Unreliable Information as a Risk Factor for Worse Mental Fatigue among Residents in Fukushima after the Nuclear Power Station Accident

Yui Yumiya,[1] Michio Murakami,[2] Yoshitake Takebayashi,[2] Satoshi Suzuki[3] and Tetsuya Ohira[1]

[1]Department of Epidemiology, Fukushima Medical University School of Medicine, Fukushima, Fukushima, Japan
[2]Department of Health Risk Communication, Fukushima Medical University School of Medicine, Fukushima, Fukushima, Japan
[3]Fukushima Prefectural Centre for Environmental Creation, Tamura, Fukushima, Japan

After the Fukushima nuclear accident in 2011, there was confusion among the public caused by uncoordinated information about radiation provided by diverse channels. We explored the association between information sources regarding reconstruction progress after the disaster and mental fatigue in Fukushima. We used data from the annual public opinion survey by the Fukushima Prefectural Government on its policies from 2013 to 2015, which contained survey responses from 1,300 community residents randomly selected from the 28 municipalities in the Fukushima Prefecture. The survey contained a question assessing mental fatigue: "How often do you usually feel mentally tired or depressed?" In total, 2,130 participants (758 participants in 2013, 699 participants in 2014, and 673 participants in 2015) were analyzed. The respondents were classified as two categories, "high mental fatigue" and "low mental fatigue," based on their responses to this question. Overall, the proportion of participants with high mental fatigue was 13.2%. There was no association between the year of survey or occupation and high mental fatigue. Cluster analysis was performed to classify information sources. Then, we conducted a cross-sectional analysis of the associations between clusters of information sources and high mental fatigue. We found that unreliable information sources, such as "Internet" and "a combination of TV, radio, and word of mouth," were significantly associated with high mental fatigue, compared with reliable information sources, such as "municipal public relations in addition to major media (newspaper, TV, and radio)." These findings provide important insights into how information sources affect mental fatigue following a disaster.

Introduction

Great East Japan Earthquake occurred in Fukushima on March 11, 2011, and the subsequent Fukushima Daiichi Nuclear Power Station accident led to the necessary evacuation of the local residents residing near the power station, drastically changing their lives. A number of these displaced residents suffered from mental health issues (Oe et al. 2016a). According to the Fukushima Health Management Survey, the perception of radiation risk was associated with psychological distress after the Fukushima Daiichi Nuclear Power Station accident (Suzuki et al. 2015; Oe et al. 2016b). Likewise, this finding was consistent with a previous study indicating that mental health issues after the Chernobyl nuclear disaster were related to risk perception (Bromet and Havenaar 2007). Risk perception and anxiety have been associated with various factors, including trusted information and demographics, such as women, older age, and occupation (Takebayashi et al. 2017).

Several scales were employed to measure mental health, including the Kessler Psychological Distress Scale (K6), which is a nationally and internationally validated brief six-item mental health screening tool (Kessler et al. 2003), previously used in a variety of settings. Also, Fatigue Visual Analog Scales have frequently been used in clinical practice to evaluate fatigue severity and have been validated (Hewlett et al. 2011).

Our modern information-rich society enables people to gain access to various sources of information *via* mass media (e.g., TV, radio, brochures, and the Internet) and interpersonal means (e.g., family or friends) (Muusses et al. 2012). The use of different information sources is directly

associated with perceived reliability (Muusses et al. 2012). Furthermore, sociodemographic, psychological, and medical information needs affect people's use of different information sources (Muusses et al. 2012). However, such information souces include not only authoritative or highly trusted media sources but also inaccurate and unreliable messages, thus leading to misconceptions and unhealthy consequences (Maeda et al. 2015). In particular, several large-scale human-made and natural disasters have been widely covered by uncoordinated objective and subjective messages through various channels (Barnes et al. 2008). One study demonstrated a significant association between viewing disaster-related TV and psychological outcomes (Nishi et al. 2012).

The extensive and complicated accident in Fukushima resulted in significant media coverage from a wide range of contemporary media sources, causing local residents to become distressed and confused (Sugimoto et al. 2013). In particular, the mass media reported on factors such as radiation risk based on poor scientific evidence and alarmism, which led to public anxiety (Sugimoto et al. 2013). Furthermore, such reports, including objective and subjective uncoordinated messages, reduced the trust in the authorities (Prezelj et al. 2016). Consequently, local medical and public health professionals were faced with difficulties in delivering information, especially regarding radiation risk (Goto et al. 2014; Kayama et al. 2014). Yet, it remains to be investigated the relationship between the use of different information sources and psychological outcomes after such a large-scale catastrophe. An in-depth understanding of these relationships would be useful to better develop strategies to mitigate mental distress as part of the global emergency preparedness and disaster response.

Here, we hypothesize that the use of different information sources would affect mental fatigue and explored the associations between the use of different information sources and mental fatigue after the nuclear power station accident in Fukushima. The data were extracted from the annual public opinion survey from 2013 to 2015 on prefectural policies conducted by the Fukushima Prefecture Government Public Consultation Unit. We have thus identified the information sources associated with high levels of mental fatigue.

Materials and Methods

Study design and participants

We obtained permission from the Fukushima Prefectural Government to use data from the annual public opinion survey on prefectural policies conducted by the Fukushima Prefecture Government Public Consultation Unit to support policy formation. We used survey data from 2013 to 2015 for the current study. Details of the annual public opinion survey have been described elsewhere (Hasegawa et al. 2018; Suzuki et al. 2018). In brief, self-administered questionnaires were sent to 1,300 community residents randomly selected from the 28 municipalities of Fukushima Prefecture each year, using a two-stage stratified random sampling method (Fig. 1).

In the first stage of sampling, stratification was done on the population size of municipalities. The municipalities in Fukushima Prefecture were divided into three different strata: cities with more than 100,000 population, cities with less than 100,000 population, and counties (towns and villages). Based on the demographic data of each municipality shown in the national census survey, survey areas were made in each stratum at equal intervals. In the second stage, appropriate survey participants were selected from the basic resident registers of the selected survey areas. The number of participants differed over the years of the survey. There were 803 participants (response rate = 61.8%) in 2013, 741 (57.0%) in 2014, and 713 (54.8%) in 2015. As a result, our initial dataset included 2,257 participants across 2013, 2014, and 2015. In this study, we only analyzed respondents aged 20 years or older (n = 2,142). Furthermore, we excluded 12 participants who did not provide information regarding progress of reconstruction after the disaster. In total, 2,130 participants (758 participants in 2013, 699 participants in 2014, and 673 participants in 2015) were retained and analyzed (Table 1). The ratio of males/females for participants was 0.79 in 2013, 0.67 in 2014, and 0.74 in 2015.

This was a cross-sectional study design. The Fukushima Medical University Ethics Committee (No. 28) approved this study and gave us permission to use their data.

Questionnaire items

Previous research has clarified factors relating to poor mental health, including female sex, low socioeconomic status, poor social support, experience of severe disaster damage, and closeness to the disaster site (Galea et al. 2007). We therefore collected data on mental fatigue and its causes, information sources regarding the progress of reconstruction after the disaster, and characteristics of respondents, including age, sex, regional area, occupation, and mental health support.

We assessed our main outcome variable, mental fatigue, by asking participants the following question: How often do you usually feel mentally tired or depressed? Mental fatigue was defined according to frequency ("often," "sometimes," "slightly," "none," and "do not know"). Those who responded "often" were categorized as having "high mental fatigue," whereas other responses, except for six people who answered "do not know," were categorized as "low mental fatigue." A previous review revealed that a single-item measure of self-rated mental health is consistently associated with multi-item measures of mental health, including the K6 scale (Ahmad et al. 2014). However, we did not confirm the reliability and validity of the present questionnaire. The causes of mental fatigue were given in multiple choice format, and options were classified into eight categories: "health," "economic status," "job," "unemployed," "school" (education or future path after graduation), "life in the future," "human relationships," and "others."

Information regarding the progress of reconstruction from the disaster came from ten sources: newspaper; TV and/or radio; Internet except administrative websites; Internet including administrative websites, Facebook, or Twitter; prefecture public relations; municipal public relations; national public relations; printed papers except administration papers; word of mouth; and others.

Regional areas were classified into four groups: the mountainous area [Aizu]; central area [Nakadori]; coastal area [Hamadori] other than Evacuation Order Areas (EOAs); and EOAs. The "living region" for evacuees referred to the areas where the evacuees lived
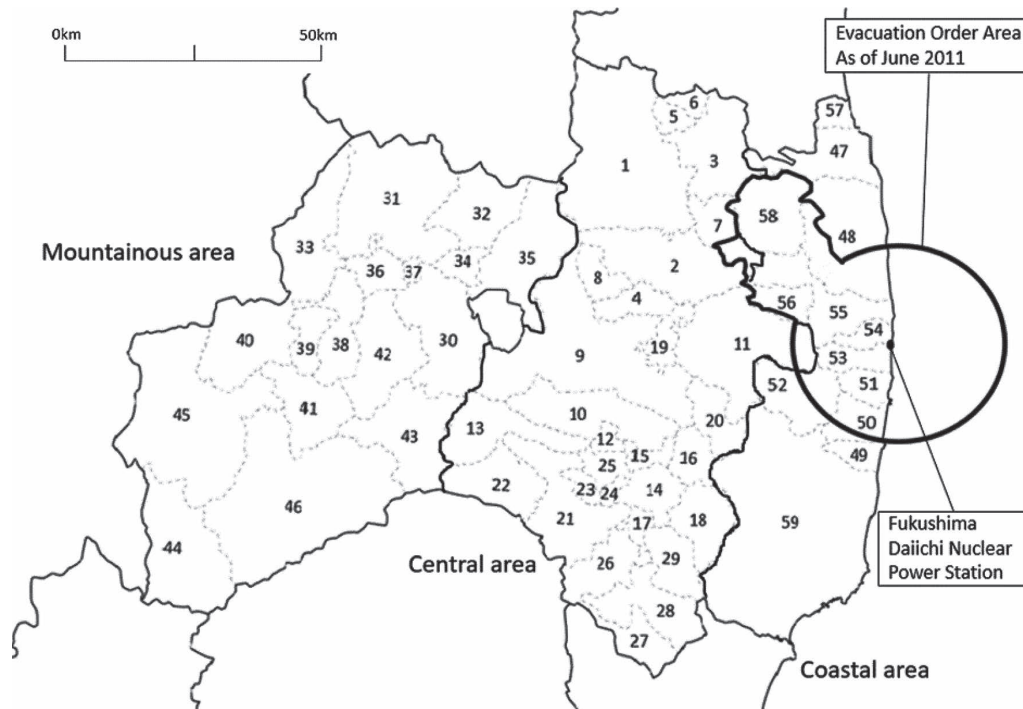
Fig. 1. Map of municipalities in Fukushima Prefecture.
Central area: 1. Fukushima City, 2. Nihonmatsu City, 3. Date city, 4. Motomiya City, 5. Ko-ori Town, 6. Kunimi Town, 7. Kawamata Town, 8. Otama Village, 9. Koriyama City, 10. Sukagawa City, 11. Tamura City, 12. Kagamiishi Town, 13. Tenei Village, 14. Ishikawa Town, 15. Tamakawa Village, 16. Hirata Village, 17. Asakawa Town, 18. Furudono Town, 19. Miharu Town, 20. Ono Town, 21. Shirakawa City, 22. Nishigou Village, 23. Izumizaki Village, 24. Nakajima Village, 25. Yabuki Town, 26. Tanagura Town, 27. Yamatsuri Town, 28. Hanawa Town, 29. Samegawa Village.
Mountainous area: 30. Aizuwakamatsu City, 31. Kitakata City, 32. Kitashiobara Village, 33. Nishiaizu Town, 34. Bandai Town, 35. Inawashiro Town, 36. Aizubange Town, 37. Yugawa Village, 38. Yanaizu Town, 39. Mishima Town, 40. Kaneyama Town, 41. Showa Village, 42. Aizumisato Town, 43. Shimogo Town, 44. Hinoemata Village, 45. Tadami Town, 46. Minami-aizu Town.
Coastal area excluding evacuation order areas (EOAs): 47. Soma City, 57. Shinchi Town, 59. Iwaki City.
EOAs: 48. Minamisoma City, 49. Hirono Town, 50. Naraha Town, 51. Tomioka Town, 52. Kawauchi Village, 53. Okuma Town, 54. Futaba Town, 55. Namie Town, 56. Katsurao Village, 58. Iitate Village.
Survey area for each year:
2013: 1-5, 7, 9-12, 18, 20-21, 23, 26-27, 30-31, 33, 38, 42, 46-49, 51-52, 59.
2014: 1-4, 6, 8-11, 14, 18, 20-22, 24, 26, 30-31, 35, 37, 42, 46-49, 52, 55, 59.
2015: 1-5, 7, 9-12, 15, 19, 21-22, 25-26, 30-31, 34, 36, 42, 46-48, 51, 54, 57, 59.

prior to the nuclear power station accident.

Eleven options were provided for occupation and recategorized. Those who answered "managerial," "office worker," and "other professionals" were categorized as "office workers etc.," and those who answered "agriculture, forestry, and fisheries workers," "chamber of commerce and industry service self-employed workers," and "freelance professions" were categorized as "self-employed." Those who answered "part-time workers," "housewives/husbands," "students," and "others" were categorized as "others." Those who answered "unemployed" were categorized as "unemployed."

A questionnaire item about support for mental health was also asked: "Who do you consult with if you have concerns about mental health (family or relatives/friends/co-workers/supervisors/teachers or school counselors/community experts/professionals/others/no one/do not know)?" Those who had someone to consult about mental health problems were categorized as "presence of mental support," whereas those who did not have were categorized as having an "absence of mental support."

Statistical analysis

We began with hierarchical cluster analysis, utilizing Ward's method to create clusters regarding the use of different information sources. We defined the use of individual information sources as "1" and no use as "0." Variables were not normalized for analysis. The demarcation of the clusters formed by Ward's method was judged by the researchers based on their understanding of the context.

Chi-square tests were used to determine the differences in sociodemographic characteristics, including age, sex, regional area, and occupation among clusters. Chi-square tests were also performed to investigate differences in the proportion of responses regarding information source usage between participants with high mental fatigue ("high") and participants with low mental fatigue ("low"). Based on the association of factors, the potential variables were cross tabulated with the two levels of mental fatigue. These associations were also assessed by the Chi-square tests in univariate analysis.

We further employed a hierarchical binary logistic regression analysis, including four models, to examine the bivariate associations between information sources regarding reconstruction progress after

Table 1. Basic individual attributes of respondents.

| Items | Year [n] | | | |
	2013 [758]	2014 [699]	2015 [673]	Total [2,130]
Sex				
Female	420	417	384	1,221
Male	331	279	286	896
No response and others	7	3	3	13
Age				
20s	48	46	39	133
30s	84	85	74	243
40s	102	89	93	284
50s	128	125	112	365
60s or older	396	354	355	1,105
Regional area				
Mountainous area	111	104	93	308
Central area	433	382	383	1,198
Coastal area other than EOAs	139	137	131	407
EOAs	38	43	32	113
No response and others	37	33	34	104
Occupation				
Self-employed	119	103	105	327
Office workers etc	208	175	155	538
Others	226	241	246	713
Unemployed	197	173	164	534
No response	8	7	3	18
Mental support				
Presence of mental support	625	578	548	1,751
Absence of mental support	88	80	93	261
No response and others (do not know)	45	41	32	118
Mental fatigue*				
High	109	85	80	274
Low	625	602	581	1,808
No response and others (do not know)	24	12	12	48

EOAs, evacuation order areas.

*Mental fatigue is divided into two categories according to the responses to the following question: "How often do you usually feel mentally tired or depressed? "

The response of "often" is categorized as "High".

The responses of "sometimes," "slightly," and "none" are categorized as "Low".

the disaster and high mental fatigue. In Model 1, clusters of information sources were determined as explanatory variables. Survey years were added to Model 2. In Model 3, we sequentially introduced individual attributes (age, sex, regional area, and occupation), and in Model 4, we further added mental support, as these factors are previously known to be associated with mental health issues (Suzuki et al. 2015; Oe et al. 2016a). Dummy variables were created for year, sex, age, regional area, occupation, mental support, and clusters of information sources. In the survey year of 2013, female participants, age of 60 years or older, habitation in a mountainous area (the less-affected area), "office workers etc." employment, and the presence of mental support were used as references. For information sources, Cluster 3 was selected as the reference, as it showed the lowest proportion of respondents with high mental fatigue between 2013 and

2015 (Fig. 2). Adjusted odds ratios (aORs) from the logistic regression models and their 95% confidence intervals (95% CIs) were used to depict relationships between the explanatory variables and high mental fatigue.

Then, subgroup analysis by sex and age was performed, as previous studies have reported that sex and age are related to mental health (Galea et al. 2007; Takebayashi et al. 2017). Age was grouped into 20-year brackets and used to avoid overfitting in the subgroup analysis. Only clusters of information sources were also used as explanatory variables to avoid overfitting. The validity of the absence of covariates was confirmed by comparing the little differences in aORs for clusters of information sources between Model 1 and the other models. All analyses allowed more than ten events of the outcome measure per variable. Furthermore, Chi-square tests and resid-

Cluster 1 includes major media (newspaper, TV and radio) and multiple public relations sources (national, prefecture, and municipal).

Cluster 2 includes various information sources such as the Internet, and lower use of TV and radio.

Cluster 3 comprises municipal public relations sources in addition to major media (newspaper, TV, and radio).

Cluster 4 includes TV, radio and word of mouth, and lower use of newspapers and public relations.

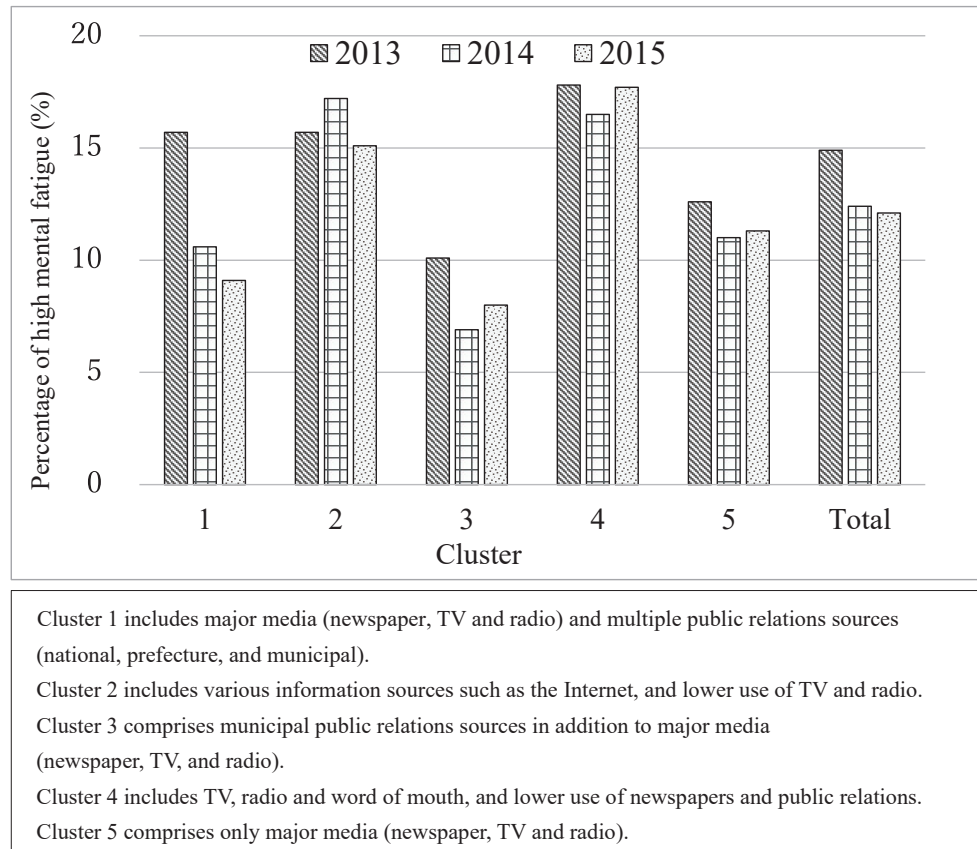Cluster 5 comprises only major media (newspaper, TV and radio).

Fig. 2. High mental fatigue of each cluster by yearly trend.
  The annual change in the percentage of people who had high mental fatigue (high mental fatigue was defined as a response of "often" to the following question: "How often do you usually feel mentally tired or depressed?") among five clusters (respondents were divided into five clusters by use of information sources regarding progress of reconstruction after the disaster).

ual analyses were used to examine differences in the cause of mental fatigue among participants in the high mental fatigue group.

  Multicollinearity was assessed by using the variance inflation factor (VIF). The impact of multicollinearity was small, because the VIF for the explanatory variables in all models was less than 3.0. Missing data were not included in each analysis. All analyses were conducted using IBM SPSS Statistics 24. For all analyses, a p-value of 0.05 was used to determine statistical significance.

Results

Cluster of information sources

  We determined five clusters based on the researcher's understanding of the context. Fewer than five clusters grouped together too many information sources into each cluster, and more than five clusters created unwieldy outcomes with less than 200 participants in some clusters. Table 2 summarizes the information sources for each cluster. Cluster 1 (599 participants) included major media, such as newspapers, TV, and radio, and multiple public relations sources (national, prefecture, and municipal); Cluster 2 (366 participants) included various information sources such as the Internet, and lower use of TV and radio; Cluster 3 (237 participants) was comprised of municipal public relations

sources in addition to major media (newspapers, TV, and radio); Cluster 4 (399 participants) included higher use of the combination of TV, radio, and word of mouth and lower use of newspapers and public relations; and Cluster 5 (529 participants) included only major media.

  Since personal factors, such as sociodemographic characteristics, including age, sex, regional area, and occupation, may also have affected the seeking of information, sociodemographic characteristics were compared among the five clusters (Table 3). Significant differences in age, sex, regional area, occupation, and presence of mental support were observed among clusters. More than 65% of participants in Cluster 1 were aged 60 years or older, the highest proportion among all clusters. On the other hand, Clusters 2 and 4 were comprised of more diverse age groups. More than 60% of those in each cluster were female, except for Clusters 2 and 5. Cluster 5 had the highest proportion of residents living in mountainous areas and the lowest proportion of residents in the coastal area other than EOAs and the EOAs. In Cluster 3, over 10% of participants were from EOAs. Cluster 1 included the highest proportion of respondents with "others" employment. Over 35% of participants were unemployed in Cluster 3.

Table 2. Types of information sources describing reconstruction progress after the disaster.

Items	Cluster [n (%)]					Total
	1 [599]	2 [366]	3 [237]	4 [399]	5 [529]	[2,130]
Newspaper	520 (86.8)	263 (71.9)	237 (100)	97 (24.3)	529 (100)	1,646 (77.3)
TV and/or radio	562 (93.8)	173 (47.3)	237 (100)	399 (100)	529 (100)	1,900 (89.2)
Internet (except administrative websites)	36 (6.0)	141 (38.5)	0 (0)	0 (0)	0 (0)	177 (8.3)
Internet (administrative websites, Facebook or Twitter)	29 (4.8)	107 (29.2)	0 (0)	0 (0)	0 (0)	136 (6.4)
Prefecture public relations	492 (82.1)	81 (22.1)	0 (0)	35 (8.8)	0 (0)	608 (28.5)
Municipal public relations	358 (59.8)	151 (41.3)	237 (100)	110 (27.6)	0 (0)	856 (40.2)
National public relations	229 (38.2)	11 (3.0)	0 (0)	0 (0)	0 (0)	240 (11.3)
Printed papers except administration papers	93 (15.5)	5 (1.4)	0 (0)	0 (0)	0 (0)	98 (4.6)
Word of mouth	102 (17.0)	57 (15.6)	0 (0)	149 (37.3)	0 (0)	308 (14.5)
Others	6 (1.0)	19 (5.2)	0 (0)	0 (0)	0 (0)	25 (1.2)

Furthermore, Cluster 2 had 35% office workers etc., which was higher than all other clusters. Access to mental health advisors was most prevalent in Cluster 3 and lowest in Cluster 2. There were no significant differences between different survey years.

Factors associated with high mental fatigue

The proportion of participants with high mental fatigue was 13.2%. Table 4 describes the individual attribute of study participants with high mental fatigue evaluated *via* univariate analyses. Different information sources, categorized into five clusters, age, sex, regional area, and absence of mental support, were significantly associated with high mental fatigue. There was no association between the year of survey or occupation and high mental fatigue. The aORs, estimated by multivariable binomial logistic regression analysis, are shown in Table 5. As shown in Model 1, Cluster 2 was more likely to have high mental fatigue (aOR = 2.13, 95% CI = 1.23-3.68), as well as Cluster 4 (aOR = 2.35, 95% CI = 1.37-4.02). These significant associations remained stable in Model 2. In Models 3 and 4, controlling for individual attributes, Clusters 2, 4, and 5 were significantly associated with high mental fatigue. As far as individual attributes, male sex was negatively associated with high mental fatigue (aOR = 0.68, 95% CI = 0.51-0.91 in Model 3; aOR = 0.67, 95% CI = 0.49-0.90 in Model 4). Absence of mental support was significantly associated with high mental fatigue (aOR = 1.57, 95% CI = 1.08-2.28 in Model 4). Sex, regional area, and occupation were also significantly associated with high mental fatigue.

Clusters 2 (aOR = 2.90, 95% CI = 1.46-5.79) and 4 (aOR = 2.29, 95%CI = 1.17-4.50) were significantly associated with high mental fatigue among females (Table 6). These significant associations were not observed among males (Cluster 2: aOR = 1.32, 95% CI = 0.53-3.32; Cluster 4: aOR = 2.41, 95% CI = 0.99-5.87). For age subgroups,

there were non-significant associations between clusters and high mental fatigue, except for Cluster 2 in the 40s-50s age group (aOR = 3.54, 95% CI = 1.31-9.61) (Table 6).

With regard to causes of high mental fatigue among clusters (Table 7), Cluster 2 had significantly higher proportions of economic status, school, and life in the future, and Cluster 4 had higher proportion with job problems. In all clusters, "health" was the greatest cause of stress.

Discussion

This study demonstrates that high mental fatigue is related to the type of information source, after adjusting for various risk factors, such as female sex, age, regional area, occupation, and absence of mental support. In terms of information sources, Clusters 3 (municipal public relations in addition to major media) and 1 (major media and multiple public relations) showed low mental fatigue. Information sources from Clusters 2 (the Internet) and 4 (combination of TV, radio, and word of mouth) were significantly associated with high mental fatigue, regardless of covariate adjustments. Cluster 5 (major media only) was significantly associated with covariate adjustment. These findings are consistent with those of previous research, showing a strong relationship among trusting information from friends, TV, and radio, obtaining information *via* the Internet from sources other than those supported by scientific evidence, and high-risk perception (Murakami et al. 2016), which was a strong risk factor for mental distress after the nuclear power station accident (Suzuki et al. 2015; Oe et al. 2016b; Miura et al. 2017). Furthermore, our findings that those who obtained information from institutions, including national, municipal, and public relations institutions, responded with low mental fatigue are also consistent with those of the previous study that showed that risk perception was lower among people who trusted information from the central government compared with those who did

Table 3. Characteristics of study participants among the five clusters.

Items	Cluster [n (%)][a]					Univariate analysis[b] p
	1 [599]	2 [366]	3 [237]	4 [399]	5 [529]	
Age [n = 2,130]						
20s	14 (2.3)	39 (10.7)	6 (2.5)	52 (13.0)	22 (4.2)	< 0.001
30s	50 (8.3)	67 (18.3)	17 (7.2)	57 (14.3)	52 (9.8)	
40s	47 (7.8)	59 (16.1)	26 (11.0)	78 (19.5)	74 (14.0)	
50s	85 (14.2)	78 (21.3)	46 (19.4)	54 (13.5)	102 (19.3)	
60s or older	403 (67.3)	123 (33.6)	142 (59.9)	158 (39.6)	279 (52.7)	
Sex [n = 2,117]						
Female	359 (60.4)	187 (51.5)	143 (60.6)	256 (64.5)	276 (52.4)	< 0.001
Male	235 (39.6)	176 (48.5)	93 (39.4)	141 (35.5)	251 (47.6)	
Regional area [n = 2,026]						
Mountainous area	85 (15.0)	42 (12.2)	29 (12.6)	49 (13.0)	103 (20.2)	< 0.001
Central area	331 (58.5)	198 (57.7)	136 (59.1)	222 (59.0)	311 (60.9)	
Coastal area other than EOAs	123 (21.7)	78 (22.7)	41 (17.8)	84 (22.3)	81 (15.9)	
EOAs	27 (4.8)	25 (7.3)	24 (10.4)	21 (5.6)	16 (3.1)	
Occupation [n = 2,112]						
Office workers etc	96 (16.1)	136 (37.7)	50 (21.3)	117 (29.5)	139 (26.5)	< 0.001
Self-employed	95 (15.9)	52 (14.4)	32 (13.6)	55 (13.9)	93 (17.7)	
Others	242 (40.6)	111 (30.7)	65 (27.7)	136 (34.4)	159 (30.3)	
Unemployed	163 (27.3)	62 (17.2)	88 (37.4)	88 (22.2)	133 (25.4)	
Years [n = 2,130]						
2013	209 (34.9)	125 (34.2)	71 (30.0)	164 (41.1)	189 (35.7)	0.27
2014	201 (33.6)	119 (32.5)	88 (37.1)	122 (30.6)	169 (31.9)	
2015	189 (31.6)	122 (33.3)	78 (32.9)	113 (28.3)	171 (32.3)	
Mental support [n = 2,012]						
Presence of mental support	524 (90.7)	289 (83.3)	202 (92.2)	321 (85.1)	415 (84.5)	< 0.001
Absence of mental support	54 (9.3)	58 (16.7)	17 (7.8)	56 (14.9)	76 (15.5)	

Cluster 1 includes major media (newspaper, TV and radio) and multiple public relations sources (national, prefecture, and municipal).
Cluster 2 includes various information sources such as the Internet, and lower use of TV and radio.
Cluster 3 comprises municipal public relations sources in addition to major media (newspaper, TV, and radio).
Cluster 4 includes TV, radio and word of mouth, and lower use of newspapers and public relations.
Cluster 5 comprises only major media (newspaper, TV and radio).
EOAs, evacuation order areas.
[a]Due to missing answers, the number of respondents in some items may not add up to the sum shown in the column header.
[b]Chi-square test.

not (Murakami et al. 2016).

Our study showed that only females who used the Internet displayed possible associations with high mental fatigue. The reason for this inconsistency between sexes is not clear but may be attributed to the effect of the means of information delivery on sex. Generally, information from the Internet tended to include shocking, surprising, or unreliable contextual information intent on persuasion, such as to convey a narrative message rather than scientific findings (Murakami et al. 2016). Further research should explore

the relationships among sex differences, use of information sources, and psychological factors.

Our data suggest that the use of information from authoritative sources, including public relations (especially municipal public relations), possibly reduced mental fatigue compared with other sources. We therefore suggest that the extensive distribution of information from public relations sources, especially municipal relations, through the Internet, TV, and radio is a prospective way to mitigate mental fatigue. It should be noted that Cluster 2 (the high mental

Table 4. Individual attributes of study participants with high mental fatigue.

Items	Mental fatigue* [n (%)][a] Low 1,808 (86.8)	High 274 (13.2)	Univariate analysis[b] p
Cluster [n = 2,082]			
1	519 (88.1)	70 (11.9)	< 0.01
2	299 (84.0)	57 (16.0)	
3	212 (91.8)	19 (8.2)	
4	323 (82.6)	68 (17.4)	
5	455 (88.3)	60 (11.7)	
Age [n = 2,082]			
20s	101 (78.9)	27 (21.1)	0.02
30s	203 (84.6)	37 (15.4)	
40s	245 (86.9)	37 (13.1)	
50s	309 (85.8)	51 (14.2)	
60s or older	950 (88.6)	122 (11.4)	
Sex [n = 2,071]			
Female	1,016 (85.3)	175 (14.7)	0.01
Male	783 (89.0)	97 (11.0)	
Regional area [n = 1,984]			
Mountainous area	278 (92.4)	23 (7.6)	< 0.001
Central area	1,018 (86.6)	158 (13.4)	
Coastal area other than EOAs	342 (86.8)	52 (13.2)	
EOAs	87 (77.0)	26 (23.0)	
Occupation [n = 1,878]			
Office workers etc	458 (88.4)	60 (11.6)	0.41
Self-employed	199 (84.0)	38 (16.0)	
Others	598 (86.7)	92 (13.3)	
Unemployed	376 (86.8)	57 (13.2)	
Years [n = 2,082]			
2013	625 (85.1)	109 (14.9)	0.24
2014	602 (87.6)	85 (12.4)	
2015	581 (87.9)	80 (12.1)	
Mental support [n = 1,974]			
Presence of mental support	1,501 (87.5)	215 (12.5)	< 0.01
Absence of mental support	210 (81.4)	48 (18.6)	

Cluster 1 includes major media (newspaper, TV and radio) and multiple public relations sources (national, prefecture, and municipal).
Cluster 2 includes various information sources such as the Internet, and lower use of TV and radio.
Cluster 3 comprises municipal public relations sources in addition to major media (newspaper, TV, and radio).
Cluster 4 includes TV, radio and word of mouth, and lower use of newspapers and public relations.
Cluster 5 comprises only major media (newspaper, TV and radio).
EOAs, evacuation order areas.
*Mental fatigue is divided into two categories according to the responses to the following question:
  "How often do you usually feel mentally tired or depressed? "
  The response of "often" is categorized as "High".
  The responses of "sometimes," "slightly," and "none" are categorized as "Low".
[a]Due to missing answers, the number of respondents in some items may not add up to the sum shown in the column header.
[b]Chi-square test.

fatigue cluster) represented users of various information sources, including the Internet, from the prefecture. Mental fatigue could possibly be prevented or mitigated by active updates and delivery of reliable information *via* the Internet and media. Also, the public health sector should continuously cooperate and coordinate with mass media so that scientific evidence-based findings and health messages are disseminated widely to the public. Communication between the media and public health sector is a challenge as there is often a mismatch in goals and objectives between these two bodies (Schwitzer 2013). It is therefore fruitful to build a constructive relationship between the media and

Table 5. Associations between clusters or demographic factors and high mental fatigue.

Items	Model 1 [n = 2,082]			Model 2 [n = 2,082]			Model 3 [n = 1,962]			Model 4 [n = 1,860]		
	OR	95% CI	p value*	OR	95% CI	p value*	OR	95% CI	p value*	OR	95% CI	p value*
Cluster												
3	1			1			1			1		
1	1.50	0.88-2.56	0.13	1.49	0.88-2.54	0.14	1.51	0.86-2.66	0.15	1.56	0.87-2.82	0.14
2	2.13	1.23-3.68	0.01	2.11	1.22-3.66	0.01	2.32	1.29-4.15	< 0.01	2.35	1.27-4.33	0.01
4	2.35	1.37-4.02	< 0.01	2.30	1.34-3.94	< 0.01	2.50	1.42-4.41	< 0.01	2.56	1.41-4.66	< 0.01
5	1.47	0.86-2.53	0.16	1.46	0.85-2.50	0.17	1.80	1.02-3.18	0.04	1.93	1.07-3.50	0.03
Years												
2013				1			1			1		
2014				0.83	0.61-1.13	0.23	0.82	0.60-1.14	0.24	0.84	0.61-1.17	0.30
2015				0.80	0.59-1.10	0.17	0.80	0.57-1.11	0.18	0.72	0.51-1.01	0.06
Sex												
Female							1			1		
Male							0.68	0.51-0.91	0.01	0.67	0.49-0.90	0.01
Age												
60s or older							1			1		
20s							2.43	1.42-4.14	< 0.01	2.32	1.33-4.04	< 0.01
30s							1.76	1.11-2.79	0.02	1.72	1.07-2.76	0.02
40s							1.59	1.01-2.51	0.04	1.55	0.98-2.47	0.06
50s							1.68	1.12-2.52	0.01	1.66	1.09-2.52	0.02
Regional area												
Mountainous area							1			1		
Central area							1.79	1.12-2.85	0.01	1.73	1.08-2.77	0.02
Coastal area other than EOAs							1.81	1.07-3.06	0.03	1.75	1.03-2.98	0.04
EOAs							3.32	1.75-6.30	< 0.001	2.99	1.55-5.77	< 0.01
Occupation												
Office workers etc							1			1		
Self-employed							2.42	1.55-3.78	< 0.001	2.67	1.69-4.22	< 0.001
Others							1.52	1.03-2.26	0.04	1.60	1.07-2.40	0.02
Unemployed							2.60	1.63-4.14	< 0.001	2.74	1.70-4.42	< 0.001
Mental support												
Presence of mental support										1		
Absence of mental support										1.57	1.08-2.28	0.02

≥ 1 dependencies for high mental fatigue.

Model 1 : Mental fatigue as the response variable, cluster as the explanatory variable.

Model 2 : Mental fatigue as the response variable, cluster and years as the explanatory variables.

Model 3 : Mental fatigue as the response variable, cluster, years and four individual attributes (age, sex, regional area and occupation) as the explanatory variables.

Model 4 : Mental fatigue as the response variable, cluster, years, four individual attributes and mental support as the explanatory variables.

Cluster 1 includes major media (newspaper, TV and radio) and multiple public relations sources (national, prefecture, and municipal).

Cluster 2 includes various information sources such as the Internet, and lower use of TV and radio.

Cluster 3 comprises municipal public relations sources in addition to major media (newspaper, TV, and radio).

Cluster 4 includes TV, radio and word of mouth, and lower use of newspapers and public relations.

Cluster 5 comprises only major media (newspaper, TV and radio).

OR, odds ratio; 95% CI, 95% confidence interval; EOAs, evacuation order areas.

*Binary logistic regression analysis.

Table 6. Associations between clusters (information sources describing reconstruction progress from the disaster) and high mental fatigue by sex and age.

	Female [n = 1,191]			Male [n = 880]			20s-30s [n = 368]			40s-50s [n = 642]			60s or older [n = 1,072]		
	OR	95% CI	p value*	OR	95% CI	p value*	OR	95% CI	p value*	OR	95% CI	p value*	OR	95% CI	p value*
Cluster															
3	1			1			1			1			1		
1	1.42	0.72-2.79	0.31	1.60	0.67-3.81	0.29	1.53	0.30-7.79	0.61	1.74	0.60-5.00	0.31	1.40	0.72-2.72	0.32
2	2.90	1.46-5.79	< 0.01	1.32	0.53-3.32	0.55	2.37	0.51-11.01	0.27	3.54	1.31-9.61	0.01	0.88	0.36-2.16	0.77
4	2.29	1.17-4.50	0.02	2.41	0.99-5.87	0.05	3.50	0.77-15.91	0.10	2.24	0.80-6.28	0.13	1.76	0.84-3.71	0.14
5	1.67	0.84-3.31	0.14	1.26	0.52-3.05	0.60	1.33	0.26-6.78	0.73	1.71	0.62-4.76	0.30	1.40	0.70-2.81	0.34

≥ 1 dependencies for high mental fatigue.
Cluster 1 includes major media (newspaper, TV and radio) and multiple public relations sources (national, prefecture, and municipal).
Cluster 2 includes various information sources such as the Internet, and lower use of TV and radio.
Cluster 3 comprises municipal public relations sources in addition to major media (newspaper, TV, and radio).
Cluster 4 includes TV, radio and word of mouth, and lower use of newspapers and public relations.
Cluster 5 comprises only major media (newspaper, TV and radio).
OR, odds ratio; 95% CI, 95% confidence interval.
*Binary logistic regression analysis.

Table 7. Cause of high mental fatigue by cluster.

Items	Cluster [n (%)]					Univariate analysis[a] p
	1 [70]	2 [57]	3 [19]	4 [68]	5 [60]	
Health	61 (87.1)	49 (86.0)	16 (84.2)	53 (77.9)	52 (86.7)	0.49
Economic status	33 (47.1)	33 (57.9)*	9 (47.4)	32 (47.1)	18 (30.0)**	0.04
Job	20 (28.6)	23 (40.4)	4 (21.1)	31 (45.6)*	15 (25.0)	0.05
Unemployed	11 (15.7)	9 (15.8)	2 (10.5)	7 (10.3)	6 (10.0)	0.75
School	3 (4.3)	8 (14.0)*	0 (0)	6 (8.8)	1 (1.7)	0.04
Life in the future	43 (61.4)	43 (75.4)*	14 (73.7)	45 (66.2)	23 (38.3)**	< 0.001
Human Relationships	42 (60.0)	36 (63.2)	10 (52.6)	33 (48.5)	27 (45.0)	0.19
Others	4 (5.7)	7 (12.3)	1 (5.3)	7 (10.3)	4 (6.7)	0.66

Cluster 1 includes major media (newspaper, TV and radio) and multiple public relations sources (national, prefecture, and municipal).
Cluster 2 includes various information sources such as the Internet, and lower use of TV and radio.
Cluster 3 comprises municipal public relations sources in addition to major media (newspaper, TV, and radio).
Cluster 4 includes TV, radio and word of mouth, and lower use of newspapers and public relations.
Cluster 5 comprises only major media (newspaper, TV and radio).
[a]Chi-square test.
*p < 0.05, **p < 0.01.

public health sector.

With regard to disaster preparedness, we suggest that the public health sector should adopt an online approach to information dissemination and establish constructive relationship with major media. Although our results indicate that online information was associated with high mental fatigue, delivery of information *via* the Internet is still an effective approach for informing the public. Active delivery and updating of reliable information have the potential

to reach those suffering from high mental fatigue. Risk communication lessons learned from the accident in Fukushima highlighted that building relationships between the public health sector and citizens *before* a crisis is useful for an effective communication *after* a crisis (Murakami et al. 2017). Our results demonstrate that people who use municipal public relations as a source of information experienced less mental fatigue. In addition, Murakami et al. (2016) reported that a distrust of authoritative sectors is

related to anxiety and higher risk perception. Hence, it is vital that government and municipalities who act as information providers in prefectures invest in building and maintaining trust with community residents.

We found that of all eight items, the highest proportion of high mental fatigue was caused by health, regardless of information source. It is therefore important for public health nurses to be communicators and develop and evaluate communication materials in the context of accessibility, ease of use, and usefulness by interacting with the community through diverse channels; this will develop public trust and narrow information and health inequalities (Brown et al. 2014; Murakami et al. 2017). Public health nurses working in municipal and prefectural health centers are the gatekeepers who establish the first contact with community residents. They assess the needs of the community and implement health promotion programs, collaborating with multi-sector institutions to promote a healthier community. Such health promotion activities include information provisions relating to accessing health services. Finally, it is crucial, especially for the younger generations, to improve their media literacy *via* educational interventions, both in schools and in the community; this will ensure that individuals can think critically and make educated decisions (Jeong et al. 2012).

This study has some limitations which warrant discussion. This was a cross-sectional study; thus, we can only make associations and not determine causality. An individual's mental health information needs might affect his or her use of information sources through various channels, as Oh and Song (2017) previously reported. Also, the measurement of mental fatigue was based on an original questionnaire item; the 13.2% level of high mental fatigue in this survey was similar to the 14.6 % level of high psychological distress (K6 ≥ 13) reported previously (Suzuki et al. 2015). Furthermore, the validity of the mental fatigue indicator in this study is consistent with the significant associations between demographic factors (i.e., female, age, regional area, occupation, and absence of mental support) and mental fatigue/the K6 indicator in both this study and previous studies (Goodwin et al. 2015; Suzuki et al. 2015). However, further research is needed to further validate this survey and determine its correlation with the K6 scale. Additionally, the ratio of males to females for this survey's participants is lower than the population of Fukushima Prefecture (0.98), according to the 2015 Population Census in Fukushima (Ministry of Internal Affairs and Communications of Japan 2016). This skewed ratio may have introduced bias because more responses were received from females who might be more interested in the contents of this annual public opinion survey. To reduce bias in this survey, factors were categorized by sex, and thus, the relative strength of the associations with each factor was evaluated. Another limitation is that the limited number of participants may have reduced our statistical power. Further studies are thus required to confirm the influence of factors

that were found to be insignificant in this study. Finally, this survey was aimed only at Fukushima residents; thus, our findings may not be generalized to other populations. Future studies should evaluate causal relationships regarding the effects of information sources on mental fatigue in other areas with a larger cohort.

The effects of differing information sources become increasingly important with advances in modern information-rich societies; thus, establishing a system for a reliable delivery of information is key to improving public health and communications. This study revealed strong associations between information sources and mental fatigue, especially among females, after a nuclear power accident. These findings contribute to a more comprehensive understanding and will help in developing information strategies as part of disaster preparedness and responses.

In conclusion, different information sources, especially the "Internet" and "combination of TV, radio, and word of mouth," were significantly associated with high mental fatigue compared with those who received their information from "municipal public relations in addition to major media." For disaster preparedness, the strategic distribution of reliable information from institutions, especially municipal relations, to the Internet, TV, and radio is essential to mitigate mental fatigue.

Acknowledgments

Author Contributions

Y.Y. analyzed the data, drafted the initial manuscript and revised it, and approved the final manuscript as submitted. M.M. supervised the data analyses and interpretation of the data, reviewed and revised the manuscript, and approved the final manuscript as submitted. Y.T. supervised the data analyses and interpretation of the data, reviewed and revised the manuscript, and approved the final manuscript as submitted. S.S. reviewed and revised the manuscript, and approved the final manuscript as submitted. T.O. supervised the interpretation of the data, reviewed and revised the manuscript, and approved the final manuscript as submitted.

Conflict of Interest

The authors declare no conflict of interest.

References

Ahmad, F., Jhajj, A.K., Stewart, D.E., Burghardt, M. & Bierman, A.S. (2014) Single item measures of self-rated mental health: a scoping review. *BMC Health Serv. Res.*, **14**, 398.

Barnes, M.D., Hanson, C.L., Novilla, L.M., Meacham, A.T., McIntyre, E. & Erickson, B.C. (2008) Analysis of media agenda setting during and after Hurricane Katrina: implications for emergency preparedness, disaster response, and disaster policy. *Am. J. Public Health*, **98**, 604-610.

Bromet, E.J. & Havenaar, J.M. (2007) Psychological and perceived health effects of the Chernobyl disaster: a 20-year review. *Health Phys.*, **93**, 516-521.

Brown, L.M., Haun, J.N. & Peterson, L. (2014) A proposed disaster literacy model. *Disaster Med. Public Health Prep.*, **8**, 267-275.

Galea, S., Brewin, C.R., Gruber, M., Jones, R.T., King, D.W., King, L.A., McNally, R.J., Ursano, R.J., Petukhova, M. & Kessler, R.C. (2007) Exposure to hurricane-related stressors and mental illness after Hurricane Katrina. *Arch. Gen. Psychiatry*, **64**, 1427-1434.

Goodwin, R., Takahashi, M., Sun, S. & Ben-Ezra, M. (2015) Psychological distress among tsunami refugees from the Great East Japan earthquake. *BJPsych Open*, **1**, 92-97.

Goto, A., Rudd, R.E., Lai, A.Y., Yoshida, K., Suzuki, Y., Halstead, D.D., Yoshida-Komiya, H. & Reich, M.R. (2014) Leveraging public health nurses for disaster risk communication in Fukushima City: a qualitative analysis of nurses' written records of parenting counseling and peer discussions. *BMC Health Serv. Res.*, **14**, 129.

Hasegawa, M., Murakami, M., Takebayashi, Y., Suzuki, S. & Ohto, H. (2018) Social capital enhanced disaster preparedness and health consultations after the 2011 Great East Japan Earthquake and nuclear power station accident. *Int. J. Environ. Res. Public Health*, **15**, E516.

Hewlett, S., Dures, E. & Almeida, C. (2011) Measures of fatigue: Bristol Rheumatoid Arthritis Fatigue Multi-Dimensional Questionnaire (BRAF MDQ), Bristol Rheumatoid Arthritis Fatigue Numerical Rating Scales (BRAF NRS) for severity, effect, and coping, Chalder Fatigue Questionnaire (CFQ), Checklist Individual Strength (CIS20R and CIS8R), Fatigue Severity Scale (FSS), Functional Assessment Chronic Illness Therapy (Fatigue) (FACIT-F), Multi-Dimensional Assessment of Fatigue (MAF), Multi-Dimensional Fatigue Inventory (MFI), Pediatric Quality Of Life (PedsQL) Multi-Dimensional Fatigue Scale, Profile of Fatigue (ProF), Short Form 36 Vitality Subscale (SF-36 VT), and Visual Analog Scales (VAS). *Arthritis Care Res.* (*Hoboken*), **63** Suppl 11, S263-286.

Jeong, S.H., Cho, H. & Hwang, Y. (2012) Media literacy interventions: a meta-analytic review. *J. Commun.*, **62**, 454-472.

Kayama, M., Akiyama, T., Ohashi, A., Horikoshi, N., Kido, Y., Murakata, T. & Kawakami, N. (2014) Experiences of municipal public health nurses following Japan's earthquake, tsunami, and nuclear disaster. *Public Health Nurs.*, **31**, 517-525.

Kessler, R.C., Barker, P.R., Colpe, L.J., Epstein, J.F., Gfroerer, J.C., Hiripi, E., Howes, M.J., Normand, S.L., Manderscheid, R.W., Walters, E.E. & Zaslavsky, A.M. (2003) Screening for serious mental illness in the general population. *Arch. Gen. Psychiatry*, **60**, 184-189.

Maeda, E., Sugimori, H., Nakamura, F., Kobayashi, Y., Green, J., Suka, M., Okamoto, M., Boivin, J. & Saito, H. (2015) A cross sectional study on fertility knowledge in Japan, measured with the Japanese version of Cardiff Fertility Knowledge Scale (CFKS-J). *Reprod. Health*, **12**, 10.

Ministry of Internal Affairs and Communications of Japan (2016) 2015 population census: basic complete tabulation on population and households prefectures.
http://www.stat.go.jp/data/kokusei/2015/kekka.html
[*Accessed*: February 13, 2019] (in Japanese).

Miura, I., Nagai, M., Maeda, M., Harigane, M., Fujii, S., Oe, M., Yabe, H., Suzuki, Y., Takahashi, H., Ohira, T., Yasumura, S. & Abe, M. (2017) Perception of radiation risk as a predictor of mid-term mental health after a nuclear disaster: the Fukushima

health management survey. *Int. J. Environ. Res. Public Health*, **14**, E1067.

Murakami, M., Nakatani, J. & Oki, T. (2016) Evaluation of risk perception and risk-comparison information regarding dietary radionuclides after the 2011 Fukushima nuclear power plant accident. *PLoS One*, **11**, e0165594.

Murakami, M., Sato, A., Matsui, S., Goto, A., Kumagai, A., Tsubokura, M., Orita, M., Takamura, N., Kuroda, Y. & Ochi, S. (2017) Communicating with residents about risks following the Fukushima nuclear accident. *Asia Pac. J. Public Health*, **29**, 74S-89S.

Muusses, L.D., van Weert, J.C., van Dulmen, S. & Jansen, J. (2012) Chemotherapy and information-seeking behaviour: characteristics of patients using mass-media information sources. *Psychooncology*, **21**, 993-1002.

Nishi, D., Koido, Y., Nakaya, N., Sone, T., Noguchi, H., Hamazaki, K., Hamazaki, T. & Matsuoka, Y. (2012) Peritraumatic distress, watching television, and posttraumatic stress symptoms among rescue workers after the Great East Japan earthquake. *PLoS One*, **7**, e35248.

Oe, M., Fujii, S., Maeda, M., Nagai, M., Harigane, M., Miura, I., Yabe, H., Ohira, T., Takahashi, H., Suzuki, Y., Yasumura, S. & Abe, M. (2016a) Three-year trend survey of psychological distress, post-traumatic stress, and problem drinking among residents in the evacuation zone after the Fukushima Daiichi Nuclear Power Plant accident [The Fukushima Health Management Survey]. *Psychiatry Clin. Neurosci.*, **70**, 245-252.

Oe, M., Maeda, M., Nagai, M., Yasumura, S., Yabe, H., Suzuki, Y., Harigane, M., Ohira, T. & Abe, M. (2016b) Predictors of severe psychological distress trajectory after nuclear disaster: evidence from the Fukushima Health Management Survey. *BMJ Open*, **6**, e013400.

Oh, Y.S. & Song, N.K. (2017) Investigating relationships between health-related problems and online health information seeking. *Comput. Inform. Nurs.*, **35**, 29-35.

Prezelj, I., Perko, T., Cantone, M.C., Gallego, E., Tomkiv, Y. & Oughton, D.H. (2016) The limits of public communication coordination in a nuclear emergency: lessons from media reporting on the Fukushima case. *J. Radiol. Prot.*, **36**, S45-63.

Schwitzer, G. (2013) Addressing tensions when popular media and evidence-based care collide. *BMC Med. Inform. Decis. Mak.*, **13** Suppl 3, S3.

Sugimoto, A., Nomura, S., Tsubokura, M., Matsumura, T., Muto, K., Sato, M. & Gilmour, S. (2013) The relationship between media consumption and health-related anxieties after the Fukushima Daiichi nuclear disaster. *PLoS One*, **8**, e65331.

Suzuki, S., Murakami, M., Nishikiori, T. & Harada, S. (2018) Annual changes in the Fukushima residents' views on the safety of water and air environments and their associations with the perception of radiation risks. *J. Radiat. Res.*, **59**, ii31-ii39.

Suzuki, Y., Yabe, H., Yasumura, S., Ohira, T., Niwa, S., Ohtsuru, A., Mashiko, H., Maeda, M. & Abe, M.; Mental Health Group of the Fukushima health management survey (2015) Psychological distress and the perception of radiation risks: the Fukushima health management survey. *Bull. World Health Organ.*, **93**, 598-605.

Takebayashi, Y., Lyamzina, Y., Suzuki, Y. & Murakami, M. (2017) Risk perception and anxiety regarding radiation after the 2011 Fukushima nuclear power plant accident: a systematic qualitative review. *Int. J. Environ. Res. Public Health*, **14**, E1306.