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Regular Article

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]

Misari Oe, MD, PhD,[1]* Senta Fujii, MD, PhD,[2,3] Masaharu Maeda, MD, PhD,[2,3] Masato Nagai, PhD,[2,4] Mayumi Harigane, PhD,[2] Itaru Miura, MD, PhD,[5] Hirooki Yabe, MD, PhD,[5] Tetsuya Ohira, MD, PhD,[2,4] Hideto Takahashi, PhD,[2] Yuriko Suzuki, MD, PhD,[7] Seiji Yasumura, MD, PhD[2,6] and Masafumi Abe, MD, PhD[2]

[1]*Department of Neuropsychiatry, Kurume University School of Medicine, Kurume,* [2]*Radiation Medical Science Center for the Fukushima Health Management Survey, Departments of* [3]*Disaster Psychiatry,* [4]*Epidemiology,* [5]*Neuropsychiatry,* [6]*Public Health, School of Medicine, Fukushima Medical University, Fukushima and* [7]*Department of Adult Mental Health, National Institute of Mental Health, National Center of Neurology and Psychiatry, Kodaira, Japan*

Aim: Prolonged periods of instability in terms of living environment can lead to a serious increase in mental health issues among disaster-affected individuals. The aim of this study was to assess long-term trends in mental health among adult residents in a nuclear-disaster-affected area.

Methods: Mail-based, self-administered questionnaire surveys were conducted three times (T1–T3), targeting all residents registered with the municipalities in the evacuation zone in Fukushima prefecture at the time of the disaster. Age-adjusted prevalences of the following were analyzed by sex: risk of psychological distress by the Kessler 6-item Scale, post-traumatic stress by the **P**ost-traumatic **S**tress **D**isorder Checklist, and problem drinking by CAGE.

Results: The numbers of respondents and response rates were: 73 568, 40.7% (T1); 55 076, 29.9% (T2); and 46 386, 25.0% (T3). Compared with normal Japanese levels in non-disaster settings (4.7%), the prevalence of general psychological distress by Kessler 6-item Scale ≥ 13 was still high 3 years after the event in both men (11.4%) and women (15.8%). Although the age-adjusted prevalence of psychological distress and post-traumatic stress (**P**ost-traumatic **S**tress **D**isorder Checklist ≥ 44) had decreased over time (from 19.0% [T1] to 17.8% [T3] for men, and from 25.3% [T1] to 23.3% [T3] for women), the age-adjusted prevalence of problem drinking (CAGE ≥ 2) remained steady in both men (20.7% [T2] and 20.4% [T3]; $P = 0.18$) and women (10.5% [T2] and 10.5% [T3]; $P = 0.91$).

Conclusion: Our results suggest that long-term interventions focused on post-traumatic stress as well as other mental health problems are strongly needed for disaster-affected individuals.

Key words: alcohol use, cross-sectional studies, epidemiologic studies, post-traumatic stress, stress disorders.

Correspondence: Misari Oe, MD, PhD, Department of Neuropsychiatry, Kurume University School of Medicine, Asahi-machi 67, Kurume 830-0011, Japan. Email: oe_misari@kurume-u.ac.jp
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THE GREAT EAST Japan Earthquake and tsunami occurred on 11 March 2011. The number of confirmed dead was 15 893 and 2567 people are still missing as of October 2015.[1] The Fukushima

Daiichi Nuclear Power Plant accident subsequently resulted, and became the worst nuclear event since the 1986 Chernobyl disaster, and only the second one to measure Level 7 on the International Nuclear Event Scale.[2]

As a consequence of this complex (earthquake/tsunami/nuclear) disaster, approximately 234 000 people were evacuated (as of December 2014),[3] half of whom (120 000 evacuees) were from Fukushima prefecture. About 75 000 evacuees shifted their location within Fukushima prefecture, living in temporary housing, municipally subsidized rental housing, or with a relative/friend, and about 45 000 moved from Fukushima to other parts of Japan. Among the three affected prefectures, the number of people evacuated to a region outside their original prefecture was greatest for those living in Fukushima (Fukushima: 45 934, Miyagi: 6810, and Iwate: 1453, as of December 2014).[3] Such prolonged periods of instability with respect to living environment could lead to a serious increase in the prevalence of mental health issues.

The aim of this study was to assess long-term trends in general psychological distress, post-traumatic stress, and problem drinking among adult residents who had lived in the nuclear-disaster-affected area of Fukushima prefecture.

METHODS

Study samples

The Fukushima prefectural government initiated the Fukushima Health Management Survey to monitor the long-term health of the residents of the region, to promote their future well-being, and to determine whether long-term low-dose radiation exposure had a measurable impact on their health. This multifaceted survey includes a basic survey (i.e., estimation of radiation exposure) for the whole population of Fukushima prefecture (about 2.05 million), together with more specifically targeted and detailed surveys. The comprehensive protocol of this survey has been published elsewhere.[4]

The Mental Health and Lifestyle Survey is one of the detailed surveys included in the project, and was targeted at all people registered with the municipalities (about 0.21 million) in the nationally designated evacuation zone (as of April 2011) inside Fukushima prefecture. The complete protocol of this survey has been published elsewhere.[5]

The zone includes 13 municipalities: Hirono, Naraha, Tomioka, Kawauchi, Okuma, Futaba, Namie, Katsurao, Iitate, Minamisoma, Tamura, Kawamata, and hot-spot areas in Date. We conducted the Mental Health and Lifestyle Survey as a mail-based, self-administered questionnaire, administered on a yearly basis from January 2012 (10 months after the disaster: T1). The second survey was conducted in January 2013 (22 months: T2), and the third was conducted in February 2014 (35 months: T3). All studies targeted the same cohort (13 municipalities), although, as mentioned in the Introduction, several of these areas have been released from the evacuation zone in a stepwise manner.

The target population of the adult-version of the survey (16 years or older) for each year was 180 604 (T1), 184 507 (T2), and 185 859 (T3), and the survey response rate was 40.7% (n = 73 568), 29.9% (n = 55 076) and 25.0% (n = 46 386), respectively. For the current analysis, we excluded participants who did not provide valid responses (T1: n = 135; T2: n = 12; T3: n = 4) and participants who were <20 years (T1: n = 2333; T2: n = 1902; T3: n = 1469), as we were exploring an alcohol-related variable. Consequently, a total of 71 100 participants (men: 31 185; women: 39 915) in T1, 53 162 participants (men: 23 443, women: 29 719) in T2, and 44 913 participants (men: 19 691, women: 25 222) in T3 were included in the study analyses.

Demographic and disaster-related variables

We used data on sex, age (three groups: 20–39, 40–64, and ≥65 years), original address before evacuation (two groups: municipalities still affected by the evacuation order as of March 2015, or municipalities where the order had already been lifted), place of residence (two groups: inside or outside of Fukushima prefecture), and drinking status (three categories: never or rarely; past; and current) as demographic and mental-health-related variables in this study.

Assessments

The Kessler 6-item Scale (K6) consists of six brief questions about non-specific psychological distress during the past 30 days. All items are measured on a 5-point scale (0 [never] to 4 [all the time]) to be completed within 2–3 min.[6] 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, and Kessler recommended using a cut-off score of 12/13 as an indicator of serious mental illness. We adopted the 12/13 cut-off according to Kessler's recommendation.[7]

The Post-traumatic Stress Disorder Checklist (PCL) is a 17-item self-report measure reflecting the symptoms of PTSD (according to the DSM-IV), and is meant to be completed in 5–10 min.[8] Respondents are asked to rate the degree to which they have been bothered by symptoms (1 [not at all] to 5 [extremely]) in the past months, and the total score ranges between 17 and 85. The PCL has a variety of purposes, such as screening individuals for PTSD, aiding in the diagnostic assessment of PTSD, and monitoring change in PTSD symptoms. Among the three versions of the PCL for the DSM-IV, the PCL-S (specific) was used in the survey. The PCL-S asks about symptoms in relation to an identified 'stressful experience.' We specified the 2011 Great East Japan Earthquake, the following tsunami, and the Fukushima nuclear accident as the stressful experiences. We set the cut-off score for screening high-risk cases of PTSD at 43/44 in this study according to the recommendation for diagnostic efficiency used in other studies.[9,10]

CAGE (an acronym for attempts to Cut back on drinking, being Annoyed at criticisms about drinking, feeling Guilty about drinking, and using alcohol as an Eye opener) is a four-item scale designed as a screening instrument for problem drinking.[11] The total CAGE score (0–4) was used as an index of problem drinking. We used the 1/2 cut-off according to a review by the National Institute of Alcohol Abuse and Alcoholism.[12]

Statistical analysis

The age-adjusted prevalences of K6 ≥ 13, PCL ≥ 44 and CAGE ≥ 2 were estimated across the survey period based on standard methods for analysis of covariance in male and female populations. We conducted tests for trends by modeling the survey data according to various categories. Analyses were repeated after stratifying the data according to the variables mentioned above. All hypothesis tests were two-sided and based on a 0.05 level of significance. Statistical analyses were conducted using SAS software (version 9.3, Cary, NC, USA).

Ethical considerations

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

RESULTS

Demographic and disaster-related variables

The demographic and disaster-related variables considered in the three assessments are shown in Table 1. Over 40% of the study sample lived in the municipalities that were still under the evacuation order. Around 40% of the sample was over 65 years old. About two-thirds of the men were current drinkers, while more than two-thirds of the women drank rarely or never.

Psychological distress, post-traumatic stress, and problem drinking

The median scores and prevalences of a high risk of psychological distress (K6 ≥ 13), post-traumatic stress (PCL ≥ 44), and problem drinking (CAGE ≥2) by sex are shown in Table 2. Although the prevalence of psychological distress and post-traumatic stress decreased over time, the prevalence of problem drinking increased as a whole, both in men and women.

Age-adjusted prevalence of high risk of psychological distress, post-traumatic stress, and problem drinking

The prevalences of a high risk of psychological distress (K6 ≥ 13), post-traumatic stress (PCL ≥ 44), and problem drinking (CAGE ≥2) by sex, age, and other disaster-related variables are shown in Table 3. Older male residents scored at least five points more than middle-aged men in terms of a high-risk group of post-traumatic stress over 3 years, whereas these groups were similar in terms of a high risk of psychological distress. Older female residents showed a similar tendency, and scored at least seven points more than middle-aged women in terms of a high risk of post-traumatic stress over 3 years. In terms of a high risk of both psychological distress and post-traumatic stress, those who had resided in municipalities that were still affected by the evacuation order scored at least five points more than those who lived in the municipalities where the evacuation order had been lifted during the 3 years of the study. With respect to present place of

Table 1. Demographic and disaster-related variables

	Men				Women			
	2012	2013	2014	*P*-value[†]	2012	2013	2014	*P*-value
Number of participants	31 185	23 443	19 691	—	39 915	29 719	25 222	—
Mean age (SD)	57.7 (17.2)	60.0 (16.6)	61.1 (16.5)	<0.001	57.6 (18.3)	59.4 (18.0)	60.2 (17.8)	<0.001
20–39 years (%)	19.2%	15.3%	13.9%	<0.001	21.0%	18.5%	17.3%	<0.001
40–64 years (%)	43.0%	40.5%	37.8%	—	40.7%	38.3%	36.9%	—
≥65 years (%)	37.8%	44.3%	48.3%	—	38.3%	43.2%	45.8%	—
Original address before evacuation								
Still under the evacuation order[‡‡] (%)	39.3%	43.5%	44.3%	<0.001	38.8%	43.2%	43.7%	<0.001
Order lifted[§] (%)	60.7%	56.5%	55.7%		61.2%	56.8%	56.3%	—
Living place (present address)								
Inside Fukushima prefecture (%)	82.8%	84.7%	—[¶]	<0.001	79.7%	82.1%	—[¶]	<0.001
Outside Fukushima prefecture (%)	17.2%	15.3%	—[¶]	—	20.3%	17.9%	—[¶]	—
Drinking status[††]								
Never/rare drinker (%)	27.2%	30.3%	30.3%	<0.001	69.5%	71.8%	72.1%	<0.001
Past drinker (%)	6.3%	5.2%	5.1%	—	2.0%	1.7%	1.7%	—
Current drinker (%)	66.5%	64.5%	64.6%	—	28.6%	26.6%	26.2%	—

[†]*P*-values were calculated using the χ^2-test (categorical variables), analysis of variance (continuous variables), Wilcoxon test (continuous variables), or Kruskal–Wallis test (continuous variables).
[‡]Municipalities still under the evacuation order (as of March 2015): Naraha, Tomioka, Okuma, Futaba, Namie, Katsurao, Iitate.
[§]Municipalities where the evacuation order has been lifted: Date, Kawamata, Tamura, Minamisoma, Hirono, Kawauchi.
[¶]Living place (present address) was not requested in 2014.
[††]"Rare" means less than once per month. "Past drinker" means participants who had quit drinking. "Current drinker" means participants who drank at least once per month at the time of the survey.

Table 2. Psychological distress, post-traumatic stress, and problem drinking

	Men				Women			
	2012	2013	2014	*P*-value[†]	2012	2013	2014	*P*-value
Number of participants	31 185	23 443	19 691	—	39 915	29 719	25 222	—
Median K6 (IQR)	4 (1–9)	4 (0–8)	3 (0–8)	<0.001	6 (2–11)	5 (2–10)	5 (1–9)	<0.001
K6 ≥ 13 (%)	12.4%	10.2%	8.8%	<0.001	17.3%	13.9%	11.6%	<0.001
Median PCL (IQR)	27 (20–38)	26 (20–37)	25 (19–36)	<0.001	31 (22–43)	29 (21–40)	27 (21–38)	<0.001
PCL ≥ 44 (%)	18.6%	16.3%	15.0%	<0.001	24.9%	19.9%	18.1%	<0.001
Median CAGE (IQR)	—[‡]	0 (0–1)	0 (0–1)	<0.001	—[‡]	0 (0–0)	0 (0–0)	<0.001
CAGE ≥ 2 (%)	—[‡]	17.0%	19.8%	<0.001	—[‡]	5.2%	8.7%	<0.001

[†]*P*-values were calculated using the χ^2-test (categorical variables), analysis of variance (continuous variables), Wilcoxon test (continuous variables), or Kruskal–Wallis test (continuous variables).
[‡]CAGE questionnaire was not used in 2012.
CAGE, attempts to Cut back on drinking, being Annoyed at criticisms about drinking, feeling Guilty about drinking, and using alcohol as an Eye opener; IQR, interquartile range; K6, Kessler 6-item Scale; PCL, Post-traumatic Stress Disorder Checklist.

Table 3. Age-adjusted prevalence (%) of K6 ≥ 13, PCL ≥ 44, and CAGE ≥ 2

	K6 ≥ 13				PCL ≥ 44				CAGE ≥ 2 (Among current drinkers)		
	2012	2013	2014	*P* for trend[†]	2012	2013	2014	*P* for trend	2013	2014	*P* for trend
Men	29 081	21 864	18 358	—	29 548	21 594	18 322	—	13 735	11 856	—
All participants	12.4%	11.7%	11.4%	<0.001	19.0%	18.1%	17.8%	<0.001	20.7%	20.4%	0.178
Age											
20–39 years	13.1%	12.3%	12.2%	<0.001	15.0%	13.9%	13.7%	<0.001	17.9%	17.8%	0.917
40–64 years	11.9%	11.2%	11.1%	<0.001	16.7%	15.6%	15.7%	<0.001	22.5%	21.9%	0.063
≥65 years	12.5%	12.0%	11.5%	<0.001	22.9%	22.3%	21.7%	<0.001	19.6%	19.6%	0.970
Original address before evacuation											
Still under the evacuation order	15.8%	14.9%	14.4%	<0.001	23.5%	22.3%	21.9%	<0.001	20.4%	20.2%	0.559
Order lifted	10.2%	9.5%	9.4%	<0.001	16.1%	15.2%	15.0%	<0.001	20.9%	20.5%	0.201
Living place (present address)											
Inside Fukushima prefecture	11.6%	10.7%	—[‡]	<0.001	17.9%	16.9%	—[‡]	<0.001	20.5%	—[‡]	—
Outside Fukushima prefecture	16.2%	15.1%	—[‡]	<0.001	22.7%	21.2%	—[‡]	<0.001	21.6%	—[‡]	—
Drinking status											
Never/rare drinker	12.9%	12.5%	12.2%	<0.001	19.1%	18.2%	17.9%	<0.001	—	—	—
Past drinker	18.6%	18.1%	17.8%	0.030	27.2%	26.9%	27.4%	0.745	—	—	—
Current drinker	11.5%	10.7%	10.5%	<0.001	18.0%	16.9%	16.7%	<0.001	—	—	—
Women	36 310	26 822	22 661	—	36 790	26 648	22 747		6937	5880	—
All participants	17.4%	16.3%	15.8%	<0.001	25.3%	23.6%	23.3%	<0.001	10.5%	10.5%	0.905
Age											
20–39 years	14.2%	13.2%	13.0%	<0.001	19.4%	17.4%	17.4%	<0.001	13.1%	12.3%	0.080
40–64 years	17.3%	16.0%	15.6%	<0.001	23.2%	21.2%	21.0%	<0.001	10.8%	11.1%	0.362
≥65 years	19.2%	18.3%	17.6%	<0.001	30.6%	29.5%	28.9%	<0.001	6.0%	6.5%	0.264
Original address before evacuation											
Still under the evacuation order	21.5%	19.9%	19.3%	<0.001	30.7%	28.5%	28.1%	<0.001	11.1%	10.9%	0.742
Order lifted	14.8%	13.9%	13.6%	<0.001	22.0%	20.4%	20.1%	<0.001	9.9%	10.1%	0.652
Living place (present address)											
Inside Fukushima prefecture	16.7%	15.2%	—[‡]	<0.001	24.2%	22.0%	—[‡‡]	<0.001	9.7%	—[‡]	—
Outside Fukushima prefecture	20.0%	18.6%	—[‡]	<0.001	28.9%	26.1%	—[‡]	<0.001	13.4%	—[‡]	—
Drinking status											
Never/rare drinker	17.0%	16.0%	15.6%	<0.001	24.9%	23.2%	22.9%	<0.001	—	—	—
Past drinker	22.2%	21.4%	21.3%	0.103	29.6%	28.9%	28.7%	0.199	—	—	—
Current drinker	16.7%	15.3%	14.9%	<0.001	24.1%	22.0%	21.8%	<0.001	—	—	—

[†]*P* for trend was calculated by period as a categorical variable.
[‡]Living place (present address) was not requested in 2014.
CAGE, attempts to Cut back on drinking, being Annoyed at criticisms about drinking, feeling Guilty about drinking, and using alcohol as an Eye opener; K6, Kessler 6-item Scale; PCL, Post-traumatic Stress Disorder Checklist.

residence, individuals who lived outside of Fukushima prefecture scored at least three points more than those who lived in Fukushima prefecture in 2012 and 2013, in terms of both psychological distress and post-traumatic stress. Concerning drinking status, whether men or women had been drinkers in the past did not appear to influence changes in psychological distress and post-traumatic stress over time. Additionally, the prevalence of problem drinking did not differ by age or disaster-related factors between 2013 and 2014.

DISCUSSION

Our data indicate that the prevalence of general psychological distress by K6 ≥ 13 remained high even

3 years after the disaster in both men (11.4%) and women (15.8%), compared with Japanese data for individuals in a non-disaster standard setting (4.7%, among 15–64-years-old).[13] The most important finding of our study was that the prevalence of general psychological distress and post-traumatic stress symptoms decreased over time, whereas the prevalence of problem drinking remained steady during 2012 and 2013. This discrepancy in the time course of change between problem drinking and psychological distress is consistent with previous studies.[14,15] Unexpectedly, not current drinkers but past drinkers had a high prevalence of post-traumatic stress, and the number of individuals who were at a high risk of PTSD, according to the PCL, remained relatively high over time. Although we could not determine the reasons for alcohol abstinence, we speculate that respondents who quit drinking might have done so due to problems with mental and/or physical health.

With respect to sex differences, our results are consistent with previous findings that women are more likely to suffer from anxiety and stress-related disorders, such as PTSD, while men are more likely to be affected by substance-related disorders.[16] Concerning age groups, it is notable that around 40% of our sample was over 65 years old; therefore, our results on age differences should be discussed with caution. Although the reason is unclear, previous studies have produced inconsistent evidence regarding mental health vulnerability in older adults following disasters.[17] Four distinct approaches have been proposed to explain the potential differential effects of age: the resource, exposure, inoculation, and burden perspectives.[18] The resource and exposure perspectives relate to the vulnerability of older adults, while the inoculation and burden perspectives represent the resilience of people in this age group. Interestingly, older residents seemed to have more severe post-traumatic stress but less severe psychological distress compared with those in other age groups in our study. Perhaps the older residents were more vulnerable to post-traumatic stress and felt greater losses associated with the disaster. Our results suggest that long-term interventions focused on post-traumatic stress are greatly needed.

We found clear evidence that living circumstances (i.e., whether an individual's residence was affected by the evacuation order) had an impact on their mental health over the 3 years of the study. This suggests that the increased levels of psychological distress experienced by people living in the strongly affected area continued over a long period of time after the disaster. One study in the Chernobyl disaster literature showed that, 15 years after the disaster, proximity to the event was related to poor self-perceived physical health, as well as current symptoms of depression, anxiety, and Chernobyl-related trauma distress, as measured using standardized tests.[19] In our study, the response rates of individuals living in Fukushima prefecture decreased over time, while the response rates of those from the area currently under the evacuation order (i.e., those required to live elsewhere) increased. This phenomenon might indicate that residents from regions that are currently under the evacuation order take a greater interest in mental health issues.

Our results clearly demonstrated higher levels of psychological distress and post-traumatic stress among residents whose present residence was outside of Fukushima prefecture compared with those who were living in Fukushima prefecture during the 3-year period of study. A recent systemic review on the health effects of relocation following a disaster reported that relocated individuals are more likely to experience psychological morbidity post-disaster.[20] Relocation alters regular routines associated with homes, jobs, physical activity, participation in social organizations, and health-care access.[21] It may also introduce additional stressors, for instance, evacuees may feel socially isolated, in danger, or that they are victims of discrimination.[22] Social stigma against the survivors of the Fukushima Nuclear Power Plant accident has also been discussed in recent studies.[22–24] Ben-Ezra *et al.* showed that radiation stigma was related to PTSD symptoms.[24] Public policy should consider the negative effects of relocation, especially post-relocation psychological burden.

There are several limitations to this study. First, the participants in each survey differed. We did not limit the study samples with respondents of all three assessments for this study. An advantage of this trend survey was that we could use the data of larger samples and obtain an overview of the assessments. However, it must be mentioned that we did not analyze sex differences, age groups, or living status within the samples in this study. Second, the measures used in self-rating questionnaires

are inferior to clinician-administered diagnostic tools that can be employed in interviews. Third, this study was conducted among residents in the affected area, and we did not have a control group (i.e., no comparison with individuals in other prefectures or distant areas in Fukushima prefecture). Fourth, the response rates of this study were not high. This might create a sampling bias (e.g. some distressed residents might tend not to answer the questionnaires). Fifth, we included not only past and current evacuees, but also not-evacuated residents whose municipalities had received partial evacuation. Finally, it must be noted that there were many confounding factors. For example, our team conducted interventions via telephone and mail service for the high-risk group, according to our K6 and PCL data, as post-survey support.[4] Other examples of the confounding factors might be financial issues, employment changes, temporary housing problems, or interpersonal issues. These factors might have affected the degree of psychological distress.

Despite these limitations, the present study clearly characterizes the longitudinal course of psychological distress, post-traumatic stress, and problem drinking after the disaster in Fukushima. We hope that our findings will contribute to the development of effective interventions in public health practice. Long-term continuous observational studies are needed to understand the lasting psychological distress experienced by residents affected by the triplet disaster, namely the earthquake, tsunami, and nuclear power plant accident in Fukushima.

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AUTHOR CONTRIBUTIONS

Conception and design of the study: M. A., S. Y., S. F. and M. M. Acquisition and analysis of data: S. F., M. N. and M. H. Drafting the manuscript: M. O., S. F., M. M. and M. N. Others, supervised data interpretation: I. M., H. Y., T. O., H. T., Y. S., S. Y. and M. A.

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