January–March 2004, $n = 791$; response, 75%) after the disaster. Those who gave informed consent, were personally contacted, first by means of a letter and then by telephone, 10 years after the disaster (T4, June 2010, $n = 596$; response, 61%; see Appendix I). Additional descriptive statistics showed that those who participated in the fourth wave hardly differed from those who participated in the first wave (see Appendix II). Previous studies, studying the response in the present sample, showed no indications that the non-response 2–3 weeks after the disaster biased the prevalence estimates of (mental) health problems in the period from 2–3 weeks to 4 years after the disaster.[15]

The comparison group (CG) consisted of non-exposed Dutch native adult residents of the city of Tilburg (located in another part of the Netherlands), drawn from the Registry Office of Tilburg. They lived in a comparable residential area, that is, comparable in composition of the population and known general health status, and participated at the second ($n = 694$, response 61.0%) and third surveys ($n = 526$,

response 78.5%) but not at the first wave because of time constraints. Unfortunately, we were unable to include this CG in the fourth wave because personal information had been deleted after the third wave. Other studies have shown hardly any background differences between both groups.[14,15]

Measures

To examine severe anxiety and depression symptoms, and sleeping problems, (part of) the Symptom Check List (SCL-90-R),[16,17] was used all surveys. The validity and reliability of the SCL-90-R has proven to be satisfactory, and the Dutch cut-off scores for male and female subjects of a normal population,[17] were used to identify participants with severe health disturbances (high or very high scores: male scale scores: anxiety, ≥15; depression, ≥23; sleeping problems, ≥6; female scale scores: anxiety, ≥18; depression, ≥28; sleeping problems, ≥7). Severe disaster-related PTSD symptoms, that is, disaster-related intrusions and avoidance reactions, at the four waves were assessed using the 15-item Impact of Event Scale (IES).[18,19] The reliability and structure of the Dutch IES has been proven to be adequate across various traumatic stressors.[19] A cut-off on the total IES score of >25 was used to identify victims with severe PTSD symptoms. At all measurement points, the internal consistencies of all scales were excellent (Cronbach's $\alpha \geq 0.87$). Self-reported current use of physician-prescribed tranquilizers (yes/no) was also examined at all waves.

Furthermore, data on gender, age, educational level, occupational status (having a paid job at T1), were also collected. Disaster exposure was assessed at T1. For the present study a sum was calculated of 16 dichotomous exposure and experience items: (1) severe damage/destruction to house; (2) injury to self; (3) lost a loved one; (4–5) witnessed lightly or heavily injured victims; (6) witnessed deceased victims; (7–8) heard yelling children or adults; (9) felt heart palpitations; (10) felt intense anxiety; (11–12) fled from explosions or fled from home; (13–14) protected others against projectiles or helped others seek shelter; (15) felt much feelings of guilt and/or shame; (16) felt much confusion.

Statistical analysis

Multivariate imputation by chained equations (MICE)[20] was used to solve the problem of missing values across the four waves. To gauge the variability caused by the gaps, and also to minimize any potential bias that may arise due to gaps, all covariates within the regression, as well as variables that were highly correlated to the model covariates (but not in the actual model), were included in the prediction matrix of the MICE procedure, as advocated by Buuren and van Groothuis-Oudshoorn.[20] Rubin suggested that no more than 5–10 imputations are needed.[21] We generated 10 imputations for both affected residents (AR) and the CG. Subsequently, the prevalences of chronic/persistent severe health disturbances were estimated for each of the 10 imputations, as well as their confidence intervals (CI) based on Wilson's method.[22] The results were subsequently pooled using Rubin's rules.[21] The same procedures were used to examine prevalences of the other trajectories.

To provide a detailed overview of the development of persistent health disturbances (severe symptoms at: T1, T2, T3, and T4), we also examined severe chronic symptoms as a result of severe symptoms at two subsequent waves (severe symptoms at: T1–T2, T2–T3, and T3–T4) and at three subsequent waves (severe symptoms at: T1–T2–T3 and T2–T3–T4).

Multivariate logistic regression analysis was conducted to examine the predictive value of disaster exposure (level of exposure: low, 0–5; medium, 6–8; high, 9–16) for persistent symptoms during the 10 years after the disaster. Considered confounding factors were: age, gender, low educational level, and employment status. Because the total number of survivors with persistent mental health problems ($n > 70$) was relatively low, we excluded educational level and employment status because they were not confounding associations.

The logistic model was those with persistent symptoms (severe symptoms at all four waves) versus those who did not have persistent symptoms (model 1). The latter group could have had reported symptoms at two or three consecutive waves. For the purpose of sensitivity analyses, we ran a second model (model 2) and contrasted the dependent variable as follows: those with persistent symptoms versus those who never had severe chronic symptoms at two or three consecutive waves. Each regression model was estimated for each of the 10 imputations, and the results were once again pooled with Rubin's rules. As such, the final regression results took into account both between-imputation and within-imputation variance.

RESULTS

Prevalence of severe persistent symptoms

Table 1 lists the prevalences of severe symptoms at each wave, chronic symptoms (two or three waves) and persistent symptoms (four waves). At T1, 70% of all respondents ($n = 1083$) reported severe PTSD symptoms and 6.7% of the total study sample had persistent PTSD symptoms. Thus, almost one out of 10 (73/758) with severe PTSD symptoms at T1 continued to suffer from these

Table 1. Prevalence of mental health problems and (persistent) chronic mental health problems during 10 years after a disaster ($n = 1083$)

Mental health problems	Group	T	*n*	%	(95%CI)	T	*n*	%	(95%CI)	T	*n*	%	(95%CI)	T	*n*	%	(95%CI)
Severe PTSD symptoms																	
On separate wave	AR	**1**	758	70.0	(67.2–72.7)	**2**	423	39.1	(36.2–42.1)	**3**	286	26.4	(23.6–29.2)	**4**	181	16.7	(14.2–19.1)
Chronic																	
2 waves	AR					**1–2**	357	33.0	(30.2–35.9)	**2–3**	187	17.3	(14.9–19.6)	**3–4**	95	8.8	(7.1–10.5)
3 waves	AR									**1–2–3**	173	16.0	(13.8–18.3)	**2–3–4**	75	6.9	(5.3–8.4)
Persistent																	
all 4 waves	AR													**1–2–3–4**	73	6.7	(5.1–8.2)
Severe anxiety symptoms																	
On separate wave	AR	**1**	467	43.1	(40.1–46.1)	**2**	299	27.6	(24.9–30.4)	**3**	230	21.2	(18.7–23.7)	**4**	199	18.4	(15.9–21.0)
	CG			n.a.		**2**	115	10.6	(8.3–12.9)*	**3**	125	11.5	(9.2–13.9)*			n.a.	
Chronic																	
2 waves	AR					**1–2**		19.7	(17.3–22.1)	**2–3**	127	11.7	(9.7–13.6)	**3–4**	78	7.2	(5.6–8.7)
	CG							n.a.		**2–3**	76	7.0	(5.1–8.9)+			n.a.	
3 waves	AR									**1–2–3**	102	9.4	(7.6–11.1)	**2–3–4**	54	5	(3.7–6.3)
Persistent																	
All 4 waves	AR													**1–2–3–4**	41	3.8	(2.7–5.0)
Severe depression symptoms																	
On separate wave	AR	**1**	516	47.6	(44.6–50.6)	**2**	348	32.1	(29.2–34.9)	**3**	295	27.2	(24.4–29.9)	**4**	259	23.9	(21.3–26.6)
	CG			n.a.		**2**	206	19.0	(16.1–21.9)*	**3**	204	18.8	(15.9–21.7)*			n.a.	
Chronic																	
2 waves	AR					**1–2**		23.7	(21.1–26.3)	**2–3**	167	15.4	(13.1–17.6)	**3–4**	122	11.3	(9.4–13.3)
	CG							n.a.		**2–3**	139	12.8	(10.3–15.2)			n.a.	
3 waves	AR									**1–2–3**	134	12.4	(10.4–14.4)	**2–3–4**	80	7.4	(5.8–9.0)
Persistent																	
All 4 waves	AR													**1–2–3–4**	67	6.2	(4.7–7.6)
Severe sleeping problems																	
On separate wave	AR	**1**	488	45.1	(42.1–48.1)	**2**	316	29.2	(26.4–31.9)	**3**	289	26.7	(24.1–29.4)	**4**	266	24.6	(21.9–27.3)
	CG			n.a.		**2**	149	13.8	(11.2–16.3)*	**3**	145	13.4	(10.8–15.9)*			n.a.	
Chronic																	
2 waves	AR					**1–2**	213	19.7	(17.3–22.1)	**2–3**	149	13.8	(11.7–15.9)	**3–4**	112	10.3	(8.4–12.1)
	CG							n.a.		**2–3**	88	8.1	(6.1–10.1)+			n.a.	
3 waves	AR									**1–2–3**	114	10.5	(8.6–12.4)	**2–3–4**	68	6.3	(4.8–7.8)
Persistent																	
All 4 waves	AR													**1–2–3–4**	52	4.8	(3.5–6.1)
Use of physician-prescribed tranquilizers																	
On separate wave	AR	**1**	68	6.3	(4.8–7.7)	**2**	129	11.9	(9.9–13.9)	**3**	131	12.1	(10.1–14.3)	**4**	151	13.9	(11.7–16.0)
	CG			n.a.		**2**	82	7.6	(5.6–9.5)*	**3**	107	9.9	(7.6–12.2)			n.a.	
Chronic																	
2 waves	AR					**1–2**	38	3.5	(2.4–4.6)	**2–3**	56	5.2	(3.8–6.5)	**3–4**	44	4.1	(2.9–5.4)
	CG							n.a.		**2–3**	45	4.2	(2.7–5.7)			n.a.	
3 waves	AR									**1–2–3**	**v**	2.2	(1.1–3.2)	**2–3–4**	27	2.5	(1.5–3.4)
Persistent																	
All 4 waves	AR													**1–2–3–4**	14	1.3	(0.6–2.0)

*Significant difference in prevalence of mental health problems between affected residents and comparison group at particular wave ($P < 0.05$); +significant difference in chronic mental health problems (T2–T3) between affected residents and comparison group ($P < 0.05$). T, time of measurement; T1, 2–3 weeks after the disaster; T2, 18 months after the disaster; T3, almost 4 years after the disaster; T4, 10 years after the disaster; 1–2, 2–3, 3–4, 1–2–3, 2–3–4, 1–2–3–4, severe symptoms at two (i.e. waves 1–2, 2–3, or 3–4), three (waves 1–2–3 or 2–3–4) or four waves (1–2–3–4). AR, affected residents; CG, comparison group; CI, confidence interval; n.a., not available.

Table 2. Prediction of persistent symptoms (model 1, $n = 1083$)

		Persistent PTSD symptoms			Persistent anxiety symptoms			Persistent depression symptoms			Persistent sleeping problems		
	n (%)	Adj. OR	95%CI	*P*	Adj. OR	95%CI	*P*	Adj. OR	95%CI	*P*	Adj. OR	95%CI	*P*
Gender													
Male (Ref.)	503 (46.5)	1			1			1			1		
Female	580 (53.5)	0.94	(0.53–1.67)	0.83	1.01	(0.48–2.11)	0.98	1.21	(0.70–2.11)	0.49	1.21	(0.58–2.55)	0.61
Age													
<50 years	723 (66.8)	1			1			1			1		
≥50 years	360 (33.2)	3.10	(1.67–5.73)	0.00	1.21	(0.55–2.66)	0.64	1.07	(0.56–2.05)	0.83	2.55	(1.23–5.29)	0.01
Disaster exposure													
Low (0–5, Ref.)	603 (55.7)	1			1			1			1		
Medium (6–8)	326 (30.1)	1.70	(0.82–3.53)	0.15	1.61	(0.60–4.28)	0.34	2.05	(1.02–4.11)	0.04	2.64	(1.23–5.65)	0.01
High (9–16)	154 (14.2)	4.20	(2.02–8.74)	0.00	3.43	(1.28–9.20)	0.01	2.95	(1.26–6.93)	0.01	3.74	(1.56–8.95)	0.00

Persistent symptoms, severe symptoms at 2–3 weeks, 18 months, almost 4 years, and at 10 years after the disaster. Adj. OR, odds ratio adjusted for other variables in table; CI, confidence interval; PTSD, post-traumatic stress disorder; Ref., reference category.

symptoms over a period of 10 years. According to Table 1, between 3.8% and 6.2% developed persistent anxiety, depression symptoms, or sleeping problems. Again approximately one out 10 respondents with severe symptoms at T1 developed persistent anxiety (8.8%; 41/467), depression symptoms (13%; 67/516), or sleeping problems (10.6%; 52/488). Although 68 respondents used tranquilizers at T1 (6.3%), 14 of 68 (20.6%) reported using tranquilizers at all waves. Among those with severe symptoms at T4, a large minority had persistent PTSD symptoms (40.3%; 73/181) and a smaller minority had persistent anxiety (20.6%; 41/199), depression (25.9%; 67/259), or sleeping problems (19.5%; 52/266).

Although we have no data on depression, anxiety, sleeping problems and use of tranquilizers among controls at T4, the data on the prevalence estimates at T2 and T3 were more or less stable, enabling an extrapolation to the fourth wave. That is, the not overlapping 95%CI of symptoms of both groups indicate that the 10-year post-disaster (T4) anxiety symptoms (AR, 18.4%; 95%CI: 15.9–21.0; CG, 11.5%; 95%CI: 9.2–13.9), and especially sleeping problems (AR, 24.6%; 95%CI: 21.9–27.3; CG, 13.4%; 95%CI: 10.8–15.9) were still more prevalent among AR than in control subjects at T3. In addition, the prevalences of chronic anxiety symptoms (T2–T3, 7.0%; 95%CI: 5.1–8.9) and sleeping problems (T2–T3, 8.1%; 95%CI: 6.1–10.1) among the CG appear to be similar to the prevalences of chronic symptoms (anxiety, 5.0%; 95%CI: 3.7–6.3; sleeping problems, 6.3%; 95%CI: 4.8–7.8, respectively) among AR in the period T2–T4 (an additional period of 6 years). The prevalence of depression did not deviate from the control group. Thus, these findings clearly suggest that chronic anxiety and sleeping problems were more prevalent in the long term.

Prediction of severe persistent symptoms

Table 2 (model 1) shows that high levels of disaster exposure independently predicted all examined persistent symptoms ($P < 0.01$) and that medium levels of exposure predicted persistent depression symptoms and sleeping problems ($P < 0.05$). Being aged ≥50 years was independently associated with persistent PTSD symptoms and sleeping problems ($P < 0.01$), while gender was not independently associated with any of the persistent health problems. The outcomes of model 2 (data not shown) were almost identical with one exception: in model 2, in contrast to model 1, medium levels of disaster exposure also independently predicted persistent PTSD symptoms (adjusted odds ratio [OR], 2.09; 95%CI: 1.01–4.31, $P < 0.01$). Due to low cell count, we could not examine predictors of persistent use of tranquilizers

DISCUSSION

The main outcomes are that a small but significant group of adult AR suffered from severe persistent PTSD symptomatology (6.7%) and depression symptoms (6.2%), and to a somewhat lesser extent from persistent anxiety (3.8%) and sleeping problems

(4.8%) during the 10 years after a disaster. Among those with severe symptoms 2–3 weeks after the disaster, approximately one out of 10 developed persistent symptoms up to 10 years after the event. Use of tranquilizers increased after the first wave, and approximately one out of five reported using tranquilizers at all four waves.

The ratio of persistent divided by initial prevalence estimates is important because it further enables comparisons across study outcomes. The reason is that prevalences of post-disaster health problems at particular moments or periods after disasters are partly dependent on who were considered potential victims (or were asked to participate), that is, the denominator, in calculating prevalence estimates (which may partly explain differences in estimates between studies). In a similar way, this denominator affects prevalence estimates of chronic or persistent mental health disturbances. By calculating the ratio, this denominator is eliminated, facilitating comparisons between different studies. For instance, compared to the four-wave study 6–42 months after 9/11,[6] the prevalence of severe chronic PTSD symptoms in the present sample in a comparable period (T1–T3) was much higher: 16% versus 2% (based on PTSD symptoms in the past 6 months/since previous wave), but the prevalence of these symptoms among those with severe PTSD symptoms in the first wave in the present sample appears to be smaller: 23% (16.7/70) versus 35% (2.0/5.8), respectively (S. Galea, pers. comm., 2010). A three-wave study after an earthquake in Turkey, with assessments from 1–3 to 8–20 months after the event, reported less (5.2%) chronic PTSD than the chronic PTSD symptoms (33%) in the present sample during the first 18 months.[8] The ratio of persistent/initial symptoms was also much lower: 17.2% (5.2/30.2) versus 47.1% (33/70) in the current study. Following the Newcastle earthquake in Australia, a four-wave study 27–144 weeks after the disaster found that 14.4% had persistent PTSD (based on IES cut-off >25),[12] while 33.2% reported severe PTSD symptoms during the first year (ratio 43.4%). Due to the absence of other multiwave long-term disaster studies with early assessments, we cannot compare the present long-term outcomes (prevalences of persistent symptoms and computed ratios).

Compared to non-affected residents, chronic anxiety symptoms and sleeping problems appeared to be more prevalent in the long term. No other studies with similar endpoints (i.e. up to 10 years after the disaster) are available with which to compare the results. Ten years after the disaster, 16.7% (95%CI: 14.2–19.1%) had severe PTSD symptoms. Higher prevalences of PTSD symptomatology were found 10 years after an oil platform disaster (PTSD diagnosis, 21%),[10] and 14 years after the Buffalo Creek disaster (PTSD diagnosis, 25%).[9] In line with the literature, the prevalence of late-onset severe chronic PTSD symptoms was very low (1.8%).[23]

After adjustment for age and gender, a high disaster exposure significantly predicted persistent symptoms during 10 years after the disaster. Although there are no long-term multiwave studies with which to compare the present findings, this outcome suggests that high disaster exposure may help in the early identification of those at risk for persistent severe anxiety and depression symptoms, sleeping problems and especially PTSD (adjusted OR, 3.43, 2.95, 3.74 and 4.20, respectively).

The strengths of the present study are the large sample size, four-wave study design, use of well-validated instruments and controls, but some limitations and the context of the present study need to be discussed. First, participants were adult Dutch native residents. The present findings may not be applicable to ethnic minorities. Results are based on well-validated and often used questionnaires (SCL-R-90 and IES) but not on clinical or diagnostic interviews. Although we used sophisticated statistical techniques (multiple imputation) to target the problem of missing values across the four surveys, it should be noted that the response at the fourth wave was relatively low (61%). In addition, we did not examine pre-disaster history of psychiatric illness and family history of psychopathology, which may influence persistent post-traumatic stress symptoms.[2,3]

Second, the question remains as to which time intervals between waves should be chosen. Here, time intervals differed from 18 months to approximately 6 years. Therefore it is possible that at some moment(s) between the surveys some of the participants, as in other multiwave studies, did not suffer from severe symptoms, or did not use tranquilizers (or vice versa). To our knowledge, to date there is no general consensus on which time intervals in multiwave disaster studies are preferable. In theory, multiple repeated mental health measurements, that is, for instance every 1–3 months throughout the years, may help to solve this problem. Nevertheless, this solution may introduce new complex problems (such

as the heavy burden for participants and negative influence on response rates) that presumably will counteract the advantages.

Third, after the disaster a special after-care unit offering mental health services (MHS) for AR was opened. Previous studies based on the first three waves demonstrated that among those with ongoing symptoms a large majority used MHS,[24] which may have affected outcomes.[25] This possible effect, however, may also have take place in other disaster studies.[6,26] Disaster research, especially in Western countries, has shown that at different time points after disasters in general a variable minority with current PTSD (symptomatology) use MHS.[6,27] Some disaster studies explicitly mention that respondents with severe mental health disturbances during assessment were directly referred to or offered treatment.[28,29]

Nevertheless, in line with other long-term disaster studies, results indicate that attention to the long-term effects of disasters on mental health is required. For instance, general practitioners (in several countries a patient's main doctor) should be aware that some of the disaster victims will suffer from persistent symptoms in the long term. Because this last group appears to be relatively small, there is a chance that, especially after 10 years, general practitioners simply forget to assess to what extent persistent symptoms are a result of the disaster 10 years earlier.

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REFERENCES

1. Galea S, Nandi A, Vlahov D. The epidemiology of posttraumatic stress disorder after disasters. *Epidemiol. Rev.* 2005; **27**: 78–91.
2. Norris FH, Friedman M, Watson PJ, Byrne CM, Diaz E, Kaniasty K. 60 000 disaster victims speak: Part I. An empirical review of the empirical literature, 1981–2001. *Psychiatry* 2002; **65**: 207–239.
3. Rubonis AV, Bickman L. Psychological impairment in the wake of disaster: The disaster-psychopathology relationship. *Psychol. Bull.* 1991; **109**: 384–399.
4. Neria Y, Galeo S, Norris FH (eds). *Mental Health and Disasters*. Cambridge University Press, New York, 2009.
5. Bonanno GA. Loss, trauma, and human resilience: Have we underestimated the human capacity to thrive after extremely aversive events? *Am. Psychol.* 2004; **59**: 20–28.
6. Norris FH, Tracy M, Galea S. Looking for resilience: Understanding the longitudinal trajectories of responses to stress. *Soc. Sci. Med.* 2009; **68**: 2190–2198.
7. Boe HJ, Holgersen KH, Holen A. Reactivation of posttraumatic stress in male disaster survivors: The role of residual symptoms. *J. Anxiety Disord.* 2010; **24**: 397–402.
8. Karamustafalioglu OK, Zohar J, Güveli M *et al*. Natural course of posttraumatic stress disorder: A 20-month prospective study of Turkish earthquake survivors. *J. Clin. Psychiatry* 2006; **67**: 882–889.
9. Green BL, Lindy JD, Grace MC, Leonard AC. Chronic posttraumatic stress disorder and diagnostic comorbidity in a disaster sample. *J. Nerv. Ment. Dis.* 1992; **180**: 760–766.
10. Hull AM, Alexander DA, Klein S. Survivors of the Piper Alpha oil platform disaster: Long-term follow-up study. *Br. J. Psychiatry* 2002; **181**: 433–438.
11. Brackbill RM, Hadler JL, DiGrande L *et al*. Asthma and posttraumatic stress symptoms 5 to 6 years following exposure to the World Trade Center terrorist attack. *JAMA* 2009; **302**: 502–516.
12. Lewin TJ, Carr VJ, Webster RA. Recovery from post earthquake psychological morbidity: Who suffers and who recovers? *Aust. N. Z. J. Psychiatry* 1998; **32**: 15–20.
13. Cerda M, Vlahov D, Tracy M, Galea S. Alcohol use trajectories among adults in an urban area after a disaster: Evidence from a population-based cohort study. *Addiction* 2008; **103**: 1296–1307.
14. Velden PG, van der Yzermans CJ, Grievink L. The Enschede fireworks disaster. **In**: Neria Y, Galeo S, Norris F (eds). *Mental Health and Disasters*. Cambridge University Press, Cambridge, 2009; 473–496.
15. Grievink L, Velden PG, van der Yzermans CJ, Roorda J, Stellato RK. The importance of estimating selection bias on prevalence estimates shortly after a disaster. *Ann. Epidemiol.* 2006; **16**: 782–788.
16. Derogatis LR. *SCL-90-R Administration, Scoring and Procedures Manual – II for the (Revised) Version and Other Instruments of the Psychopathology Rating Scale Series*. Clinical Psychometric Research, Towson, 1983.
17. Arrindell WA, Ettema JHM. *Manual for A Multidimensional Psychopathology Indicator SCL-90*. Swets&Zeitlinger/Swets Test Publishers, Lisse, 1986 (in Dutch).
18. Horowitz M, Wilner M, Alvarez W. Impact of event scale: A measure of subjective stress. *Psychosom. Med.* 1979; **41**: 209–218.

19. Ploeg E, van der Mooren TM, Kleber RJ, Velden PG, van der Brom D. Construct validation of the Dutch version of the Impact of Event Scale. *Psychol. Assess.* 2004; **16**: 16–26.
20. Buuren S, van Groothuis-Oudshoorn K. MICE: multivariate imputation by chained equations. *J. Stat. Softw.* 2011; **45**: 1–67.
21. Rubin DB. *Multiple Imputation for Non-Response in Surveys*. John Wiley & Sons, New York, 1987.
22. Li X, Mehrotra DV, Barnard J. Analysis of incomplete longitudinal binary data using multiple imputation. *Stat. Med.* 2006; **25**: 2107–2124.
23. Smid GE, Mooren TT, van der Mast RC, Gersons BP, Kleber RJ. Delayed posttraumatic stress disorder: Systematic review, meta-analysis, and meta-regression analysis of prospective studies. *J. Clin. Psychiatry* 2009; **70**: 1572–1582.
24. Velden PG, van der Grievink L, Kleber RJ *et al*. Post-disaster mental health problems and the utilization of mental health services: A four-year longitudinal comparative study. *Adm. Policy Ment. Health* 2006; **33**: 279–288.
25. Noorthoorn EO, Havenaar JM, de Haan HA, van Rood YR, van Stiphout WA. Mental health service use and outcomes after the Enschede fireworks disaster: A naturalistic follow-up study. *Psychiatr. Serv.* 2010; **61**: 1138–1143.
26. Rodrigues JJ, Kohn R. Use of mental health services among disaster survivors. *Curr. Opin. Psychiatry* 2008; **21**: 370–378.
27. Elhai JD, Ford JD. Service utilization after disasters. **In**: Neria Y, Galea S, Norris F (eds). *Mental Health and Disasters*. Cambridge University Press, New York, 2009; 366–386.
28. Brackbill RM, Thorpe LE, DiGrande L *et al*. Surveillance for World Trade Center disaster health effects among survivors of 157 collapsed and damaged buildings. *MMWR Surveill. Summ.* 2006; **55**(2): 1–18.
29. Chou FH, Wu HC, Chou P *et al*. Epidemiologic psychiatric studies on post-disaster impact among Chi-Chi earthquake survivors in Yu-Chi, Taiwan. *Psychiatry Clin. Neurosci.* 2007; **61**: 370–378.

APPENDIX I. RESPONSE OF AFFECTED DUTCH NATIVE RESIDENTS

Waves	Time after disaster	Crude denominator (A) *n* (excl LFTU)	No. lost, due to different reasons	Denominator (B) No. based on wave 1 response excluding LTFU	Denominator (C) No. that could be contacted (excluding LFTU and no IC)	No. responders *n*	Crude response (%) (denominator A)	Net response (%) (denominator B)	Response (%) of those who could be contacted (denominator C)
T1	2–3 weeks	3300†				1083	33		
Between T1–T2	3 weeks–18 months		5 deceased; 1 unknown address; 8 no IC						
T2	18 months	3294		1077	1069	861	26	80	81
Between T2–T3	1.5–4 years		14 deceased; 2 unknown address; 1 emigration; 91 no IC						
T3	4 years	3277		1060	961	791	24	75	81
Between T3–T4	4–10 years		42 deceased; 14 unknown address; 25 emigration; 54 no IC						
T4	10 years	3196		979	826	596	19	61	72

†Estimation based on total number (*n* ~4450), 74% of whom were of native Dutch origin. IC, informed consent to be contacted in future surveys; LFTU, lost to follow up: deceased + unknown address + emigration.

APPENDIX II. DEMOGRAPHICS, DISASTER EXPERIENCES AND SYMPTOMS

	Participants T1 ($n = 1083$) Mean/% (95%CI)	Participants T4 ($n = 596$) Mean/% (95%CI)
Age (years), mean	43.1 (42.9–43.3)	42.3 (42.0–42.6)
Gender (male, %)	46.5 (43.6–49.5)	43.2 (41.1–45.4)
Education (% high)	20.6 (18.2–23.1)	24.8 (22.8–26.7)
Employed (% high)	36.6 (33.7–39.4)	32.9 (30.8–35.0)
No damage to house (%)	79.9 (77.5–82.3)	82.4 (80.7–84.1)
No sustained injury (%)	93.3 (91.7–94.8)	91.7 (90.5–93.0)
PTSD symptoms (mean$^{\text{total IES}}$)	35.0 (34.7–35.3)	34.8 (34.3–35.3)
Anxiety symptoms (mean)	17.6 (17.5–17.7)	17.0 (16.9–17.1)
Depression symptoms (mean)	27.8 (27.7–27.9)	27.1 (26.9–27.3)
Sleeping problems (mean)	6.8 (6.7–6.8)	6.7 (6.6–6.7)
Use tranquilizers (%)	6.3 (4.8–7.7)	5.4 (4.4–6.4)

CI, confidence interval; IES, Impact of Event Scale; PTSD, post-traumatic stress disorder; T1, 2–3 weeks after disaster; T4, 10 years after disaster.