BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2016-013400
Article Type:	Research
Date Submitted by the Author:	11-Jul-2016
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Primary Subject Heading:	Mental health
Secondary Subject Heading:	Epidemiology, Public health
Keywords:	Anxiety disorders < PSYCHIATRY, SOCIAL MEDICINE, Depression & mood disorders < PSYCHIATRY

Predictors of severe psychological distress trajectory after nuclear disaster: Evidence from the Fukushima Health Management Survey

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Word count: 2953
2 figures, 3 tables, 1 supplementary file

Abstract

Objectives: The Fukushima Daiichi Nuclear Power Plant accident, which occurred after the Great East Japan Earthquake and Tsunami in March 2011, may have considerable long-term impact on the lives of area residents. The aims of this study were to determine the trajectories of psychological distress using three-year consecutive data, and to find predictive factors of severe distress that may also prove useful for public health intervention.

Methods: Data were obtained on 12,371 residents who were registered in the municipalities categorized as complete evacuation areas for 3 years after the disaster and who completed an assessment in each of the 3 years.

Results: Using group-based trajectory modeling, we identified four trajectory patterns distinguished by the levels of psychological distress, which gradually improved over time in all trajectories. Subjective sleep insufficiency, problem drinking, poor social support, and perception of radiation risk 3 years after the accident were associated with the severity of psychological distress, according to the multivariate analysis.

Conclusion: The identified factors may be useful for community-based mental health care over the long-term following a nuclear disaster.

Keywords: anxiety disorders, social medicine, depression & mood disorders

Strengths and limitations of this study

This study aims to determine the trajectories of psychological distress using three-year consecutive data, and to find predictive factors of severe distress.

A four-trajectory model was found to have the best fit and all groups showing parallel trends of gradually improving psychological distress.

Poor perceived social support, problem drinking, subjective sleep insufficiency and perception of radiation risk are related to severe psychological distress trajectory.

INTRODUCTION

The Fukushima Daiichi Nuclear Power Plant (FDNPP) accident, which occurred in 2011 after the Great East Japan Earthquake (GEJE) and Tsunami, had a significant impact on the lives of residents. It was already known that long-term mental health consequences continue to be a concern after previous nuclear disasters, such as the Chernobyl accident [1]. Three-year trend surveys revealed that the prevalence of non-specific psychological distress, posttraumatic stress response, and problem drinking were still high 3 years after the accident [2]. However, even as the population prevalence of psychological distress remains high, the trajectories of individuals' psychological distress may vary. For instance, some may realize a reduction in distress over time, while others may experience an increase or no change. Identification of such trajectories would lead to better overall understanding of long-term psychological distress after a nuclear plant accident, which in turn would enable better planning of mental health services for affected residents.

Cross-sectional studies based on the Fukushima Health Management Survey showed that drinking behaviors [3] and perception of radiation risk [4] were major risk factors for psychological distress. The effects of social support or social networks on mental health have already been reported following the 1964 Niigata earthquake [5] and the Great East Japan Earthquake [6]. It would be worthwhile to investigate whether risk factors associated with psychological distress in previous cross-sectional studies could also be associated with different trajectories of distress over time.

The aim of this study was twofold: to map the trajectories of psychological distress using three-year consecutive data, and to find predictive factors of severe distress that could also be useful for public health intervention. We hypothesized that subjective sleep insufficiency, problem drinking, negative perception of radiation risk, and poor perceived social support are positively associated with distress severity.

METHODS

This study was designed as a cohort study at three time points.

Study population

The study population was 60,432 residents born before April 1, 1998 who were registered in the municipalities categorized as complete evacuation areas during all

three fiscal-year (FY) assessments before the FDNPP accident (March 11, 2011). The residents had lived in the town of Naraha, Tomioka, Okuma, Futaba, or Namie, or in the village of Katsurao or Iitate. To avoid the problem of resettlement, we chose the residents in this area from the original sample of the mental health and lifestyle survey in the Fukushima Health Management Survey [7].

A total of three mail-based, self-administered assessments were conducted: the FY 2011 assessment was in January 2012, the FY 2012 assessment was in January 2013, and the FY 2013 assessment was in February 2014 ("FY" notation is omitted hereafter to avoid repetition). These assessments were conducted 10, 22, and 35 months after the disaster. The response rates for each assessment were 47.5% in 2011, 39.1% in 2012, and 33.5% in 2013. In total, 12,371 people completed all three assessments (see supplementary file).

Assessments

The Kessler 6-item scale (K6) [8] in its validated Japanese version [9] was used for assessing psychological distress. The K6 consists of six brief questions about depressive and anxiety symptoms during the past 30 days. All items are measured on a 5-point scale, and the assessment can be completed within 2–3 minutes. The total score (ranging between 0 and 24) has been used as an indicator of serious mental illness or mood and anxiety disorders in the general population.

The CAGE (an acronym for Cutting down, Annoyance, Guilt, and Eye-opener) is a four-item scale designed as a screening instrument for problem drinking [10]. The total CAGE score (0–4) was used as an index of problem drinking. We used 1/2 cut-off according to a review by the National Institute on Alcohol Abuse and Alcoholism [11].

To assess perceived social support, we used the abbreviated Lubben Social Network Scale (LSNS-6) [12]. The reliability and validity of the Japanese version of LSNS-6 have been confirmed [13]. The LSNS-6 comprises three questions that evaluate kinship ties and a comparable set of three questions that evaluate non-kinship ties. All items are answered on a 5-point Likert-type scale, and the total scale score is an equally weighted sum of the six items (range 0 to 30).

In this study, subjective sleep insufficiency was evaluated by the question, "Is your total sleep time sufficient or not?" The answers (yes or no) were collected. This question did

not include any suggested sleep length.

We also solicited sociodemographic characteristics and information on disaster-related variables. The number of relocations after the disaster was asked because several studies have shown higher general psychological distress and perceived stress in people with particular relocation profiles [14, 15] [16], despite a study that showed protective effects under specific conditions [17].

Analysis Plan

There is growing evidence from longitudinal studies of psychological symptoms following disasters [18], especially using semi-parametric group-based modeling [19, 20] or latent growth mixture modeling [21, 22] with multiple assessments. This type of modeling is suitable for finding heterogeneity in the longitudinal patterns [20]. Although grouping methods using cut-off scores are also used for longitudinal studies after natural disasters [23-25], this method has disadvantages: categorizing a continuous variable diminishes statistical power, and it is also difficult to find heterogeneity above / below cut-off scores. We thus conducted semi-parametric group-based modeling for this study.

All analyses were performed using SAS software, version 9.4 (SAS, Cary, NC, USA). Group-based trajectory modeling using SAS software with user-written procedure PROC TRAJ [26, 27] was used to identify trajectories of psychological distress. The Bayesian Information Criterion (BIC) and Akaike's Information Criterion (AIC) were used to select the best-fitting model. For criteria of trajectory membership, we chose 5% membership, because our aim in this study was to understand the whole picture of the trajectories.

There was a large number of missing data points for the CAGE assessment (the number missing in the original responses was n=6609, or 53.4% of the sample). This is partially due to inclusion of respondents 15–19 years old, who are prohibited from drinking alcohol in Japan, and people who do not habitually use alcohol. We decided to perform a data correction, giving a null point for missing data. For other variables, we did not perform data corrections.

RESULTS

Sociodemographic characteristics and disaster-related variables

Sociodemographic characteristics and disaster-related variables are shown in Table 1.

About 40% of the study sample was at least 65 years old at the time of the disaster. than 80% of the respondents reported that their homes were damaged to varying degrees. A total of 45.4% of the respondents had a frequent (5 or more) relocation profile, while 21.4% of the respondents experienced bereavement of a family member or loved one.

Table 1 Sociodemographic characteristics and disaster-related variables of the study sample: evacuees after the March 2011 nuclear disaster in Japan

		Study sample (n=12,371)
		n
Gender:	Male	5,290
	Female	7,081
Age in 2011 (yrs)	15–24	445
	25–34	1,011
	35–44	1,347
	45–54	1,643
	55–64	3,171
	65–74	2,719
	75–84	1,717
	≥85	318
Residence registration at time of disaster:	Naraha	1,220
	Tomioka	2,451
	Okuma	2,041
	Futaba	1,270
	Namie	4,232
	Katsurao	280
	Iitate	877
Education:	Elementary or junior high school	2,827
	Senior high school	6,024
	Junior college or professional school	1,984
	University or graduate school	1,092
	No answer	444

Disaster-related variables		
Disaster-related home damage	Yes	9,053
	No	1,948
	No answer	1,370
Disaster-related bereavement	Yes	2,572
	No	9,443
	No answer	356
Five or more relocations after the disaster, in 2012	Yes	5,477
	No	6,584
	No answer	310

The number of relocations was asked not in 2011, but in 2012.

Trajectories of psychological distress

The mean scores on the K6 sample-wide were 7.10 (SD 5.92) in 2011, 6.50 (SD 5.68) in 2012, and 5.97 (SD 5.44) in 2013. Comparing goodness-of-fit for models with different numbers of trajectories of psychological distress over time, a four-trajectory model was found to have the best fit (AIC, -93358.38; BIC, -93402.84). The four trajectories using K6 scores are shown in Figure 1. The trajectories are distinguished by the average levels of psychological distress during the follow-up (i.e., resistant, mild, moderate, and severe), and all groups showing parallel trends of gradually improving psychological distress. About half of the sample (n=6170) was categorized into the mild distress group, whose average scores were 5.5 in 2011 and 4.5 in 2013. More than one-quarter of respondents (n=3313) belonged to the moderate distress group, with average scores of 11.9 in 2011 and 9.9 in 2013. Approximately 20% of the sample (n=2244) was categorized into the resistant group, whose average scores were 1.2 in 2011 and 0.80 in 2013, while 5.7% of the sample (n=644) showed severe distress, with consistently high average scores of 18.9 in 2011 and 17.9 in 2013.

Problem drinking and social support among the groups

Mean CAGE and LSNS-6 scores for each group are shown in Figure 2. One-way revealed a main effect for the CAGE, $F(3, 12367) = 29.87$, $p < 0.001$, and for the $F(3, 11661) = 131.22$, $p < 0.001$. Post hoc tests with Bonferroni correction significant differences in CAGE and LSNS-6 scores among the four groups, except for

the CAGE score between the moderate and severe distress groups (p = 1.0).

Perception of radiation risks

The risk perception profile for radiation in each group is shown in Table 2. Chi-square tests revealed significant group differences in delayed effects (χ^2=871.0, df = 9, p < 0.001), and in genetic effects (χ^2 = 991.7, df = 9, p < 0.001). The most frequent response in the resistant group was "Very unlikely," whereas approximately half of the respondents in the severe distress group answered "Very likely" regarding their assessment of delayed effects and genetic effects.

Table 2 Perception of risk of delayed and genetic effects of radiation in 2013, by group

Delayed effects

Group	Very unlikely N (%)	Unlikely N (%)	Likely N (%)	Very likely N (%)	Data missing N(%)	Total N (%)
Resistant	879 (39.9%)	669 (29.8%)	347 (15.5%)	233 (10.4%)	116 (5.2%)	2,244(100%)
Mild distress	1,611 (26.1%)	1,970 (31.9%)	1244 (20.2%)	939 (15.2%)	406 (6.6%)	6,170 (100%)
Moderate distress	548 (16.5%)	879 (26.5%)	856 (25.8%)	821 (24.8%)	209 (6,3%)	3,313 (100%)
Severe distress	67 (10.4%)	94 (14.6%)	146 (22.7%)	273 (42.4%)	64 (9.9%)	644 (100%)

Genetic effects

Group	Very unlikely	Unlikely	Likely	Very likely		Total
Resistant	725 (32.3%)	676 (30.1%)	423 (18.9%)	275 (12.3%)	145 (6.5%)	2,244 (100%)
Mild distress	1,219 (19.8%)	1,826 (29.6%)	1547 (25.1%)	1,114 (18.1%)	464 (7.5%)	6,170 (100%)
Moderate distress	384 (11.6%)	744 (22.5%)	970 (29.3%)	968 (29.2%)	247 (7.5%)	3,313 (100%)
Severe	54 (8.4%)	72 (11.2%)	121 (18.8%)	326	71 (11.0%)	644 (100%)

distress	(50.6%)

Subjective sleep insufficiency

The overall proportion of subjective sleep insufficiency was 35.8% (N = 4424; including missing data N = 921). The proportions of subjective sleep insufficiency were 16.7% (N = 374) in the resistant group, 32.7% (N = 2018) in the mild distress group, 48.8% (N = 1616) in the moderate distress group, and 64.6% (N = 416) in the severe distress group. Chi-square tests revealed that these group differences were significant ($\chi^2 = 972.0$, df = 3, $p < 0.001$).

Factors related with the severe distress trajectory

In order to explore the factors related to the severe distress group, we conducted logistic regression analysis using a forced entry method. Variables considered in the model were CAGE in 2013 (score ≥ 2 as problem drinking), LSNS-6 score in 2013 (score ≤ 12 as poor perceived social support), and risk perception in 2013: genetic effects ("Very likely" as high perceived risk), adjusting for gender and age as potential confounders in model 1 (Table 3). All variables showed significant effects and odds ratios. The results remained significant after adjusting for disaster-related variables (home damage, bereavement, relocations) as additional potential confounders in model 2 (Table 3).

Table 3 Multivariate logistic regression analysis of the severe distress group

Predictor	Model 1 Sociodemographic factors and health-related variables	Model 2 Model 1 + disaster-related variables
	OR (95% CI)	OR (95% CI)
Gender (female)	1.38 (1.14–1.68)**	1.51 (1.21–1.89)**
Age (65y or more) at the disaster	1.73 (1.43–2.10)**	1.82 (1.46–2.26)**
Problem drinking (CAGE 2 or more) in 2013	1.62 (1.19–2.20)**	1.77 (1.26–2.49)**
Subjective sleep insufficiency in 2013	4.01 (3.26–4.94)**	3.86 (3.07–4.86)**
Poor perceived social support (LSNS-6 12 or less) in 2013	2.31 (1.88–2.83)**	2.39 (1.90–2.99)**
Perception of radiation risk (genetic effects: very likely) in 2013	3.76 (3.12–4.53)**	3.91 (3.17–4.83)**
Disaster-related home damage		0.90 (0.68–1.20)
Disaster-related bereavement		1.16 (0.91–1.47)
Relocation 5 times or more after the disaster (in 2012)		1.26 (1.02–1.55)*

CI = confidence interval; OR = odds ratio

*p < 0.05, **p < 0.01

DISCUSSION

Using group-based trajectory modeling, we identified four trajectories of psychological distress over time during the three year follow-up, which represented different average levels of psychological distress, and which all showed gradual improvement. The declining pattern of psychological distress in the long-term was in line with studies after the Three Mile Island [28, 29] and the Chernobyl [30] accidents. However, we could not find heterogeneous patterns of trajectories (e.g., recovery or worsening) across the 3 years. This might be because of the timing of the surveys. The first survey in 2011 was conducted almost one year after the disaster, which means that we were not able to differentiate any acute or sub-acute-phase impact soon after the disaster from the consistent symptom resistance.

In a study on depressive trajectories after the September 11, 2001 attacks, drastic changes were observed only between 8 (first assessment) and 14 (second assessment) months after the events and there were only gradual changes at follow-up at 26 and 42

months [20].

Our study demonstrated that the number in the mild distress group (47.6%) that scored around 5 points of K6 was larger than in the resistant group (19.3%). It has been reported that the optimal cut-off points were estimated as 4/5 for the Japanese version of the K6 for screening in a general population, and the prevalence of screened cases in the community sample was 31.3% [31]. Sone et al. (2016) [24] reported that the change in prevalence of psychological distress after changing the cut-off point (K6 score ≥5) was 50.6% (2011) and 38.6% (2014) in a tsunami-affected area after the GEJE. Another study by Yokoyama et al. (2014) [32] in Iwate Prefecture showed that a total of 42.6% of the respondents 6–11 months after the GEJE had moderate (5–12 of K6) or serious (13+ of K6) distress. Compared with these results, our results suggest that residents in the evacuation area in Fukushima Prefecture had persistent psychological distress after the nuclear accident.

Support was found for the hypothesis that subjective sleep insufficiency, problem drinking, poor social support, and perception of radiation risk 3 years after the accident were associated with psychological distress trajectories. Among these, perception of radiation risk was a factor unique to nuclear disasters. Our result that those who believed that radiation exposure was very likely to cause delayed and genetic health effects were significantly more likely to be categorized into the severe distress group, is in line with other cross-sectional studies [4, 33]. Suzuki et al. (2015) [4] showed that radiation risks were associated with psychological distress 2 years after the FDNPP accident. Another cross-sectional study conducted with a relatively small sample (n = 285) in 2014 in Kawauchi village, which is located within 30 km of FDNPP, revealed that about half of the residents had anxieties about the health effects of radiation on children, and about the health effects of radiation on offspring [33]. These results suggest the importance of risk communication as a strategy for preventing severe mental disorders, such as depression and committing suicide.

The relationship between poor social support (or social isolation) and psychological distress after the GEJE in Miyagi Prefecture has been reported [6, 24]. A longitudinal study with two time points (2011 and 2014) using LSNS-6 and K6 [24] showed that being free from social isolation was associated with improvement of psychological distress. Another research group demonstrated that individual and community-level social support were significantly associated with low psychological distress [6].

Separated families and communities in Fukushima have produced one of the main psychosocial consequences of the Fukushima disaster [34]. In addition, alcohol misuse might appear in response to social isolation. Morita et al. (2015) [35] reported a case of an individual who had been exposed to social isolation after evacuation of his neighborhood, and his alcohol intake had increased. A relationship between prolonged sleep difficulties and lack of social support after the GEJE has also been reported [36].

Our results may be useful for facilitating a community-based mental health care network in Fukushima. For example, the Fukushima Center for Disaster Mental Health, which has been providing outreach service and psychoeducational programs for the evacuees, residents, and various stakeholders based on the transdisciplinary model, is expected to promote long-term support [34]. It seems easier for the health providers to ask lifestyle habits than to ask psychological symptoms directly. Our results contribute to the better design of interventions on mental health.

One of the major public issues of growing concern in Fukushima is suicide [37]. After the disaster, the standardized suicide mortality ratio in Fukushima decreased initially (108 in 2010, 107 in 2011, 94 in 2012, and 96 in 2013) but then rose to 126 in 2014, thus exceeding the pre-disaster level. It is known that there seems to be a drop in suicidal behaviors after natural disasters, which has been referred to as the 'honeymoon' phase; however, a delayed increase in suicidal behaviors has also been reported [38]. The association between behavioral problems (e.g. sleep disturbance, problem drinking) and suicide has been documented [39, 40]. Our results might provide useful information for feedback and intervention for the high-risk group on mental health.

Several limitations should be considered in this study. First, the use of self-rating questionnaires for the assessments provides less accuracy compared with the use of clinician-administered diagnostic tools. Second, we could not measure pre-disaster psychological distress or other mental health problems. Continued pre-existing distress might by misunderstood as disaster-related distress. However, it is understandable in community-based care that pre-, peri-, and post-disaster issues coexist both at the personal and community levels. Moreover, as already mentioned, we could not measure acute and sub-acute phases of posttraumatic distress (i.e., < 1 year post-disaster). Third, because of the relative low response rates, one should not overgeneralize the results.

Despite these limitations, this study demonstrated that poor perceived social support,

problem drinking, subjective sleep insufficiency and perception of radiation risk were related to long-lasting psychological distress after the FDNPP accident. Assessing these factors might be effective for community-based mental health care after nuclear disasters in the long-term.

Disclaimer

The findings and conclusions of this article are solely the responsibility of the authors and do not represent the official views of the government of Fukushima Prefecture.

Acknowledgements

We would like to thank all the members of the Fukushima Health Management Survey, especially the mental health group members, for data collection and suggestions. We also thank Prof. Norito Kawakami, Department of Mental Health, School of Public Health, the University of Tokyo, for critical manuscript reading.

Contributors

MM and MO conceived the original idea for the study. MO performed the analyses of the data and drafted the manuscript. TO and MN contributed to the statistical analyses and the interpretation of the data. HY, YS, MH, and MA contributed with critical comments. All of the authors approved the final version.

Competing interests

Dr. Oe reports personal fees from Meiji Seika Pharma Co., Ltd., personal fees from Sumitomo Dainippon Pharma Co., Ltd., personal fees from Otsuka Pharmaceutical Co., Ltd., personal fees from GlaxoSmithKline K.K., personal fees from Janssen Pharmaceutical K.K. , personal fees from Mitsubishi Tanabe Pharma Corporation, outside the submitted work; . Other authors have nothing to disclose.

Funding

This study was supported by the national “Health Fund for Children and Adults Affected by the Nuclear Incident.”

Ethical approval

This study was approved by the Ethics Review Committee of Fukushima Medical University (No. 1316) and the Ethical Committee of Kurume University (No. 14234).

Data sharing statement: No additional data available.

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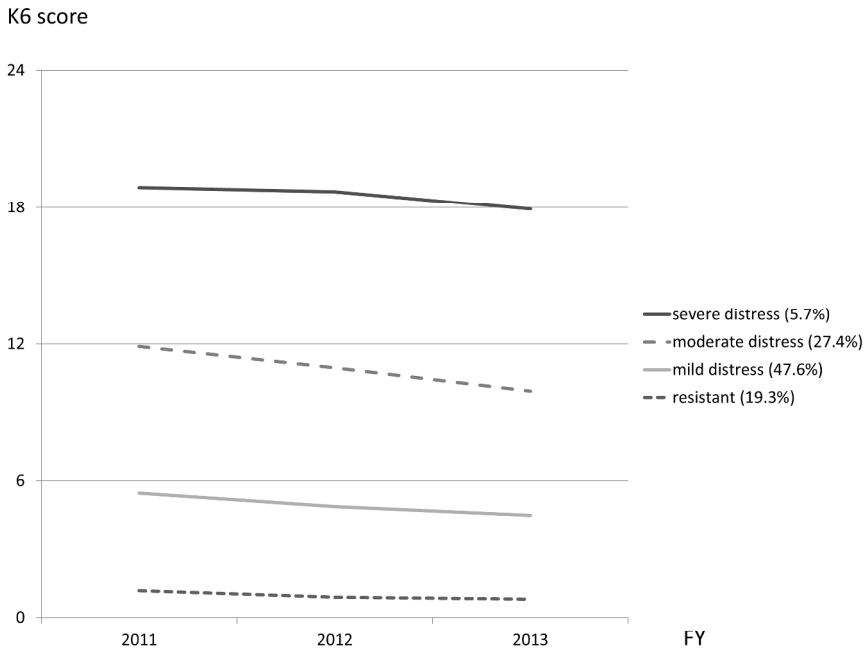
Figure legends

Figure 1 Trajectories of the four-group model of psychological distress

Figure 2 Mean CAGE scores (upper) and LSNS-6 scores (lower) by group.

* $p < 0.05$



Trajectories of the four-group model of psychological distress

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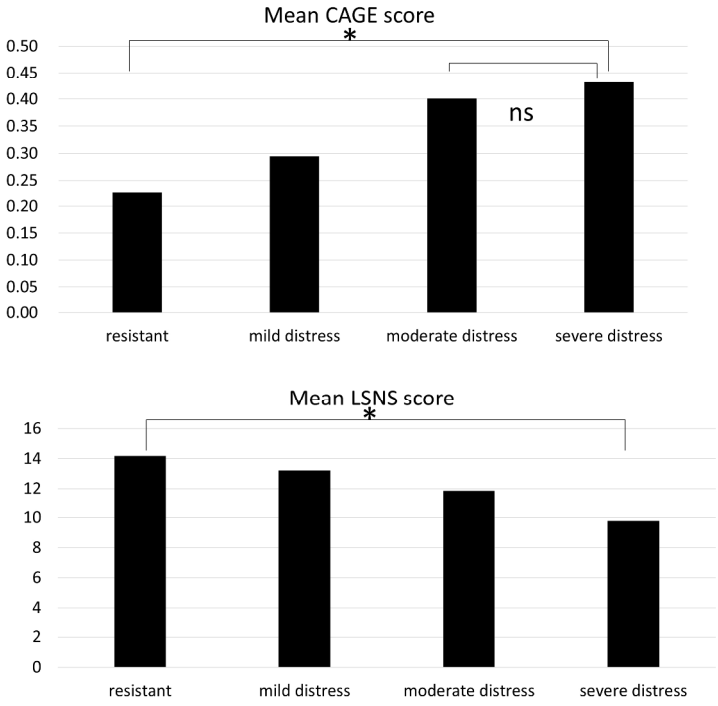

Mean CAGE scores (upper) and LSNS-6 scores (lower) by group.
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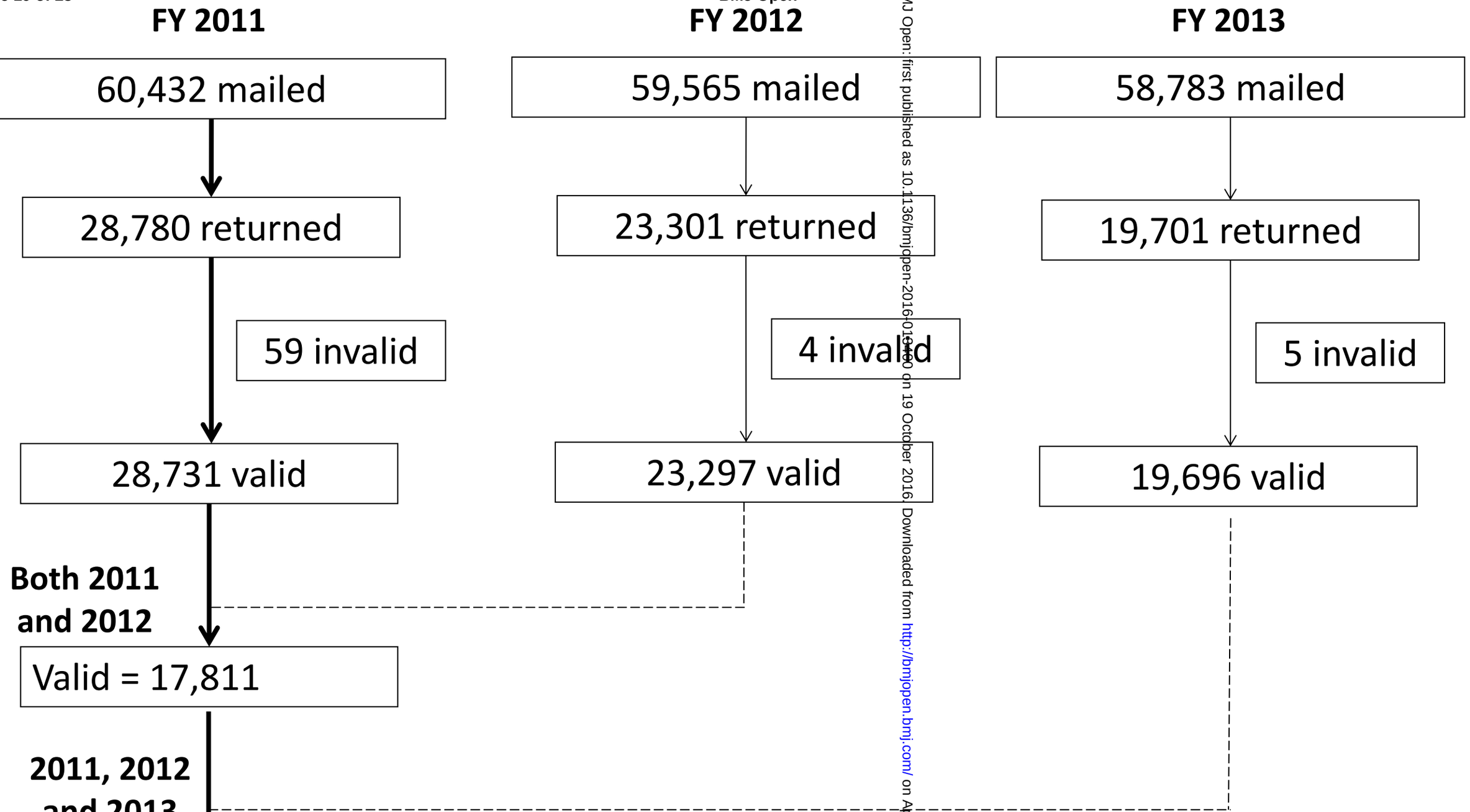

Supplementary File 1 Study Samples

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page Number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Abstract (p.2)
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract (p.2)
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Introduction (p.3, first and second paragraph)
Objectives	3	State specific objectives, including any prespecified hypotheses	Introduction (p.3, third paragraph)
Methods			
Study design	4	Present key elements of study design early in the paper	Methods (p.3, first sentence)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Methods (p.3, "study population" section)
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	(a) Cohort study Methods (p.3, "Study population" section)
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	(b) N/A, because this study is not a matched study.
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Methods (p.4, "Assessments" section)
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Methods (p.4, "Assessments" section)
Bias	9	Describe any efforts to address potential sources of bias	Information bias was addressed in Methods, "Analysis plan" section, third paragraph (about missing data of CAGE).
Study size	10	Explain how the study size was arrived at	Study size was not calculated in advance,

			because our study population was all the residents who had responded all three assessments.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	N/A, our data does not have quantitative variables.
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Methods, (p.5, "Analysis plan" section)
		(*b*) Describe any methods used to examine subgroups and interactions	Methods, (p.5, "Analysis plan" section)
		(*c*) Explain how missing data were addressed	Methods, (p.5, "Analysis plan" section, third paragraph (about missing data of CAGE)
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	Cohort study , see Supplementary file (p.4)
		(*e*) Describe any sensitivity analyses	From our point of view, no sensitivity analyses were required.

Continued on next page

Results			**Page Number**
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	See Supplementary file (p.4)
		(b) Give reasons for non-participation at each stage	See Supplementary file (p.4)
		(c) Consider use of a flow diagram	See Supplementary file (p.4)
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Results (p.5, "Sociodemographic characteristics and disaster-related variables" section)
		(b) Indicate number of participants with missing data for each variable of interest	Results section. e.g. Table 2
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	Methods (p.4, "Study population" section)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	Results (p.5-10)
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Results (p.9, "Factors related with the severe distress trajectory" section)
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	Results, from the first paragraph to the fourth paragraph (p.10-12). Each first sentences show key results.
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Results, in the seventh paragraph (p.12)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Interpretations were addressed in the Discussion by themes.
Generalisability	21	Discuss the generalisability (external validity) of the study results	Generalisability was addressed in the limitation

			section (the seventh paragraph, p.12).
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	p.13

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Predictors of severe psychological distress trajectory after nuclear disaster: Evidence from the Fukushima Health Management Survey

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2016-013400.R1
Article Type:	Research
Date Submitted by the Author:	02-Sep-2016
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Primary Subject Heading:	Mental health
Secondary Subject Heading:	Epidemiology, Public health
Keywords:	Anxiety disorders < PSYCHIATRY, SOCIAL MEDICINE, Depression & mood disorders < PSYCHIATRY

Predictors of severe psychological distress trajectory after nuclear disaster: Evidence from the Fukushima Health Management Survey

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Word count: 3,620
2 figures, 3 tables, 1 supplementary file

Abstract

Objectives: The Fukushima Daiichi Nuclear Power Plant accident, which occurred after the Great East Japan Earthquake and Tsunami in March 2011, may have considerable long-term impact on the lives of area residents. The aims of this study were to determine the trajectories of psychological distress using three-year consecutive data, and to find predictive factors of severe distress that may also prove useful for public health intervention.

Methods: Data were obtained on 12,371 residents who were registered in the municipalities categorized as complete evacuation areas for 3 years after the disaster and who completed an assessment in each of the 3 years.

Results: Using group-based trajectory modeling, we identified four trajectory patterns distinguished by the levels of psychological distress, which gradually improved over time in all trajectories. Subjective sleep insufficiency, problem drinking, poor social support, and perception of radiation risk 3 years after the accident were associated with the severity of psychological distress, according to the multivariate analysis.

Conclusion: The identified factors may be useful for community-based mental health care over the long-term following a nuclear disaster.

Keywords: anxiety disorders, social medicine, depression & mood disorders

Strengths and limitations of this study

The measure used to assess psychological distress has been validated in Japanese.

The number of respondents is large, although the response rate declines over time.

The use of self-rating questionnaires for the assessments offers lower accuracy compared with clinician-administered diagnostic tools.

Pre-disaster psychological distress or other mental health problems could not be measured; therefore, we do not know the extent to which these may have influenced the results.

INTRODUCTION

The Fukushima Daiichi Nuclear Power Plant (FDNPP) accident, which occurred in 2011 after the Great East Japan Earthquake (GEJE) and Tsunami, had a significant impact on the lives of residents. It was already known that long-term mental health consequences continue to be a concern after previous nuclear disasters, such as the Chernobyl accident[1]. Three-year trend surveys revealed that the prevalence of non-specific psychological distress, posttraumatic stress response, and problem drinking were still high 3 years after the accident[2]. However, even as the population prevalence of psychological distress remains high, the trajectories of individuals' psychological distress may vary.

Longitudinal research on trauma substantiates the presence of heterogeneous symptom trajectories over time [3-5]. Recent studies on these trajectories after disasters show that the majority of individuals do not develop psychopathology, whereas a substantial proportion experience psychological distress or develop mental disorders [6-8]. For example, Bonanno (2013) represented six categories of trajectories of stress responses, including minimal-impact resilience, distress-improvement, recovery, delayed symptom elevations, chronic dysfunction, and continued pre-existing distress[9]. Most studies have reported at least three or four trajectories, which include minimal-impact or resistant, resilience or recovery, and chronic dysfunction [5-8 10]. Some studies indicate that the intentional trauma, e.g., terrorism and non-intentional trauma, e.g., motor vehicle accidents follow different trajectories [11 12]; however, another review failed to show associations between PTSD and disaster typology [13]. A longitudinal study was conducted after the nuclear accident at Three Mile Island, following individual trajectories of long-term (10-year) psychiatric distress among 109 mothers of young children, and a sharply bipolar division between chronic high distress and continuous low distress was observed. [14]. Identification of such trajectories would lead to better overall understanding of long-term psychological distress after a nuclear plant accident, which in turn would enable better planning of mental health services for affected residents.

Cross-sectional studies based on the Fukushima Health Management Survey showed that drinking behaviors [15] and perception of radiation risk [16] were major risk factors for psychological distress. The effects of social support or social networks on mental health have already been reported following the 1964 Niigata earthquake [17] and the Great East

Japan Earthquake [18]. It would be worthwhile to investigate whether risk factors associated with psychological distress in previous cross-sectional studies could also be associated with different trajectories of distress over time.

The aim of this study was twofold: to map the trajectories of psychological distress using three-year consecutive data, and to find predictive factors of severe distress that could also be useful for public health intervention. We hypothesized that subjective sleep insufficiency, problem drinking, negative perception of radiation risk, and poor perceived social support are positively associated with distress severity.

METHODS

This study was designed as a cohort study at three time points.

Study population

The study population was 60,432 residents born before April 1, 1998 who were registered in the municipalities categorized as complete evacuation areas during all three fiscal-year (FY) assessments before the FDNPP accident (March 11, 2011). The residents had lived in the town of Naraha, Tomioka, Okuma, Futaba, or Namie, or in the village of Katsurao or Iitate. To avoid the problem of resettlement, we chose the residents in this area from the original sample of the mental health and lifestyle survey in the Fukushima Health Management Survey [19].

A total of three mail-based, self-administered assessments were conducted: the FY 2011 assessment was in January 2012, the FY 2012 assessment was in January 2013, and the FY 2013 assessment was in February 2014 ("FY" notation is omitted hereafter to avoid repetition). These assessments were conducted 10, 22, and 35 months after the disaster. The response rates for each assessment were 47.5% in 2011, 39.1% in 2012, and 33.5% in 2013. In total, 12,371 people completed all three assessments (see supplementary file).

Assessments

The Kessler 6-item scale (K6) [20] in its validated Japanese version [21 22] was used for assessing psychological distress. The K6 consists of six brief questions about depressive and anxiety symptoms during the past 30 days. All items are measured on a 5-point scale, and the assessment can be completed within 2–3 minutes. The total score (ranging between 0 and 24) has been used as an indicator of serious mental illness or mood and

anxiety disorders in the general population. This scale showed adequate internal consistency (α = 0.85) [22].

The CAGE (an acronym for Cutting down, Annoyance, Guilt, and Eye-opener) is a four-item scale designed as a screening instrument for problem drinking [23]. The total CAGE score (0–4) was used as an index of problem drinking. We used 1/2 cut-off according to a review by the National Institute on Alcohol Abuse and Alcoholism [24]. The Japanese version of the CAGE showed adequate internal consistency (α = 0.83) and concurrent validity [25].

To assess perceived social support, we used the abbreviated Lubben Social Network Scale (LSNS-6) [26]. The Japanese version of the LSNS-6 showed adequate internal consistency (α = 0.82), test-retest reliability (r = 0.92) and validity[27]. The LSNS-6 comprises three questions that evaluate kinship ties and a comparable set of three questions that evaluate non-kinship ties. All items are answered on a 5-point Likert-type scale, and the total scale score is an equally weighted sum of the six items (range 0 to 30).

In this study, subjective sleep insufficiency was evaluated by the question, "Is your total sleep time sufficient or not?" The answers (yes or no) were collected. This question did not include any suggested sleep length.

We also solicited sociodemographic characteristics and information on disaster-related variables. The number of relocations after the disaster was asked because several studies have shown higher general psychological distress and perceived stress in people with particular relocation profiles [28 29 30], despite a study that showed protective effects under specific conditions [31].

Analysis Plan

There is growing evidence from longitudinal studies of psychological symptoms following disasters [4], especially using semi-parametric group-based modeling [5 32] or latent growth mixture modeling [33 34] with multiple assessments. This type of modeling is suitable for finding heterogeneity in the longitudinal patterns [32]. Although grouping methods using cut-off scores are also used for longitudinal studies after natural disasters [35-37], this method has disadvantages: categorizing a continuous variable diminishes statistical power, and it is also difficult to find heterogeneity above / below cut-off scores. We thus conducted semi-parametric group-based modeling for this study.

All analyses were performed using SAS software, version 9.4 (SAS, Cary, NC, USA). Group-based trajectory modeling using SAS software with user-written procedure PROC TRAJ [38 39] was used to identify trajectories of psychological distress. The Bayesian Information Criterion (BIC) and Akaike's Information Criterion (AIC) were used to select the best-fitting model. For criteria of trajectory membership, we chose 5% membership, because our aim in this study was to understand the whole picture of the trajectories.

There was a large number of missing data points for the CAGE assessment (the number missing in the original responses was n=6609, or 53.4% of the sample). This is partially due to inclusion of respondents 15–19 years old, who are prohibited from drinking alcohol in Japan, and people who do not habitually use alcohol. We decided to perform a data correction, giving a null point for missing data. For other variables, we did not perform data corrections.

RESULTS

Sociodemographic characteristics and disaster-related variables

Sociodemographic characteristics and disaster-related variables are shown in Table 1. About 40% of the study sample was at least 65 years old at the time of the disaster. More than 80% of the respondents reported that their homes were damaged to varying degrees. A total of 45.4% of the respondents had a frequent (5 or more) relocation profile, while 21.4% of the respondents experienced bereavement of a family member or loved one.

Table 1 Sociodemographic characteristics and disaster-related variables of the study sample: evacuees after the March 2011 nuclear disaster in Japan

		Study sample (n=12,371)
		n
Gender:	Male	5,290
	Female	7,081
Age in 2011 (yrs)	15–24	445
	25–34	1,011
	35–44	1,347
	45–54	1,643
	55–64	3,171
	65–74	2,719
	75–84	1,717
	≥85	318
Residence registration at time of disaster:	Naraha	1,220
	Tomioka	2,451
	Okuma	2,041
	Futaba	1,270
	Namie	4,232
	Katsurao	280
	Iitate	877
Education:	Elementary or junior high school	2,827
	Senior high school	6,024
	Junior college or professional school	1,984
	University or graduate school	1,092
	No answer	444
Disaster-related variables		
Disaster-related home damage	Yes	9,053
	No	1,948
	No answer	1,370

Disaster-related bereavement	Yes	2,572
	No	9,443
	No answer	356
Five or more relocations after the disaster, in 2012	Yes	5,477
	No	6,584
	No answer	310

The number of relocations was asked not in 2011, but in 2012.

Trajectories of psychological distress

The mean scores on the K6 sample-wide were 7.10 (SD 5.92) in 2011, 6.50 (SD 5.68) in 2012, and 5.97 (SD 5.44) in 2013. Comparing goodness-of-fit for models with different numbers of trajectories of psychological distress over time, a four-trajectory model was found to have the best fit (AIC, -93358.38; BIC, -93402.84). The four trajectories using K6 scores are shown in Figure 1. The trajectories are distinguished by the average levels of psychological distress during the follow-up (i.e., resistant, mild, moderate, and severe), and all groups showing parallel trends of gradually improving psychological distress. About half of the sample (n=6170) was categorized into the mild distress group, whose average scores were 5.5 in 2011 and 4.5 in 2013. More than one-quarter of respondents (n=3313) belonged to the moderate distress group, with average scores of 11.9 in 2011 and 9.9 in 2013. Approximately 20% of the sample (n=2244) was categorized into the resistant group, whose average scores were 1.2 in 2011 and 0.80 in 2013, while 5.7% of the sample (n=644) showed severe distress, with consistently high average scores of 18.9 in 2011 and 17.9 in 2013.

Problem drinking and social support among the groups

Mean CAGE and LSNS-6 scores for each group are shown in Figure 2. One-way ANOVA revealed a main effect for the CAGE, $F(3, 12367) = 29.87$, $p < 0.001$, and for the LSNS-6, $F(3, 11661) = 131.22$, $p < 0.001$. Post hoc tests with Bonferroni correction demonstrated significant differences in CAGE and LSNS-6 scores among the four groups, except for the CAGE score between the moderate and severe distress groups ($p = 1.0$).

Perception of radiation risks

The risk perception profile for radiation in each group is shown in Table 2. Chi-square tests revealed significant group differences in delayed effects (χ^2=871.0, df = 9, $p < 0.001$), and in genetic effects ($\chi^2 = 991.7$, df = 9, $p < 0.001$). The most frequent response in the resistant group was "Very unlikely," whereas approximately half of the respondents in the severe distress group answered "Very likely" regarding their assessment of delayed effects and genetic effects.

Table 2 Perception of risk of delayed and genetic effects of radiation in 2013, by group

Delayed effects

Group	Very unlikely N (%)	Unlikely N (%)	Likely N (%)	Very likely N (%)	Data missing N(%)	Total N (%)
Resistant	879 (39.9%)	669 (29.8%)	347 (15.5%)	233 (10.4%)	116 (5.2%)	2,244(100%)
Mild distress	1,611 (26.1%)	1,970 (31.9%)	1244 (20.2%)	939 (15.2%)	406 (6.6%)	6,170 (100%)
Moderate distress	548 (16.5%)	879 (26.5%)	856 (25.8%)	821 (24.8%)	209 (6,3%)	3,313 (100%)
Severe distress	67 (10.4%)	94 (14.6%)	146 (22.7%)	273 (42.4%)	64 (9.9%)	644 (100%)

Genetic effects

Group	Very unlikely	Unlikely	Likely	Very likely	Data missing	Total
Resistant	725 (32.3%)	676 (30.1%)	423 (18.9%)	275 (12.3%)	145 (6.5%)	2,244 (100%)
Mild distress	1,219 (19.8%)	1,826 (29.6%)	1547 (25.1%)	1,114 (18.1%)	464 (7.5%)	6,170 (100%)
Moderate distress	384 (11.6%)	744 (22.5%)	970 (29.3%)	968 (29.2%)	247 (7.5%)	3,313 (100%)
Severe distress	54 (8.4%)	72 (11.2%)	121 (18.8%)	326 (50.6%)	71 (11.0%)	644 (100%)

Subjective sleep insufficiency

The overall proportion of subjective sleep insufficiency was 35.8% (N = 4424; including missing data N = 921). The proportions of subjective sleep insufficiency were 16.7% (N = 374) in the resistant group, 32.7% (N = 2018) in the mild distress group, 48.8% (N = 1616) in the moderate distress group, and 64.6% (N = 416) in the severe distress group. Chi-square tests revealed that these group differences were significant ($\chi^2 = 972.0$, df = 3, $p < 0.001$).

Factors related with the severe distress trajectory

In order to explore the factors related to the severe distress group, we conducted logistic regression analysis using a forced entry method. Variables considered in the model were CAGE in 2013 (score ≥ 2 as problem drinking), LSNS-6 score in 2013 (score ≤ 12 as poor perceived social support), and risk perception in 2013: genetic effects ("Very likely" as high perceived risk), adjusting for gender and age as potential confounders in model 1 (Table 3). All variables showed significant effects and odds ratios. The results remained significant after adjusting for disaster-related variables (home damage, bereavement, relocations) as additional potential confounders in model 2 (Table 3).

Table 3 Multivariate logistic regression analysis of the severe distress group

Predictor	Model 1 Sociodemographic factors and health-related variables	Model 2 Model 1 + disaster-related variables
	OR (95% CI)	OR (95% CI)
Gender (female)	1.38 (1.14–1.68)**	1.51 (1.21–1.89)**
Age (65y or more) at the disaster	1.73 (1.43–2.10)**	1.82 (1.46–2.26)**
Problem drinking (CAGE 2 or more) in 2013	1.62 (1.19–2.20)**	1.77 (1.26–2.49)**
Subjective sleep insufficiency in 2013	4.01 (3.26–4.94)**	3.86 (3.07–4.86)**
Poor perceived social support (LSNS-6 12 or less) in 2013	2.31 (1.88–2.83)**	2.39 (1.90–2.99)**
Perception of radiation risk (genetic effects: very likely) in 2013	3.76 (3.12–4.53)**	3.91 (3.17–4.83)**
Disaster-related home damage		0.90 (0.68–1.20)
Disaster-related bereavement		1.16 (0.91–1.47)
Relocation 5 times or more after the disaster (in 2012)		1.26 (1.02–1.55)*

CI = confidence interval; OR = odds ratio

*p < 0.05, **p < 0.01

DISCUSSION

Using group-based trajectory modeling, we identified four trajectories of psychological distress over time during the three year follow-up, which represented different average levels of psychological distress, and which all showed gradual improvement. The declining pattern of psychological distress in the long-term was in line with studies after the Three Mile Island [40 41] and the Chernobyl [42] accidents. However, the trajectories in this study were approximately parallel, and we could not find heterogeneous patterns of trajectories (e.g., recovery or worsening) across the 3 years, in contrast with Bonnano's model [9]. This might be because of the timing of the surveys. The first survey in 2011 was conducted almost one year after the disaster, which means that we were not able to differentiate any acute or sub-acute-phase impact soon after the disaster from the consistent symptom resistance. In a study on depressive trajectories after the September 11, 2001 attacks, drastic changes were observed only between 8 (first assessment) and 14 (second assessment) months after the events and there were only gradual changes at follow-up at 26 and 42 months [32]. In contrast, a study conducted 6 years after the 2004 Indian Ocean tsunami identified four distinct trajectories compared with an indirect exposure group; the observed trajectories included a recovery group characterized by a gradual decrease in posttraumatic symptoms between 1 year and 6 years after the disaster [10].

Our study demonstrated that the number in the mild distress group (47.6%) that scored around 5 points of K6 was larger than in the resistant group (19.3%). It has been reported that the optimal cut-off points were estimated as 4/5 for the Japanese version of the K6 for screening in a general population, and the prevalence of screened cases in the community sample was 31.3% [22]. Sone et al. (2016) [36] reported that the change in prevalence of psychological distress after changing the cut-off point (K6 score ≥5) was 50.6% (2011) and 38.6% (2014) in a tsunami-affected area after the GEJE. Another study by Yokoyama et al. (2014) [43] in Iwate Prefecture showed that a total of 42.6% of the respondents 6–11 months after the GEJE had moderate (5–12 of K6) or serious (13+ of K6) distress. Compared with these results, our results suggest that residents in the evacuation area in Fukushima Prefecture had persistent psychological distress after the nuclear accident.

Support was found for the hypothesis that subjective sleep insufficiency, problem drinking, poor social support, perception of radiation risk 3 years after the accident, and frequent relocations after the disaster were associated with psychological distress

trajectories. Among these, perception of radiation risk was a factor unique to nuclear disasters. Our result that those who believed that radiation exposure was very likely to cause delayed and genetic health effects were significantly more likely to be categorized into the severe distress group, is in line with other cross-sectional studies [16 44]. Suzuki et al. (2015) [16] showed that radiation risks were associated with psychological distress 2 years after the FDNPP accident. Another cross-sectional study conducted with a relatively small sample (n = 285) in 2014 in Kawauchi village, which is located within 30 km of FDNPP, revealed that about half of the residents had anxieties about the health effects of radiation on children, and about the health effects of radiation on offspring [44]. These results suggest the importance of risk communication as a strategy for preventing severe mental disorders and their consequences, such as depression and committing suicide, which are recognized as major public concerns in Fukushima [45].

In comparison with other studies after the GEJE, the relationship between poor social support (or social isolation) and psychological distress in Miyagi Prefecture has been reported [18 36]. A longitudinal study with two time points (2011 and 2014) using LSNS-6 and K6 [36] showed that being free from social isolation was associated with improvement of psychological distress. Another research group demonstrated that individual and community-level social support were significantly associated with low psychological distress [18]. Separated families and communities in Fukushima have produced one of the main psychosocial consequences of the Fukushima disaster [46], and post-disaster housing instability may affect both physical and mental health [28]. A relationship between prolonged sleep difficulties and lack of social support after the GEJE has also been reported [47].

Our results may be useful for facilitating a community-based mental health care network in Fukushima. For example, the Fukushima Center for Disaster Mental Health, which has been providing outreach service and psychoeducational programs for the evacuees, residents, and various stakeholders based on the transdisciplinary model, is expected to promote long-term support [46]. It seems easier for the health providers to ask lifestyle habits than to ask psychological symptoms directly. Our results contribute to the better design of interventions on mental health.

The present study has a number of strengths, including the use of questionnaires that have been validated in Japanese and a large number of respondents, even as the response rate declines over time. Before the FDNPP accident, there was no

well-designed, multiple-assessment study during the initial 3 years after a nuclear accident: in the case of the Chernobyl disaster, no well-designed studies were conducted during the initial 5-year aftermath [1]; and in the wake of the Three Mile Island disaster, large-scale (e.g., n > 1,000) longitudinal studies on mental health were lacking [14].

Several limitations should be considered in this study. First, the use of self-rating questionnaires for the assessments provides less accuracy compared with the use of clinician-administered diagnostic tools. Second, we could not measure pre-disaster psychological distress or other mental health problems. Continued pre-existing distress might by misunderstood as disaster-related distress. However, it is understandable in community-based care that pre-, peri-, and post-disaster issues coexist both at the personal and community levels. Moreover, as already mentioned, we could not measure acute and sub-acute phases of posttraumatic distress (i.e., < 1 year post-disaster). Third, because of the relative low response rates, one should not overgeneralize the results.

Despite these limitations, this study demonstrated that poor perceived social support, problem drinking, subjective sleep insufficiency, perception of radiation risk and frequent relocations after the disaster were related to long-lasting psychological distress after the FDNPP accident. Assessing these factors might be effective for community-based mental health care after nuclear disasters in the long-term. Future research including the continuance of the mental health and lifestyle survey as a part of the Fukushima Health Management Survey is strongly needed to examine longitudinal trajectories and determine both the risk and resilience factors of survivors that will inform interventions and public policies.

Disclaimer

The findings and conclusions of this article are solely the responsibility of the authors and do not represent the official views of the government of Fukushima Prefecture.

Acknowledgements

We would like to thank all the members of the Fukushima Health Management Survey, especially the mental health group members, for data collection and suggestions. We also thank Prof. Norito Kawakami, Department of Mental Health, School of Public Health, the University of Tokyo, for critical manuscript reading.

Contributors

MM and MO conceived the original idea for the study. MO performed the analyses of the data and drafted the manuscript. TO and MN contributed to the statistical analyses and the interpretation of the data. HY, YS, MH, and MA contributed with critical comments. All of the authors approved the final version.

Competing interests

Dr. Oe reports personal fees from Meiji Seika Pharma Co., Ltd., personal fees from Sumitomo Dainippon Pharma Co., Ltd., personal fees from Otsuka Pharmaceutical Co., Ltd., personal fees from GlaxoSmithKline K.K., personal fees from Janssen Pharmaceutical K.K. , personal fees from Mitsubishi Tanabe Pharma Corporation, outside the submitted work; . Other authors have nothing to disclose.

Funding

This study was supported by the national "Health Fund for Children and Adults Affected by the Nuclear Incident."

Ethical approval

This study was approved by the Ethics Review Committee of Fukushima Medical University (No. 1316) and the Ethical Committee of Kurume University (No. 14234).

Data sharing statement: No additional data available.

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Figure legends

Figure 1 Trajectories of the four-group model of psychological distress

Figure 2 Mean CAGE scores (upper) and LSNS-6 scores (lower) by group.

* $p < 0.05$

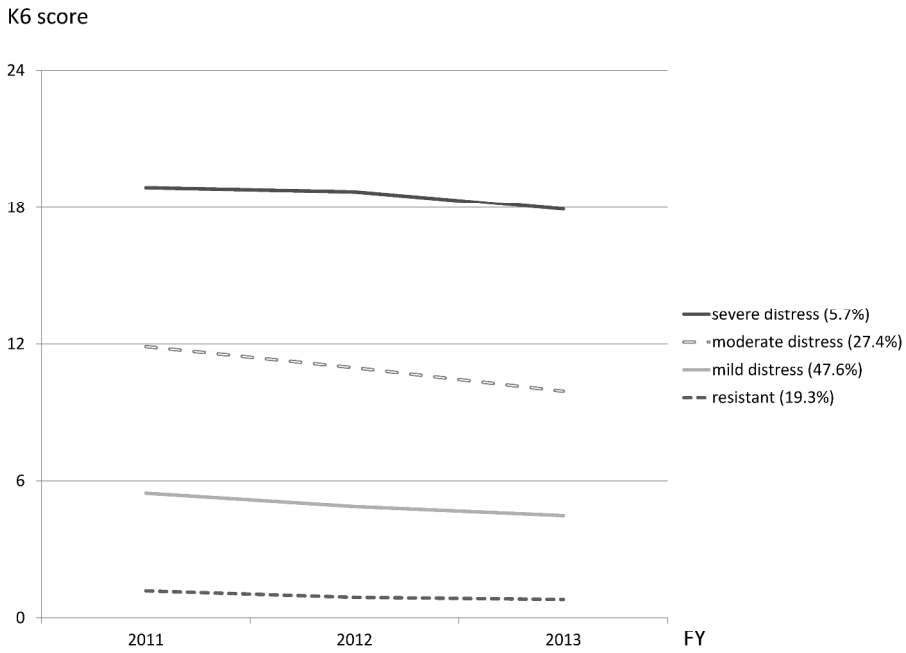

Figure 1 Trajectories of the four-group model of psychological distress

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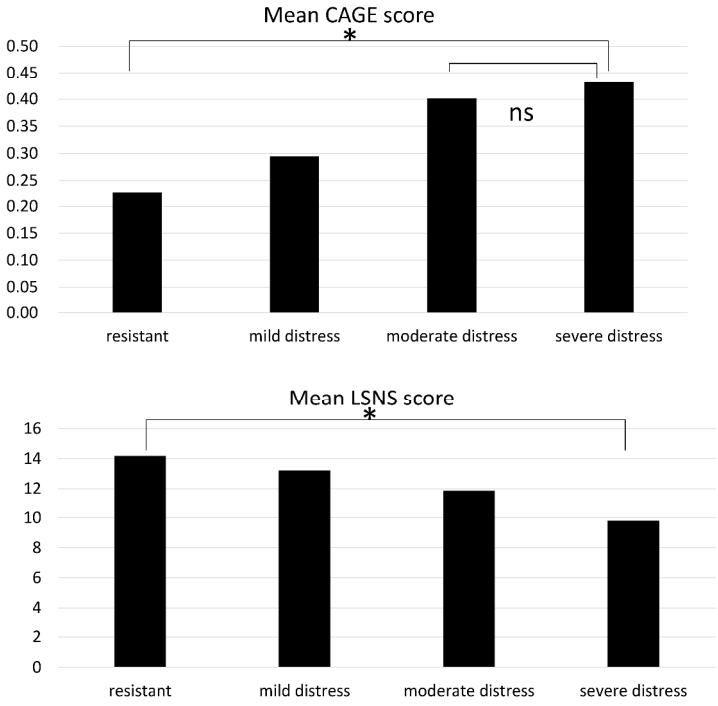

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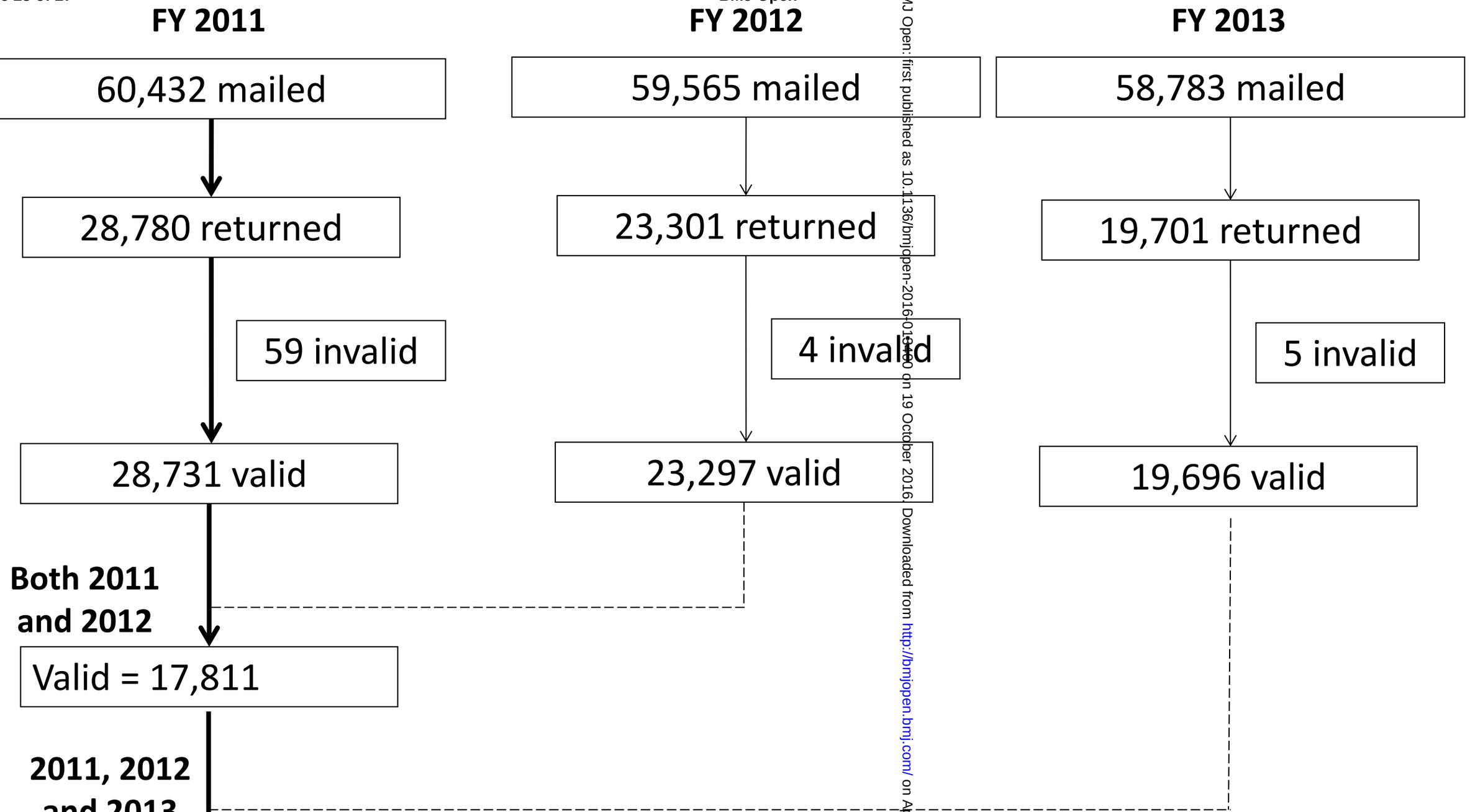

Supplementary File 1 Study Samples

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page Number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Abstract (p.2)
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract (p.2)
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Introduction (p.3, first and second paragraph)
Objectives	3	State specific objectives, including any prespecified hypotheses	Introduction (Forth paragraph, p4)
Methods			
Study design	4	Present key elements of study design early in the paper	Methods (p.4, first sentence)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Methods (p.4, "study population" section)
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	(a) Cohort study Methods (p.4, "Study population" section)
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	(b) N/A, because this study is not a matched study.
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Methods (p.4-5, "Assessments" section)
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Methods (p.4-5, "Assessments" section)
Bias	9	Describe any efforts to address potential sources of bias	Information bias was addressed in Methods, "Analysis plan" section, third paragraph (about missing data of CAGE).
Study size	10	Explain how the study size was arrived at	Study size was not calculated in advance,

			because our study population was all the residents who had responded all three assessments.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	N/A, our data does not have quantitative variables.
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Methods, (p.5-6, "Analysis plan" section)
		(*b*) Describe any methods used to examine subgroups and interactions	Methods, (p.5-6, "Analysis plan" section)
		(*c*) Explain how missing data were addressed	Methods, (p.5-6, "Analysis plan" section, third paragraph (about missing data of CAGE)
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	Cohort study , see Supplementary file (p.4)
		(*e*) Describe any sensitivity analyses	From our point of view, no sensitivity analyses were required.

Continued on next page

Results			**Page Number**
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	See Supplementary file (p.4)
		(b) Give reasons for non-participation at each stage	See Supplementary file (p.4)
		(c) Consider use of a flow diagram	See Supplementary file (p.4)
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Results (p.6, "Sociodemographic characteristics and disaster-related variables" section)
		(b) Indicate number of participants with missing data for each variable of interest	Results section. e.g. Table 2
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	Methods (p.4, "Study population" section)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	Results (p.6-12)
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	N/A
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Results (p.11, "Factors related with the severe distress trajectory" section)
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	Results, from the first paragraph to the third paragraph (p.13-14). Each first sentences show key results.
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Results, in the seventh paragraph (p.15)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Interpretations were addressed in the Discussion by themes.
Generalisability	21	Discuss the generalisability (external validity) of the study results	Generalisability was addressed in the limitation

			section (the seventh paragraph, p.15).
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	p.16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.