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Alcohol Consumption Behaviors in the Immediate Aftermath of Earthquakes

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Abstract

Objectives: Earthquakes are distressing natural phenomena that can potentially disrupt normal health behaviors. The aim of this study was to investigate changes in alcohol consumption behaviors in the immediate aftermath of mild to moderate earthquakes.

Setting: This retrospective cohort study conducted at a large academic hospital in Tokyo, Japan, from April 2004 to March 2017.

Participants: We included all adult patients presenting to the emergency room with acute alcohol intoxication.

Primary and secondary outcome measures: Our outcome was the number of such patients per 24-hour period, comparing days with and without earthquake activity. We conducted simple generalized autoregressive conditional heteroscedasticity (GARCH) analysis, followed by multivariate GARCH including year-fixed effects and secular changes in alcohol taxation. Subanalyses were conducted by gender and age group.

Results: During the study period, 706 earthquakes were observed with median magnitude of 5.2 (SD: 1.0). During this period, 6,395 patients were admitted with acute ethanol intoxication; mean age was 42.6 (SD: 16.9) years and 4,592 (71.8%) were male. In univariate analyses, daytime earthquake was marginally inversely related to the number of acutely intoxicated patients (β coefficient: -0.19, 95% CI: -0.40 - 0.01). This finding remained similar in multivariate analyses after adjustment for covariates. In analyses stratified by gender, the inverse association between daytime earthquake and alcohol intoxication was only observed among men (p<0.03 for male and p=0.99 for female). In subanalyses by age, older people were less likely to

be admitted to the hospital due to acute alcohol intoxication on days with daytime earthquakes (p=0.11), but not younger people (p=0.36).

Conclusion: On days when a mild to moderate daytime earthquake occurred, the number of patients with acute alcohol intoxication was lower compared to days without earthquakes. Even milder forms of potentially catastrophic events appear to influence social behavior; mild to moderate earthquake activity is associated with avoidance of excessive alcohol consumption.

Article summary

Strengths and limitations of this study

・This is the first and quite unique study which evaluated alcohol consumption behavior immediate aftermath earthquakes.

・Robust analyses supported the findings in this study.

・The limitation of this study was that single center with single ethnicity.

Introduction

Catastrophic earthquake activity has been reported to exert a variety of effects on both physical as well as mental health [1]. A previous study reported that approximately 42.6% of victims exhibited moderate to serious mental health problems after the Great East Japan earthquake, which occurred in March 2011 [1]. Acute health effects associated with experience of earthquake activity include acute stress disorders [2], delirium, [3] as well as acute and transient psychotic disorders. Longer term effects on victims` well-being have also been reported, including post-traumatic stress disorder and exacerbation of bipolar disorder [4-6]. Although the majority of previous research has been limited to the health impacts of rare catastrophic earthquakes, very few studies have focused on the health effects associated with substantially more common mild to moderate earthquakes.

Substance abuse is a common disorder reported in the setting of catastrophic disasters [7,8]. Several studies have explored this relationship with regard to alcohol use behaviors [9,10], with several previous studies reporting an increased prevalence of alcohol abuse after major earthquakes. [11,12] However, in the larger context of catastrophic phenomena this association remains unclear, with one report showing only a 2% increase in prevalence after a major hurricane [13] and other studies reporting a slight decrease in alcohol abuse after instances of terrorism [9,14]. As such, the effect of disasters on alcohol abuse remains controversial. Previous studies have suggested gender, age, education, and even cultural background modify these associations. [15,16]

Japan is a tectonically-active country where earthquakes are observed frequently. The Japan Meteorological Agency observed 2,025 earthquakes in 2017 and more than 6,500 earthquakes were observed in 2016 in Japan [17]. Among the, 76 (3.8%) in 2017 and 123 (1.9%) in 2016 of earthquakes were more than magnitude of 5. In addition to incidence of earthquakes, the Japan Meteorological Agency also recorded the date and time, magnitude, location, and seismic intensity [18]. Thus, the aim of this study was to evaluate the same-day association between mild to moderate earthquakes and unhealthy alcohol use behavior in Japan.

Methods

Cohort description

Patient and Public Involvement

We conducted a retrospective daily time series study using medical records data from St. Luke's International Hospital, Tokyo, Japan from April 2004 to March 2017. We included all adult patients presenting to the hospital emergency room with acute alcohol intoxication. We excluded all patients who signed opt out agreements for their anonymized data to be used in research. In addition, patients presenting with altered mental status of uncertain origin were excluded. Our outcome was patient volume of acutely intoxicated patients per 24-hour period. Outcomes were compared between days with and without earthquakes, as observed by the Japan Meteorological Agency. The ethical committee at St. Luke's International Hospital approved this study (approval number: 17-R025). In terms of data sharing, no additional patients' data were available, although data about earthquakes were available on the website of Japan Meteorological Agency [17]. This study was totally authors' own work and there was no funding to support this study. The results of this study will be disseminated through publication and will not be noticed to each participant because this was a retrospective design.

Acute alcohol intoxication

The diagnosis of acute alcohol intoxication was made clinically based on testimony by patients or their companions. Blood ethanol level of 100 mg/dl or higher was used to support the diagnosis for those in whom testimony could not be elicited directly [19].

Earthquake

All earthquake data was obtained from the Japan Meteorological Agency [17]. Recorded data contains time and date of occurrence, the Richter magnitude, the depth of epicentre, and Shindo scale data for any earthquake sensed. With a range of 0 to 7, Shindo is the unique measurement scale used in Japan for seismic intensities in a specific area [18]. Unlike the Richter scale, which represents the size of earthquake itself and is unique for each earthquake, Shindo scaling reflects intensity of observed shaking in a given area, and is based on distance from epicenter at which the seismic activity was observed. Generally speaking, the further the observed area is from the epicenter, the lower the Shindo measurement is for that area. A Shindo score of 1 is comparable to mild sense of shaking observed only when sitting quietly in a structure, while a Shindo score of 4 is defined as observable shaking enough to cause startle, awakenings from sleep, and which may be felt while walking. A Shindo score of 7 equates to severe shaking in which it is impossible to remain standing or to move without crawling. We defined daytime earthquake as those observed between 9 a.m. to 5 p.m., while night time earthquake was defined as occurring between 5 p.m. to 12 a.m.

Study site

St. Luke's International Hospital is located in Chuo-ku, Tokyo, Japan. The hospital, a 520-bed tertiary-level community teaching hospital, accepts more than 10,000 ambulance admissions a year. Located close to Ginza, a major entertainment district popular for bars and restaurants serving alcohol, St. Luke`s receives the largest number of ambulances per year, including approximately 50% of ambulances dispatched from the Ginza area. We included only earthquakes which were observed in this metropolitan Tokyo area in the analyses.

Category of day in relation to work week and seasonality

Because the incidence of acute alcohol intoxication is considered to vary substantially by day of the week, we divided days into three categories: weekdays, the day prior to a non-working day, and non-working day (generally understood in Japan to be Saturday, Sunday, and designated national holidays). For days overlapping categories, we considered the day prior to a non-working day was most dominant. For instance, as January 1st, 2nd, and 3rd are designated national holidays in Japan, we categorized January 1st and 2nd as days prior to non-working day, and 3rd as a non-working day.

As the incidence of acute alcohol intoxication is also considered to be related to seasonality, we categorized March, April and May into spring; June, July and August into summer; September, October and November into fall; December, January and February into winter.

Statistical analyses

Because the occurrence of earthquakes on a certain day was considered to be autocorrelated and have autoregressive conditional heteroscedasticity (ARCH) effect (Figure), we applied multivariate generalized autoregressive conditional heteroscedasticity (GARCH) approach with dynamic conditional correlation to investigate the association between patient presentation to the ER with acute alcohol intoxication and occurrence of earthquakes [20-22]. In terms of primary outcome, we first applied a simple GARCH model with each variable examining the relationship between hospital admission for acute alcohol intoxication and earthquake activity, category of day, and seasonality. This was followed by a multivariate GARCH(1,1) model performed with variables found to have p value of 0.2 or lower in the simple GARCH model, as well as year-fixed effect and changes in alcohol taxation. β coefficient and 95% confidence intervals (CI) were calculated. In addition, we stratified the analyses by both gender and age (50 years or older versus less than 50 years). Moreover, we separately analyzed data before the Great East Japan earthquake on March 11, 2011 and after the earthquake. We also conducted sensitivity analyses to check robustness with the following three methods: including Richter scale magnitude as covariate to evaluate whether the results differ according to magnitude of the earthquake; introducing different lag times between the earthquake and hospital visits(e.g. 1, 3 or 7 days later from earthquakes); excluding days in which severe earthquakes (Shindo scale ≥4) occurred. All analyses were performed using Stata 14.0 (Stata Corp, TX, USA).

Results

During the study period, earthquakes were observed 706 times with median Shindo score in the catchment area of 2 (Interquartile range 1). During the 4,747 days in the study period, earthquakes were observed on 500 days. During this period, 6,395 patients were treated with acute ethanol intoxication with mean age of 42.6 (*SD* 16.9); 4,592 (71.8%) were male.

Table 1 shows the results for number of patients with acute ethanol intoxication from the simple and multivariate GRACH models. In univariate analyses, daytime earthquake was marginally and inversely related to the number of acutely intoxicated patients (β coefficient: -0.19, 95% CI: -0.40 - 0.01). Days prior to a non-working day (β coefficient: 0.26, 95%CI: 0.15 - 0.37) was significantly and non-working days (β coefficient: 0.08, 95%CI: -0.01 - 0.14) was marginally significantly related to acute intoxication. These findings remained similar in multivariate analyses after adjusting for both occurrence of a daytime earthquake, category of day, seasonality, year-fixed effect and change in alcohol taxation.

In sensitivity analysis, including Richter scale magnitude as a covariate to evaluate whether the results differ according to magnitude of the earthquake, daytime earthquake was still marginally related to decreased patient volume (β coefficient: -0.23, 95% CI: -0.47 - 0.01). However, the magnitude of earthquake itself had no relation with patient volume (β coefficient: 0.01, 95% CI: -0.02 - 0.04). When we introduced different lag times between the earthquake and hospital visits, daytime earthquake was also marginally related to decreased patient volume significantly (β coefficient: -0.18, 95% CI: -0.38 - 0.01 for 1 day later from earthquake; β coefficient: -0.18, 95% CI: -0.38 - 0.02 for 3 days later from earthquake; and β coefficient: -0.18, 95% CI: -0.38 - 0.02 for 7 day later from earthquake), while different lag times themselves were not associated with patient volume. When we excluded days in which severe earthquakes

(Shindo scale ≥4) occurred, findings were similar [daytime earthquake (β coefficient: -0.18, 95% CI: -0.38 - 0.02)].

Table 2 shows the result for the number of patients with alcohol intoxication from univariate and multivariate analyses stratified by gender. The inverse association between daytime earthquake and alcohol intoxication seen in pooled analysis was only observed among men (p<0.03 for male and p=0.99 for female). Although a positive association between the day before non-working days and acute alcohol intoxication were observed in both males (p<0.01) and females (p<0.01), higher rates of intoxication on non-working days was only observed in women (p=0.02 for female and p=0.35 for male). Among male patients, the number of patients with acute alcohol intoxication rose during winter compared to spring (p=0.01), but not among females (p=0.42).

Table 3 shows the result for the number of patients with alcohol intoxication from univariate and multivariate analyses stratified by age group. Older people were less likely to be admitted to ER due to acute alcohol intoxication on days when daytime earthquakes occurred (p=0.11), but the same pattern was not seen among younger people (p=0.36). Both older and younger patients with acute alcohol intoxication were more likely to be admitted on the days before non-working days, as well as on non-working days compared to weekdays. However, in terms of seasonality, older people were significantly more likely to be admitted to the ER with acute alcohol intoxication in the winter season (p<0.01), but not younger people (p=0.83)

In terms of stratification by the date of the Great East Japan earthquake, daytime earthquake was inversely related to the number of acutely intoxicated patients after the Great East Japan earthquake (β coefficient: -0.28, 95% CI: -0.55 - -0.02), while daytime earthquake was not related before the Great East Japan earthquake (β coefficient: -0.02, 95% CI: -0.32 - 0.29).

Discussion

Our study found several predictors of the number of intoxicated patients presenting to the ER of a major urban hospital in Japan. Notably, there was an inverse relationship between the number of intoxicated patients and daytime earthquakes observed in older patients and men.

Although previous studies that evaluated drinking behavior after catastrophic earthquakes reported both positive and negative effects, we found that non-catastrophic earthquakes may exert a dampening (i.e. a health-favorable) effect on excess alcohol consumption. This finding was considered to be a kind of stress-related growth, which is the theory that people grow from negative events [23]. We speculate that people may avoid risky behaviors, such as going out with companions after work to indulge in excessive amounts of drinking, immediately after an earthquake. When people experience earthquakes, many may suspect additional tectonic activity; multiple earthquakes in a single day are common and were observed on 83 (16.7%) days in our study. As a result, we suspect that many people choose to go home rather than go out, as has been documented in reports about catastrophic earthquakes [24]. People may avoid social activities, such as after-work gatherings, on days in which even mild, but nevertheless frightening, natural phenomena has occurred, thereby lowering the opportunities for excessive drinking and other risky social behaviors. Lower blood alcohol levels noted on earthquake days also suggests that even imbibers may limit the amount of alcohol consumed on such days. Similar social behaviors have been observed after the Great East Japan earthquake in 2011, though whether these behavioral changes are conscious or unconscious remains unclear [25].

We found both age and gender differences in the relationship between daytime earthquakes and acute alcohol intoxication. There were statistically fewer male patients with acute alcohol intoxication on days when a daytime earthquake occurred compared to days without seismic activity. Interestingly, this relationship was not found for female patients. A previous systematic review reported differing patterns of alcohol use between men and women are driven by both biological and psycho-socio-cultural factors [26]. As a result, men are more likely to seek sensation, including hazardous drinking, than women in ordinal settings [27,28]. However, it is possible that mild earthquakes may affect these psycho-socio-cultural factors more for men than women. Social capital may play an important role for this [29]. Because most Japanese male workers drink with colleagues after work [30], some may suggest others not to go out for drinking after work on the day with earthquakes.

In terms of age, fewer older patients with acute alcohol intoxication were observed on days with earthquakes, despite an unchanged number of younger patients presenting with acute alcohol intoxication on these days. A previous surveys about alcohol use reported that younger people tended to have more binge drinking and heavy episodic drinking not only in Japan [31], but also other countries [32]. Psychologically disturbing natural phenomenon, however mild, may also exert specific inhibitory psycho-socio-cultural effects on risky behaviors of younger people. Further research is needed to evaluate the potential mechanisms for these differences.

Significantly fewer patients with acute alcohol intoxication were observed on days with daytime earthquakes compared to that on days without daytime earthquakes after the date of the Great East Japan earthquake, while the finding was not observed before the date of the Great East Japan earthquake. This suggests that people still have catastrophic earthquake in their mind and avoid sensation seeking from stress-related growth.

Our study has some limitations. First, not all potential patients with acute alcohol intoxication were transferred to our hospital, resulting in a measure of selection bias. However, as our hospital has the largest number and highest rate of ambulance acceptances in Tokyo, with more than 50% of ambulances dispatched to the local entertainment area were transferred to us, we assume that this bias is neither large nor differential. In addition, the findings may not be applied to other countries, because ethnicity and cultural diversity could exist [33]. Second, as we were unable to accurately record information about when patients started to consume alcohol, a precise knowledge of the temporal relationship between alcohol consumption, intoxication, and earthquakes is difficult to assess. Similarly, as qualitative data concerning patients` physical and emotional perception of seismic activity is not available, further studies are warranted in this area. In addition, the evaluation for acute stress disorder may be useful to explain gender and age difference of findings.

Conclusion

On days when mild to moderate daytime earthquakes occurred, our hospital experienced fewer number of patients with acute alcohol intoxication presenting to the emergency room. This pattern was also seen for men and elderly patients. Even mild natural phenomena may lead to changes in social behavior that result in avoidance of excessive alcohol use.

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References

1. Yokoyama Y, Otsuka K, Kawakami N, et al. Mental health and related factors after the Great East Japan earthquake and tsunami. *PLoS One.* 2014;9(7):e102497.
2. Zhou P, Zhang Y, Wei C, Liu Z, Hannak W. Acute stress disorder as a predictor of posttraumatic stress: A longitudinal study of Chinese children exposed to the Lushan earthquake. *Psych J.* 2016;5(3):206-214.
3. Awata S. [Disaster psychiatry in late life]. *Nihon Rinsho.* 2013;71(10):1864-1869.
4. Navarro-Mateu F, Salmeron D, Vilagut G, et al. Post-Traumatic Stress Disorder and other mental disorders in the general population after Lorca's earthquakes, 2011 (Murcia, Spain): A cross-sectional study. *PLoS One.* 2017;12(7):e0179690.
5. Cai D, Zhu Z, Sun H, et al. Maternal PTSD following Exposure to the Wenchuan Earthquake Is Associated with Impaired Mental Development of Children. *PLoS One.* 2017;12(4):e0168747.
6. Derivois D, Cenat JM, Joseph NE, Karray A, Chahraoui K. Prevalence and determinants of post-traumatic stress disorder, anxiety and depression symptoms in street children survivors of the 2010 earthquake in Haiti, four years after. *Child Abuse Negl.* 2017;67:174-181.
7. Seligman J, Felder SS, Robinson ME. Substance Abuse and Mental Health Services Administration (SAMHSA) Behavioral Health Disaster Response App. *Disaster Med Public Health Prep.* 2015;9(5):516-518.
8. Moise IK, Ruiz MO. Hospitalizations for Substance Abuse Disorders Before and After Hurricane Katrina: Spatial Clustering and Area-Level Predictors, New Orleans, 2004 and 2008. *Prev Chronic Dis.* 2016;13:E145.
9. North CS, Pfefferbaum B. Mental health response to community disasters: a systematic review. *JAMA.* 2013;310(5):507-518.
10. Vlahov D, Galea S, Resnick H, et al. Increased use of cigarettes, alcohol, and marijuana among Manhattan, New York, residents after the September 11th terrorist attacks. *Am J Epidemiol.* 2002;155(11):988-996.
11. Pollice R, Bianchini V, Roncone R, Casacchia M. Marked increase in substance use among young people after L'Aquila earthquake. *Eur Child Adolesc Psychiatry.* 2011;20(8):429-430.
12. Keyes KM, Hatzenbuehler ML, Hasin DS. Stressful life experiences, alcohol consumption, and alcohol use disorders: the epidemiologic evidence for four main types of stressors. *Psychopharmacology (Berl).* 2011;218(1):1-17.
13. David D, Mellman TA, Mendoza LM, Kulick-Bell R, Ironson G, Schneiderman N. Psychiatric morbidity following Hurricane Andrew. *J Trauma Stress.* 1996;9(3):607-612.
14. Knudsen HK, Roman PM, Johnson JA, Ducharme LJ. A changed America? The effects of September 11th on depressive symptoms and alcohol consumption. *J Health Soc Behav.* 2005;46(3):260-273.
15. Cepeda A, Saint Onge JM, Kaplan C, Valdez A. The association between disaster-related experiences and mental health outcomes among drug using African American Hurricane Katrina evacuees. *Community Ment Health J.* 2010;46(6):612-620.

16. Bianchini V, Roncone R, Giusti L, Casacchia M, Cifone MG, Pollice R. PTSD Growth and Substance Abuse Among a College Student Community: Coping Strategies after 2009 L'aquila Earthquake. *Clin Pract Epidemiol Ment Health.* 2015;11:140-143.

17. Japan Meteorological Agency. Shindo database. 2018; http://www.jma.go.jp/jma/indexe.html. Accessed April 10, 2018.

18. Ruckinger S, von Kries R, Toschke AM. An illustration of and programs estimating attributable fractions in large scale surveys considering multiple risk factors. *BMC Med Res Methodol.* 2009;9:7.

19. Vonghia L, Leggio L, Ferrulli A, et al. Acute alcohol intoxication. *Eur J Intern Med.* 2008;19(8):561-567.

20. Bollerslev T. Generalized autoregressive conditional heteroskedasticity. *Journal of econometrics.* 1986;31(3):307-327.

21. Engle RF. Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica: Journal of the Econometric Society.* 1982:987-1007.

22. Engle R. Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business & Economic Statistics.* 2002;20(3):339-350.

23. Park CL, Cohen LH, Murch RL. Assessment and prediction of stress-related growth. *J Pers.* 1996;64(1):71-105.

24. Ito K, Aono A, and Ohmori N. Empirical Study on Stop-Offs en Route Home in the Aftermath of an Earthquake Disaster in the Tokyo Metropolitan Area – Analyses Based on an Online Questionnaire Survey about the Great East Japan Earthquake. Journal of the City Planning Institute of Japan, Vol.48, No.3, pp. 873-878, 2013.

25. Zare M, Afrouz SG. Crisis management of tohoku; Japan earthquake and tsunami, 11 march 2011. *Iran J Public Health.* 2012;41(6):12-20.

26. Erol A, Karpyak VM. Sex and gender-related differences in alcohol use and its consequences: Contemporary knowledge and future research considerations. *Drug Alcohol Depend.* 2015;156:1-13.

27. Bosque-Prous M, Espelt A, Borrell C, et al. Gender differences in hazardous drinking among middle-aged in Europe: the role of social context and women's empowerment. *Eur J Public Health.* 2015;25(4):698-705.

28. Holmila M, Raitasalo K. Gender differences in drinking: why do they still exist? *Addiction.* 2005;100(12):1763-1769.

29. Zarzar PM, Jorge KO, Oksanen T, Vale MP, Ferreira EF, Kawachi I. Association between binge drinking, type of friends and gender: a cross-sectional study among Brazilian adolescents. *BMC Public Health.* 2012;12:257.

30. Hagihara A, Tarumi K, Nobutomo K. Work stressors, drinking with colleagues after work, and job satisfaction among white-collar workers in Japan. *Subst Use Misuse.* 2000;35(5):737-756.

31. Osaki Y, Kinjo A, Higuchi S, et al. Prevalence and Trends in Alcohol Dependence and Alcohol Use Disorders in Japanese Adults; Results from Periodical Nationwide Surveys. *Alcohol Alcohol.* 2016;51(4):465-473.

32. Quinn PD, Harden KP. Differential changes in impulsivity and sensation seeking and the escalation of substance use from adolescence to early adulthood. *Dev Psychopathol.* 2013;25(1):223-239.

33. Betsy T. Risk-taking behaviour in men. Substance use and gender. 2003; https://pdfs.semanticscholar.org/2067/3ca32192d2577058acc9430f2ae6ad988d31.pdf. Accessed August 4, 2018.

	Univariate GARCH* model			Multivariate GARCH* model		
Variable	β coefficient	95%CI†	*p* value	β coefficient	95%C†	*p* value
Earthquake factors						
Incidence of earthquake	0.00	(-0.12 — 0.12)	0.95			
Number of earthquake a day, times	-0.02	(-0.06 — 0.03)	0.46			
The depth of epicenter, km	0.00	(-0.01 — 0.01)	0.85			
The highest magnitude in a day	0.00	(-0.02 — 0.02)	0.98			
The highest shindo in a day	0.00	(-0.08 — 0.07)	0.92			
Daytime earthquake§	-0.19	(-0.40 — 0.01)	0.06	-0.18	(-0.38 — 0.02)	0.07
Nighttime earthquake‡	0.12	(-0.12 — 0.35)	0.34			
Date						
Categories of day						
Weekday		Reference			Reference	
The day before non-working day	**0.26**	**(0.15 — 0.37)**	**<0.01**	**0.25**	**(0.15 — 0.36)**	**<0.01**
Non-working day	0.08	(-0.01 — 0.17)	0.05	0.08	(-0.01 — 0.16)	0.08
Season						
Spring		Reference			Reference	
Summer	0.02	(-0.09 — 0.13)	0.73	0.02	(-0.09 — 0.12)	0.78
Fall	0.05	(-0.06 — 0.17)	0.35	0.03	(-0.76 — 0.14)	0.55
Winter	0.10	(-0.01 — 0.22)	0.07	**0.12**	**(0.02 — 0.23)**	**0.02**

Table 1. β coefficients for number of patients with acute ethanol intoxication from univariate and multivariate GARCH model

*GARCH represents generalized autoregressive conditional heteroskedasticity. Multivariate GARCH model was adjusted for variables found to have *p* value of 0.2 or less in simple GARCH model, as well as year-fixed effect and changes in alcohol taxation.; †CI represents confidence interval; §Daytime earthquake means that earthquake was observed between 9 a.m. to 5 p.m.; ‡Nighttime earthquake means that earthquake was observed between 5 p.m. to 12 p.m.. Numbers in bold indicate that the p value is less than 0.05.

	Male (*n* = 4,646)				Female (*n* = 1,826)			
	Univariate GARCH*		Multivariate GARCH*		Univariate GARCH*		Multivariate GARCH*	
Variable	β coefficient (95%CI†)	*p* value	β coefficient (95%CI†)	*p* value	β coefficient (95%C†)	*p* value	β coefficient (95%C†)	*p* value
Earthquake factors								
Incidence of earthquake	0.00 (-0.11 — 0.10)	0.98			-0.01 (-0.07 — 0.05)	0.86		
Number of earthquake a day, times	-0.01 (-0.05 — 0.02)	0.39			0.00 (-0.02 — 0.02)	0.79		
The depth of epicenter, km	0.00 (-0.00 — 0.00)	0.98			0.00 (-0.01 — 0.01)	0.78		
The highest magnitude in a day	0.00 (-0.02 — 0.02)	0.98			0.00 (-0.01 — 0.01)	0.98		
The highest shindo in a day	-0.01 (-0.07 — 0.05)	0.81			0.00 (-0.03 — 0.04)	0.94		
Daytime earthquake§	**-0.19 (-0.36 — -0.02)**	**0.02**	**-0.19 (-0.36 — -0.02)**	**0.03**	0.00 (-0.09 — 0.10)	0.95	0.00 (-0.10 — 0.10)	0.99
Nighttime earthquake‡	0.05 (-0.14 — 0.25)	0.59			0.05 (-0.07 — 0.16)	0.41		
Date								
Categories of day								
Weekday	Reference				Reference			
The day before non-working day	**0.19** (0.10 — 0.28)	**<0.01**	**0.19** (0.10 — 0.28)	**<0.01**	**0.08 (0.03 — 0.13)**	**<0.01**	**0.08 (0.03 — 0.13)**	**<0.01**
Non-working day	0.04 (-0.04 — 0.11)	0.34	0.04 (-0.04 — 0.11)	0.35	**0.05 (0.01 — 0.09)**	**0.02**	**0.05 (0.01 — 0.09)**	**0.02**
Season								

Spring	Reference				Reference			
Summer	-0.00 (-0.10 — 0.09)	0.93	-0.00 (-0.10 — 0.09)	0.93	0.02 (-0.03 — 0.07)	0.42	0.02 (-0.03 — 0.08)	0.37
Fall	0.02 (-0.07 — 0.12)	0.63	0.02 (-0.08 — 0.11)	0.74	0.02 (-0.04 — 0.07)	0.55	0.01 (-0.04 — 0.07)	0.58
Winter	**0.12 (0.02 — 0.21)**	**0.01**	**0.12 (0.02 — 0.21)**	**0.01**	-0.02 (-0.07 — 0.03)	0.43	-0.02 (-0.07 — 0.03)	0.42

Table 2. β coefficients for number of patients with acute ethanol intoxication from univariate and multivariate GARCH model by gender

*GARCH represents generalized autoregressive conditional heteroskedasticity. Multivariate GARCH model was adjusted for variables found to have *p* value of 0.2 or less in simple GARCH model, as well as year-fixed effect and changes in alcohol taxation; †CI represents confidence interval; §Daytime earthquake means that earthquake was observed between 9 a.m. to 5 p.m.; ‡Nighttime earthquake means that earthquake was observed between 5 p.m. to 12 p.m.. Numbers in bold indicate that the p value is less than 0.05.

Variable	50 years or older (n = 2,202)				Younger than 50 years (n = 4,270)			
	Univariate GARCH*		Multivariate GARCH*		Univariate GARCH*		Multivariate GARCH*	
	β coefficient (95%CI†)	p value	β coefficient (95%CI†)	p value	β coefficient (95%C†)	p value	β coefficient (95%C†)	p value
Earthquake factors								
Incidence of earthquake	-0.03 (-0.10 — 0.04)	0.37			0.03 (-0.07 — 0.13)	0.54		
Number of earthquake a day, times	-0.01 (-0.03 — 0.01)	0.35			0.00 (-0.04 — 0.03)	0.82		
The depth of epicenter, km	0.00 (-0.00 — 0.00)	0.67			0.00 (-0.01 — 0.01)	0.98		
The highest magnitude in a day	-0.01 (-0.02 — 0.01)	0.39			0.01 (-0.01 — 0.03)	0.54		
The highest shindo in a day	-0.02 (-0.06 — 0.02)	0.35			0.02 (-0.04 — 0.08)	0.58		
Daytime earthquake§	-0.09 (-0.20 — 0.01)	0.09	-0.09 (-0.19 — 0.02)	0.11	-0.07 (-0.23 — 0.10)	0.39	-0.08 (-0.24 — 0.09)	0.36
Nighttime earthquake‡	0.03 (-0.09 — 0.15)	0.65			0.09 (-0.09 — 0.28)	0.32		
Date								
Categories of day								
Weekday	Reference				Reference			
The day before non-working day	**0.06** (0.01 — 0.12)	**0.02**	**0.06** (0.01 — 0.12)	**0.03**	**0.19 (0.11 — 0.28)**	**<0.01**	**0.19 (0.11 — 0.28)**	**<0.01**
Non-working day	-0.04 (-0.08 — 0.01)	0.09	-0.04 (-0.09 — 0.01)	0.08	**0.11 (0.04 — 0.18)**	**<0.01**	**0.11 (0.05 — 0.18)**	**<0.01**
Season								

Spring	Reference				Reference			
Summer	-0.03 (-0.09 — 0.02)	0.26	-0.03 (-0.09 — 0.02)	023	0.06 (-0.03 — 0.14)	0.20	0.06 (-0.03 — 0.15)	0.17
Fall	0.01 (-0.05 — 0.07)	0.73	0.01 (-0.05 — 0.06)	0.82	0.04 (-0.05 — 0.12)	0.40	0.03 (-0.05 — 0.12)	0.45
Winter	**0.10 (0.04 — 0.15)**	**<0.01**	**0.10 (0.04 — 0.15)**	**<0.01**	0.01 (-0.08 — 0.10)	0.81	0.01 (-0.08 — 0.79)	0.83

Table 3. β coefficients for number of patients with acute ethanol intoxication from univariate and multivariate GARCH model by age

*GARCH represents generalized autoregressive conditional heteroskedasticity; †CI represents confidence interval; §Daytime earthquake means that earthquake was observed between 9 a.m. to 5 p.m.; ‡Nighttime earthquake means that earthquake was observed between 5 p.m. to 12 p.m..

Numbers in bold indicate that the p value is less than 0.05.

Figure legend:

Figure 1. Daily number of earthquake.

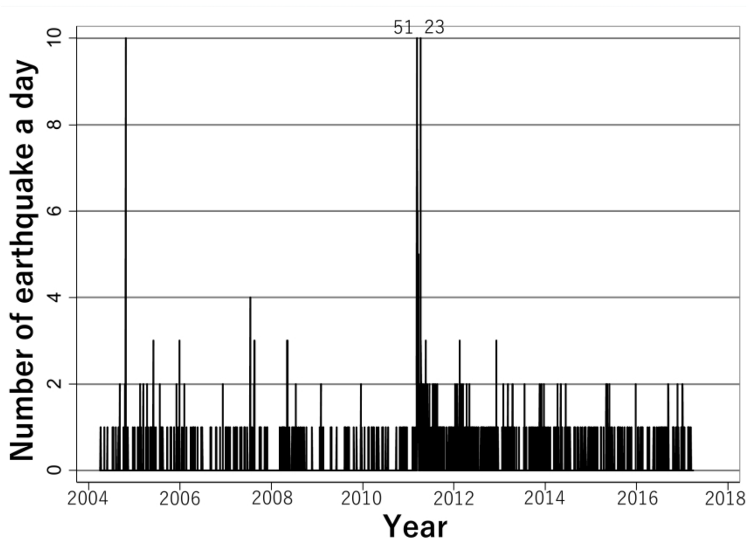

Figure 1. Daily number of earthquake.

279x215mm (300 x 300 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

Check	Page, session		Item No	Recommendation
X	Page1. Title	**Title and abstract**	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
X	Page2-3, abstract			(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
		Introduction		
X	Page4-5, introduction	Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
X	Page5, last in Introduction	Objectives	3	State specific objectives, including any prespecified hypotheses
		Methods		
X	Page6, first paragraph in Methods	Study design	4	Present key elements of study design early in the paper
X	Page6, first paragraph in Methods	Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
X	Page6, first paragraph in Methods	Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
X	Page6, first and second paragraph in Methods			(*b*) For matched studies, give matching criteria and number of exposed and unexposed
X	Page7-8, third paragraph in Methods	Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
X	Page7-8, third paragraph in Methods	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
X	Page7-8, third paragraph in Methods	Bias	9	Describe any efforts to address potential sources of bias
X	Page9, third paragraph in statistical analyses	Study size	10	Explain how the study size was arrived at
X	Page8, first and second paragraph in statistical analyses	Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why

X	Page8, first and second paragraph in statistical analyses	Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
X	Page8, first and second paragraph in statistical analyses			(*b*) Describe any methods used to examine subgroups and interactions
X	Page8, first and second paragraph in statistical analyses			(*c*) Explain how missing data were addressed
X	N/A			(*d*) If applicable, explain how loss to follow-up was addressed
X	Page8, first and second paragraph in statistical analyses			(*e*) Describe any sensitivity analyses
		Results		
X	Page10, result session	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
X	Page10, result session			(b) Give reasons for non-participation at each stage
X	N/A			(c) Consider use of a flow diagram
X	Page10, result session	Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
X	Page10, result session			(b) Indicate number of participants with missing data for each variable of interest
X	Page10, result session			(c) Summarise follow-up time (eg, average and total amount)
X	Page10, result session, table1	Outcome data	15*	Report numbers of outcome events or summary measures over time
X	Page10-11, result session	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
X	Page10-11, result session			(*b*) Report category boundaries when continuous variables were categorized
X	Page10-11, result session			(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
X	Page10-11, result session, Table2.	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
		Discussion		
X	Page12, first	Key results	18	Summarise key results with reference to

	paragraph in discussion			study objectives
X	Page 12-14 in discussion	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
X	Page 14	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
X	Page 14	Generalisability	21	Discuss the generalisability (external validity) of the study results
		Other information		
X	Page1	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

*Give information separately for exposed and unexposed groups.

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 http://www.strobe-statement.org.

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Alcohol Consumption Behaviors in the Immediate Aftermath of Earthquakes: Time series study

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Alcohol Consumption Behaviors in the Immediate Aftermath of Earthquakes: Time series study

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Abstract

Objectives: Earthquakes are a distressing natural phenomenon that can disrupt normal health-related behaviors. The aim of this study was to investigate changes in alcohol consumption behaviors in the immediate aftermath of mild to moderate earthquakes.

Setting: This retrospective cohort study was conducted at a large academic hospital in Tokyo, Japan from April 2004 to March 2017.

Participants: We included all adult patients presenting with acute alcohol intoxication in the emergency room.

Primary and secondary outcome measures: Our outcome was the number of such patients per 24 hour period comparing days with and without earthquake activity. We conducted a simple generalized autoregressive conditional heteroscedasticity (GARCH) analysis, followed by a multivariate GARCH, including year-fixed effects and secular changes in alcohol taxation. Subanalyses were conducted by gender and age group.

Results: During the study period, 706 earthquakes were observed with a median magnitude of 5.2 (SD: 1.0). During this period, 6,395 patients were admitted with acute ethanol intoxication; the mean age was 42.6 (SD: 16.9) years, and 4,592 (71.8%) patients were male. In univariate analyses, the occurrence of daytime earthquakes was marginally inversely related to the number of acutely intoxicated patients (β coefficient: -0.19, 95% CI: -0.40 - 0.01). This finding remained similar in multivariate analyses after adjustment for covariates. In analyses stratified by gender, the inverse association between daytime earthquakes and alcohol intoxication was only observed among men ($p<0.03$ for males and $p=0.99$ for females). In subanalyses by age, older people were

less likely to be admitted to the hospital due to acute alcohol intoxication on days with daytime earthquakes (p=0.11), but this was not the case for younger people (p=0.36).

Conclusion: On days when a mild to moderate daytime earthquake occurred, the number of patients with acute alcohol intoxication was lower compared to days without earthquakes. Even milder forms of potentially catastrophic events appear to influence social behavior; mild to moderate earthquake activity is associated with the avoidance of excessive alcohol consumption.

Article summary

Strengths and limitations of this study

- This unique study is the first to evaluate alcohol consumption behavior in the immediate aftermath of earthquakes.
- Robust analyses supported the findings in this study.
- The limitation of this study was its analysis of a single center with a single ethnicity.

Introduction

Catastrophic earthquake activity has been reported to exert a variety of effects on both physical and mental health [1]. A previous study reported that approximately 42.6% of victims exhibited moderate to serious mental health problems after the Great East Japan earthquake, which occurred in March 2011 [1]. Acute health effects associated with earthquake activity include acute stress disorders [2], delirium, [3] and acute and transient psychotic disorders. Longer-term effects on victims' well-being have also been reported, including post-traumatic stress disorder and exacerbation of bipolar disorder [4-6]. Although most previous research has been limited to the health impacts of rare catastrophic earthquakes, very few studies have focused on the health effects associated with substantially more common mild to moderate earthquakes.

Substance abuse is a common disorder reported in the setting of catastrophic disasters [7,8]. Several studies have explored this relationship with regard to alcohol use behaviors [9,10], with several previous studies reporting an increased prevalence of alcohol abuse after major earthquakes. [11,12] However, in the larger context of catastrophic phenomena, this association remains unclear, with one report showing only a 2% increase in prevalence after a major hurricane [13] and other studies reporting a slight decrease in alcohol abuse after instances of terrorism [9,14]. Moreover, some suggested that disasters have rarely increased the prevalence of substance use disorders. Instead, increased alcohol abuse after disaster can often reflect an exacerbation of existing abuse rather than new onset disorders [15]. As such, the effect of disasters on alcohol abuse remains controversial. Previous studies have suggested that gender, age, education, and even cultural background modify these associations. [16,17]

91 Japan is a tectonically active country where earthquakes are observed frequently. The Japan
92 Meteorological Agency observed 2,025 earthquakes in 2017, and more than 6,500 earthquakes were observed in
93 2016 in Japan [18]. Among the 76 earthquakes in 2017 and 123 events in 2016, 3.8% and 1.9%, respectively, were
94 greater than a magnitude of 5. In addition to the incidence of earthquakes, the Japan Meteorological Agency
95 recorded the date, time, magnitude, location, and seismic intensity [19]. Thus, the aim of this study was to evaluate
96 the same-day association between mild to moderate earthquakes and unhealthy alcohol use behavior in Japan.

Methods

Study design and cohort description

We conducted a retrospective daily time series study using medical record data from St. Luke's International Hospital in Tokyo, Japan from April 2004 to March 2017. We included all patients who were 20 or older and presented to the hospital emergency room with acute alcohol intoxication. We excluded all patients who signed opt-out agreements for their anonymized data to be used in research. In addition, patients presenting with an altered mental status of uncertain origin were excluded. Our outcome was a patient volume of acutely intoxicated patients per 24-hour period. Outcomes were compared between days with and without earthquakes, as observed by the Japan Meteorological Agency. The ethical committee at St. Luke's International Hospital approved this study (approval number: 17-R025).

Research ethics application

In terms of data sharing, no additional patient data were available, although data about earthquakes were available on the Japan Meteorological Agency website [18]. This study was entirely the authors' own work, and no funding supported this study. The results of this study will be disseminated through publication, and individual participants will not be alerted because this was a retrospective design.

Acute alcohol intoxication

Emergency physicians at the hospital clinically diagnosed acute alcohol intoxication based on testimonies by patients or their companions. A blood ethanol level of 100 mg/dl or higher was used to support the diagnosis for those whose testimonies could not be elicited directly [20].

Earthquake

All earthquake data were obtained from the Japan Meteorological Agency [18]. The recorded data contain the time and date of occurrence, the Richter magnitude, the depth of epicenter, and Shindo scale data for any earthquake detected. With a range of 0 to 7, Shindo is the unique measurement scale used in Japan for seismic intensities in a specific area [19]. Unlike the Richter scale, which represents the size of the earthquake itself and is unique for each earthquake, Shindo scaling reflects the intensity of the observed shaking in a given area and is based on the distance from the epicenter at which the seismic activity was observed. Generally speaking, the further the observed area is from the epicenter, the lower the Shindo measurement is for that area. A Shindo score of 1 is comparable to mild shaking observed only when sitting quietly in a structure, while a Shindo score of 4 is defined as observable shaking that is intense enough to startle, awaken people from sleep, and can be detected while walking. A Shindo score of 7 equates to severe shaking in which it is impossible to remain standing or move without crawling. In terms of the severity of the earthquake, we defined earthquakes with a Shindo score of 1 – 3 as mild to moderate earthquakes and those with a Shindo score of 4 or more as severe earthquakes. We defined a daytime earthquake as one observed between 9 a.m. and 5 p.m., while a nighttime earthquake was defined as occurring between 5 p.m. and 12 a.m. The reason why we divided earthquakes as above is that a daytime earthquake was believed to affect the subsequent drinking behavior on the same night. In contrast, a nighttime earthquake that may have occurred while drinking alcohol was believed to have a different effect on drinking behavior. The remaining time period, from 12am to 9am, was considered as having little effect on alcohol behavior.

Study site

St. Luke's International Hospital is located in Chuo-ku, Tokyo, Japan. The hospital, a 520-bed tertiary-level community teaching hospital, accepts more than 10,000 ambulance admissions a year. Located close to Ginza, a major entertainment district popular for bars and restaurants serving alcohol, St. Luke`s receives the largest number of ambulances per year, including approximately 50% of ambulances dispatched from the Ginza area. We included only earthquakes that were observed in this metropolitan Tokyo area in the analyses.

Category of day in relation to work week and seasonality

Because the incidence of acute alcohol intoxication is considered to vary substantially by the day of the week, we divided the days into three categories: weekdays, days prior to a non-working day, and non-working days (generally understood in Japan to be Saturday, Sunday, and designated national holidays). For days overlapping categories, we considered days prior to a non-working day the most dominant. For instance, because December 31, January 1st, 2nd, and 3rd are designated national holidays in Japan, we categorized December 31, January 1st and 2nd as "days prior to a non-working day", and 3rd as a "non-working day".

As the incidence of acute alcohol intoxication is also considered to be related to seasonality, we categorized March, April and May as spring; June, July and August as summer; September, October and November as fall; December, January and February as winter.

Statistical analyses

Because the occurrence of earthquakes on a certain day was considered to be autocorrelated and have an autoregressive conditional heteroscedasticity (ARCH) effect (Figure), we applied a multivariate generalized autoregressive conditional heteroscedasticity (GARCH) approach with dynamic conditional correlation to investigate the association between patient presentation in the ER and acute alcohol intoxication and occurrence of earthquakes [21-23]. In terms of the primary outcome, we first applied a simple GARCH model with each variable examining the relationship between hospital admission for acute alcohol intoxication and earthquake activity, category of day, and seasonality. This was followed by a multivariate GARCH(1,1) model with variables found to have a p value of 0.2 or lower in the simple GARCH model, as well as a year-fixed effect and changes in alcohol taxation. Alcohol taxation had changed five times during study periods, and it is included the model as a categorical variable. Because the taxation rates were similar during the study periods (e.g., 45.1%-46.6% for beer, 16.2%-18.1% for sake), the impact of alcohol taxation change on the results was considered to be limited. The β coefficient and 95% confidence intervals (CI) were calculated. In addition, we stratified the analyses by both gender and age (50 years or older versus less than 50 years). Moreover, we separately analyzed data before the Great East Japan earthquake on March 11, 2011 and after the earthquake. We also conducted sensitivity analyses to check robustness with the following three methods: using the Richter scale magnitude as a covariate to evaluate whether the results differ according to the magnitude of the earthquake; introducing different lag times between the earthquake and hospital visits (e.g., 1, 3 or 7 days after the earthquakes), excluding days in which severe earthquakes (Shindo scale ≥4) occurred; and having the data stratified by day of the week. All analyses were performed using Stata 14.0 (Stata Corp, TX, USA).

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Results

During the study period, earthquakes were observed 706 times with a median Shindo score in the catchment area of 2 (interquartile range 1). During the 4,747 days in the study period, earthquakes were observed on 500 days. During this period, 6,571 patients were extracted from the electronic medical record. Among them, 99 were excluded because they were younger than 20 years old, and 77 were excluded based on the blood alcohol level. Finally, 6,395 patients with a mean age of 42.6 (*SD* 16.9) were treated for acute ethanol intoxication; 4,592 (71.8%) were male (Table 1).

Table 2 shows the results for the number of patients with acute ethanol intoxication from the simple and multivariate GRACH models. In univariate analyses, the daytime earthquake figure was marginally and inversely related to the number of acutely intoxicated patients (β coefficient: -0.19, 95% CI: -0.40 - 0.01). The number of days prior to a non-working day (β coefficient: 0.26, 95%CI: 0.15 - 0.37) was significantly related and the number of non-working days (β coefficient: 0.08, 95%CI: -0.01 - 0.14) was marginally significantly related to acute intoxication. These findings remained similar in multivariate analyses after adjusting for both occurrences of a daytime earthquake, category of day, seasonality, year-fixed effect and change in alcohol taxation.

In a sensitivity analysis, including Richter scale magnitude as a covariate to evaluate whether the results differ according to the magnitude of the earthquake, the daytime earthquake number was still marginally related to decreased patient volume (β coefficient: -0.23, 95% CI: -0.47 - 0.01). However, the magnitude of the earthquake itself had no relationship with patient volume (β coefficient: 0.01, 95% CI: -0.02 - 0.04). When we introduced different lag times between the earthquake and hospital visits, the number of daytime earthquakes was also marginally significantly related to decreased patient volume (β coefficient: -0.18, 95% CI: -0.38 - 0.01 for 1 day after an earthquake; β coefficient: -0.18, 95% CI: -0.38 - 0.02 for 3 days after an earthquake; and β coefficient: -0.18, 95% CI: -0.38 - 0.02 for 7 days after an earthquake), while different lag times themselves were not associated with patient volume. When we excluded days in which severe earthquakes (Shindo scale ≥4) occurred, the findings were similar [daytime earthquake (β coefficient: -0.18, 95% CI: -0.38 - 0.02)]. In the analyses by stratification of day of the week, the number of daytime earthquakes was not related to patient volume on weekdays (β coefficient: 0.01, 95% CI: -0.28 - 0.30) but tend to be negatively related to patient volume on days off (β coefficient: -0.15, 95% CI: -0.49 - 0.19). The analysis was not concaved in the days prior to days off.

Table 3 shows the result of the number of patients with alcohol intoxication from univariate and multivariate analyses stratified by gender. The inverse association between daytime earthquake and alcohol intoxication seen in a pooled analysis was only observed among men (p<0.03 for males and p=0.99 for females). Although a positive association between the day before non-working days and acute alcohol intoxication were observed in both males (p<0.01) and females (p<0.01), higher rates of intoxication on non-working days were only observed in women (p=0.02 for females and p=0.35 for males). Among male patients, the number of patients with acute alcohol intoxication rose in the winter compared to spring (p=0.01), but not among females (p=0.42).

Table 4 shows the result for the number of patients with alcohol intoxication from univariate and multivariate analyses stratified by age group. Older people were less likely to be admitted to the ER due to acute alcohol intoxication on days when daytime earthquakes occurred (p=0.11), but the same pattern was not seen among younger people (p=0.36). Both older and younger patients with acute alcohol intoxication were more likely to be admitted on days before non-working days as well as on non-working days compared to weekdays. However, in terms of seasonality, older people were significantly more likely to be admitted to the ER with acute alcohol intoxication in the winter (p<0.01), but not younger people (p=0.83)

In terms of stratification by the date of the Great East Japan earthquake, the number of daytime earthquakes was inversely related to the number of acutely intoxicated patients after the Great East Japan earthquake (β coefficient: -0.28, 95% CI: -0.55 - -0.02), while the number of daytime earthquakes was not related to the number before the Great East Japan earthquake (β coefficient: -0.02, 95% CI: -0.32 - 0.29).

Discussion

Our study found several predictors of the number of intoxicated patients presenting in the ER of a major urban hospital in Japan. Notably, there was an inverse relationship between the number of intoxicated patients and daytime earthquakes observed in older patients and men.

Although previous studies that evaluated drinking behavior after catastrophic earthquakes reported both positive and negative effects, we found that non-catastrophic earthquakes may exert a dampening (i.e., a health-favorable) effect on excess alcohol consumption. This finding was considered to be a type of stress-related growth, which is the theory that people develop from negative events [24]. We speculate that people may avoid risky behaviors, such as going out with companions after work, to indulge in excessive amounts of drinking immediately after an earthquake. When people experience earthquakes, many may suspect additional tectonic activity; multiple earthquakes in a single day are common and were observed on 83 (16.7%) days in our study. As a result, we suspect that many people choose to go home rather than go out, as has been documented in reports about catastrophic earthquakes [25]. People may avoid social activities, such as after-work gatherings, on days in which even mild but nevertheless frightening natural phenomena have occurred, thereby reducing the opportunities for excessive drinking and other risky social behaviors. Lower blood alcohol levels noted on earthquake days also suggest that even imbibers may limit the amount of alcohol consumed on such days. Similar social behaviors have been observed after the Great East Japan earthquake in 2011, although whether these behavioral changes are conscious or unconscious remains unclear [26].

We found both age and gender differences in the relationship between daytime earthquakes and acute alcohol intoxication. There were statistically fewer male patients with acute alcohol intoxication on days when a daytime earthquake occurred compared to days without seismic activity. Interestingly, this relationship was not found for female patients. A previous systematic review reported that differing patterns of alcohol use between men and women are driven by both biological and psycho-socio-cultural factors [27]. As a result, men are more likely to seek sensations, including hazardous drinking, than women in ordinary settings [28,29]. However, it is possible that mild earthquakes may affect these psycho-socio-cultural factors more for men than women. Social capital may play an important role in this [30]. Because most Japanese male workers drink with colleagues after work [31], some may suggest that others not go out to drink after work on days with earthquakes.

In terms of age, fewer older patients with acute alcohol intoxication were observed on days with earthquakes, despite an unchanged number of younger patients presenting with acute alcohol intoxication on these days. A previous survey about alcohol use reported that younger people tended to indulge in more binge drinking and heavy episodic drinking in Japan [32] and other countries [33]. Psychologically disturbing natural phenomena, however mild, may also exert specific inhibitory psycho-socio-cultural effects on risky behaviors of younger people. Further research is needed to evaluate the potential mechanisms for these differences.

Significantly fewer patients with acute alcohol intoxication were observed on days with daytime earthquakes compared to those on days without daytime earthquakes after the Great East Japan earthquake, while the finding was not observed before the Great East Japan earthquake. This suggests that people still have catastrophic earthquakes in mind and avoid sensation seeking from stress-related growth.

Our study has some limitations. First, not all potential patients with acute alcohol intoxication were transferred to our hospital, resulting in a measure of selection bias. However, because our hospital has the largest number and highest rate of ambulance acceptances in Tokyo, with more than 50% of ambulances dispatched to the local entertainment area were transferred to us, and we assume that this bias is neither large nor differential. In addition, the findings may not be applicable to other countries because ethnicity and cultural diversity could exist [34]. Second, because we were unable to accurately record information about when patients started to consume alcohol, precise knowledge of the temporal relationship between alcohol consumption, intoxication, and earthquakes is difficult to assess. Similarly, because qualitative data concerning patients` physical and emotional perception of seismic activity is not available, further studies are warranted in this area. In addition, an evaluation for acute stress disorder may be useful to explain the gender and age difference of findings. Finally, an earthquake itself may somewhat impact hospital operations. However, the emergency department of hospitals had operated as usual on and after the Great East Japan earthquake. Therefore, the impact is considered to be limited.

Conclusion

On days when mild to moderate daytime earthquakes occurred, our hospital had fewer patients with acute alcohol intoxication presenting in the emergency room. This pattern was also seen for men and elderly patients. Even mild natural phenomena may lead to changes in social behavior that result in avoidance of excessive alcohol use.

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References

1. Yokoyama Y, Otsuka K, Kawakami N, et al. Mental health and related factors after the Great East Japan earthquake and tsunami. *PLoS One.* 2014;9(7):e102497.
2. Zhou P, Zhang Y, Wei C, Liu Z, Hannak W. Acute stress disorder as a predictor of posttraumatic stress: A longitudinal study of Chinese children exposed to the Lushan earthquake. *Psych J.* 2016;5(3):206-214.
3. Awata S. [Disaster psychiatry in late life]. *Nihon Rinsho.* 2013;71(10):1864-1869.
4. Navarro-Mateu F, Salmeron D, Vilagut G, et al. Post-Traumatic Stress Disorder and other mental disorders in the general population after Lorca's earthquakes, 2011 (Murcia, Spain): A cross-sectional study. *PLoS One.* 2017;12(7):e0179690.
5. Cai D, Zhu Z, Sun H, et al. Maternal PTSD following Exposure to the Wenchuan Earthquake Is Associated with Impaired Mental Development of Children. *PLoS One.* 2017;12(4):e0168747.
6. Derivois D, Cenat JM, Joseph NE, Karray A, Chahraoui K. Prevalence and determinants of post-traumatic stress disorder, anxiety and depression symptoms in street children survivors of the 2010 earthquake in Haiti, four years after. *Child Abuse Negl.* 2017;67:174-181.
7. Seligman J, Felder SS, Robinson ME. Substance Abuse and Mental Health Services Administration (SAMHSA) Behavioral Health Disaster Response App. *Disaster Med Public Health Prep.* 2015;9(5):516-518.
8. Moise IK, Ruiz MO. Hospitalizations for Substance Abuse Disorders Before and After Hurricane Katrina: Spatial Clustering and Area-Level Predictors, New Orleans, 2004 and 2008. *Prev Chronic Dis.* 2016;13:E145.
9. North CS, Pfefferbaum B. Mental health response to community disasters: a systematic review. *JAMA.* 2013;310(5):507-518.
10. Vlahov D, Galea S, Resnick H, et al. Increased use of cigarettes, alcohol, and marijuana among Manhattan, New York, residents after the September 11th terrorist attacks. *Am J Epidemiol.* 2002;155(11):988-996.
11. Pollice R, Bianchini V, Roncone R, Casacchia M. Marked increase in substance use among young people after L'Aquila earthquake. *Eur Child Adolesc Psychiatry.* 2011;20(8):429-430.
12. Keyes KM, Hatzenbuehler ML, Hasin DS. Stressful life experiences, alcohol consumption, and alcohol use disorders: the epidemiologic evidence for four main types of stressors. *Psychopharmacology (Berl).* 2011;218(1):1-17.
13. David D, Mellman TA, Mendoza LM, Kulick-Bell R, Ironson G, Schneiderman N. Psychiatric morbidity following Hurricane Andrew. *J Trauma Stress.* 1996;9(3):607-612.
14. Knudsen HK, Roman PM, Johnson JA, Ducharme LJ. A changed America? The effects of September 11th on depressive symptoms and alcohol consumption. *J Health Soc Behav.* 2005;46(3):260-273.
15. *Yuval Neria; Sandro Galea; Fran H. Norris. Mental Health and Disasters.* Cambridge University Press; 2009.

16. Cepeda A, Saint Onge JM, Kaplan C, Valdez A. The association between disaster-related experiences and mental health outcomes among drug using African American Hurricane Katrina evacuees. *Community Ment Health J.* 2010;46(6):612-620.

17. Bianchini V, Roncone R, Giusti L, Casacchia M, Cifone MG, Pollice R. PTSD Growth and Substance Abuse Among a College Student Community: Coping Strategies after 2009 L'aquila Earthquake. *Clin Pract Epidemiol Ment Health.* 2015;11:140-143.

18. Japan Meteorological Agency. Shindo database. 2018; http://www.jma.go.jp/jma/indexe.html. Accessed April 10, 2018.

19. Ruckinger S, von Kries R, Toschke AM. An illustration of and programs estimating attributable fractions in large scale surveys considering multiple risk factors. *BMC Med Res Methodol.* 2009;9:7.

20. Vonghia L, Leggio L, Ferrulli A, et al. Acute alcohol intoxication. *Eur J Intern Med.* 2008;19(8):561-567.

21. Bollerslev T. Generalized autoregressive conditional heteroskedasticity. *Journal of econometrics.* 1986;31(3):307-327.

22. Engle RF. Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica: Journal of the Econometric Society.* 1982:987-1007.

23. Engle R. Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business & Economic Statistics.* 2002;20(3):339-350.

24. Park CL, Cohen LH, Murch RL. Assessment and prediction of stress-related growth. *J Pers.* 1996;64(1):71-105.

25. Ito K, Aono A, and Ohmori N. Empirical Study on Stop-Offs en Route Home in the Aftermath of an Earthquake Disaster in the Tokyo Metropolitan Area – Analyses Based on an Online Questionnaire Survey about the Great East Japan Earthquake. Journal of the City Planning Institute of Japan, Vol.48, No.3, pp. 873-878, 2013.

26. Zare M, Afrouz SG. Crisis management of tohoku; Japan earthquake and tsunami, 11 march 2011. *Iran J Public Health.* 2012;41(6):12-20.

27. Erol A, Karpyak VM. Sex and gender-related differences in alcohol use and its consequences: Contemporary knowledge and future research considerations. *Drug Alcohol Depend.* 2015;156:1-13.

28. Bosque-Prous M, Espelt A, Borrell C, et al. Gender differences in hazardous drinking among middle-aged in Europe: the role of social context and women's empowerment. *Eur J Public Health.* 2015;25(4):698-705.

29. Holmila M, Raitasalo K. Gender differences in drinking: why do they still exist? *Addiction.* 2005;100(12):1763-1769.

30. Zarzar PM, Jorge KO, Oksanen T, Vale MP, Ferreira EF, Kawachi I. Association between binge drinking, type of friends and gender: a cross-sectional study among Brazilian adolescents. *BMC Public Health.* 2012;12:257.

31. Hagihara A, Tarumi K, Nobutomo K. Work stressors, drinking with colleagues after work, and job satisfaction among white-collar workers in Japan. *Subst Use Misuse.* 2000;35(5):737-756.

32. Osaki Y, Kinjo A, Higuchi S, et al. Prevalence and Trends in Alcohol Dependence and Alcohol Use Disorders in Japanese Adults; Results from Periodical Nationwide Surveys. *Alcohol Alcohol.* 2016;51(4):465-473.

33. Quinn PD, Harden KP. Differential changes in impulsivity and sensation seeking and the escalation of substance use from adolescence to early adulthood. *Dev Psychopathol.* 2013;25(1):223-239.

34. Betsy T. Risk-taking behaviour in men. Substance use and gender. 2003; https://pdfs.semanticscholar.org/2067/3ca32192d2577058acc9430f2ae6ad988d31.pdf. Accessed August 4, 2018.

	Patients (n=6,395)
Age, year, mean (SD)	42.6 (16.9)
Male, n (%)	4,592 (71.8)
Blood alcohol level, mg/dl, mean (SD)	225.4 (87.2)
Type of day when the patient visited the hospital	
Weekdays, n (%)	3,125 (48.9)
Days prior to day off, n (%)	1,220 (19.1)
Day off, n (%)	2,050 (32.1)
Season in which the patient visited the hospital	
Spring, n (%)	1,562 (24.4)
Summer, n (%)	1,558 (24.4)
Fall, n (%)	1,617 (25.3)
Winter, n (%)	1,658 (25.9)
Occurrence of earthquake when the patient visited the hospital	
Whole day, n (%)	657 (10.3)
Daytime earthquake, n (%)	197 (3.1)
Nighttime earthquake, n (%)	188 (2.94)

Table 1. Patient’s characteristics

Variable	Univariate GARCH* model			Multivariate GARCH* model		
	β coefficient	95%CI†	*p* value	β coefficient	95%C†	*p* value
Earthquake factors						
Incidence of earthquake	0.00	(-0.12 — 0.12)	0.95			
Number of earthquakes a day, times	-0.02	(-0.06 — 0.03)	0.46			
The depth of the epicenter, km	0.00	(-0.01 — 0.01)	0.85			
The highest magnitude in a day	0.00	(-0.02 — 0.02)	0.98			
The highest Shindo in a day	0.00	(-0.08 — 0.07)	0.92			
Daytime earthquake§	-0.19	(-0.40 — 0.01)	0.06	-0.18	(-0.38 — 0.02)	0.07
Nighttime earthquake‡	0.12	(-0.12 — 0.35)	0.34			
Date						
Categories of day						
Weekday		Reference			Reference	
The day before non-working day	**0.26**	**(0.15 — 0.37)**	**<0.01**	**0.25**	**(0.15 — 0.36)**	**<0.01**
Non-working day	0.08	(-0.01 — 0.17)	0.05	0.08	(-0.01 — 0.16)	0.08
Season						
Spring		Reference			Reference	
Summer	0.02	(-0.09 — 0.13)	0.73	0.02	(-0.09 — 0.12)	0.78
Fall	0.05	(-0.06 — 0.17)	0.35	0.03	(-0.76 — 0.14)	0.55
Winter	0.10	(-0.01 — 0.22)	0.07	**0.12**	**(0.02 — 0.23)**	**0.02**

Table 2. β coefficients for the number of patients with acute ethanol intoxication from the univariate and multivariate GARCH model

*GARCH stands for generalized autoregressive conditional heteroskedasticity. The multivariate GARCH model was adjusted for variables found to have a *p* value of 0.2 or less in a simple GARCH model as well as year-fixed effect and changes in alcohol taxation.; †CI represents confidence interval; §Daytime earthquake means that an earthquake was observed between 9 a.m. and 5 p.m.; ‡Nighttime earthquake means that earthquake was observed between 5 p.m. and 12 p.m.

Numbers in bold indicate that the p value is less than 0.05.

Variable	Male (*n* = 4,646) Univariate GARCH[*] β coefficient (95%CI[†])	*p* value	Male (*n* = 4,646) Multivariate GARCH[*] β coefficient (95%CI[†])	*p* value	Female (*n* = 1,826) Univariate GARCH[*] β coefficient (95%C[†])	*p* value	Female (*n* = 1,826) Multivariate GARCH[*] β coefficient (95%C[†])	*p* valu
Earthquake factors								
Incidence of earthquake	0.00 (-0.11 — 0.10)	0.98			-0.01 (-0.07 — 0.05)	0.86		
Number of earthquakes per day, times	-0.01 (-0.05 — 0.02)	0.39			0.00 (-0.02 — 0.02)	0.79		
The depth of the epicenter, km	0.00 (-0.00 — 0.00)	0.98			0.00 (-0.01 — 0.01)	0.78		
The highest magnitude in a day	0.00 (-0.02 — 0.02)	0.98			0.00 (-0.01 — 0.01)	0.98		
The highest Shindo in a day	-0.01 (-0.07 — 0.05)	0.81			0.00 (-0.03 — 0.04)	0.94		
Daytime earthquake[§]	**-0.19 (-0.36 — -0.02)**	**0.02**	**-0.19 (-0.36 — -0.02)**	**0.03**	0.00 (-0.09 — 0.10)	0.95	0.00 (-0.10 — 0.10)	0.99
Nighttime earthquake[‡]	0.05 (-0.14 — 0.25)	0.59			0.05 (-0.07 — 0.16)	0.41		
Date								
Categories of day								
Weekday	Reference				Reference			
The day before a non-working day	**0.19** (0.10 — 0.28)	**<0.01**	**0.19** (0.10 — 0.28)	**<0.01**	**0.08 (0.03 — 0.13)**	**<0.01**	**0.08 (0.03 — 0.13)**	**<0.01**
Non-working day	0.04 (-0.04 — 0.11)	0.34	0.04 (-0.04 — 0.11)	0.35	**0.05 (0.01 — 0.09)**	**0.02**	**0.05 (0.01 — 0.09)**	**0.02**
Season								
Spring	Reference				Reference			

Summer	-0.00 (-0.10 — 0.09)	0.93	-0.00 (-0.10 — 0.09)	0.93	0.02 (-0.03 — 0.07)	0.42	0.02 (-0.03 — 0.08)	0.37
Fall	0.02 (-0.07 — 0.12)	0.63	0.02 (-0.08 — 0.11)	0.74	0.02 (-0.04 — 0.07)	0.55	0.01 (-0.04 — 0.07)	0.58
Winter	**0.12 (0.02 — 0.21)**	**0.01**	**0.12 (0.02 — 0.21)**	**0.01**	-0.02 (-0.07 — 0.03)	0.43	-0.02 (-0.07 — 0.03)	0.42

Table 3. β coefficients for the number of patients with acute ethanol intoxication from the univariate and multivariate GARCH model by gender

*GARCH represents generalized autoregressive conditional heteroskedasticity. The multivariate GARCH model was adjusted for variables found to have *p* value of 0.2 or less in a simple GARCH model as well as year-fixed effect and changes in alcohol taxation; †CI represents confidence interval; §Daytime earthquake means that earthquake was observed between 9 a.m. and 5 p.m.; ‡Nighttime earthquake means that earthquake was observed between 5 p.m. and 12 p.m.

Numbers in bold indicate that the p value is less than 0.05.

Variable	50 years or older (*n* = 2,202) Univariate GARCH* β coefficient (95%CI†)	*p* value	50 years or older Multivariate GARCH* β coefficient (95%CI†)	*p* value	Younger than 50 years (*n* = 4,270) Univariate GARCH* β coefficient (95%C†)	*p* value	Younger than 50 years Multivariate GARCH* β coefficient (95%C†)	*p* valu
Earthquake factors								
Incidence of earthquake	-0.03 (-0.10 — 0.04)	0.37			0.03 (-0.07 — 0.13)	0.54		
Number of earthquakes per day, times	-0.01 (-0.03 — 0.01)	0.35			0.00 (-0.04 — 0.03)	0.82		
The depth of the epicenter, km	0.00 (-0.00 — 0.00)	0.67			0.00 (-0.01 — 0.01)	0.98		
The highest magnitude in a day	-0.01 (-0.02 — 0.01)	0.39			0.01 (-0.01 — 0.03)	0.54		
The highest Shindo in a day	-0.02 (-0.06 — 0.02)	0.35			0.02 (-0.04 — 0.08)	0.58		
Daytime earthquake§	-0.09 (-0.20 — 0.01)	0.09	-0.09 (-0.19 — 0.02)	0.11	-0.07 (-0.23 — 0.10)	0.39	-0.08 (-0.24 — 0.09)	0.36
Nighttime earthquake‡	0.03 (-0.09 — 0.15)	0.65			0.09 (-0.09 — 0.28)	0.32		
Date								
Categories of day								
Weekday	Reference				Reference			
The day before the non-working day	**0.06** (0.01 — 0.12)	**0.02**	**0.06** (0.01 — 0.12)	**0.03**	**0.19 (0.11 — 0.28)**	**<0.01**	**0.19 (0.11 — 0.28)**	**<0.01**
Non-working day	-0.04 (-0.08 — 0.01)	0.09	-0.04 (-0.09 — 0.01)	0.08	**0.11 (0.04 — 0.18)**	**<0.01**	**0.11 (0.05 — 0.18)**	**<0.01**
Season								
Spring	Reference				Reference			

Summer	-0.03 (-0.09 — 0.02)	0.26	-0.03 (-0.09 — 0.02)	023	0.06 (-0.03 — 0.14)	0.20	0.06 (-0.03 — 0.15)	0.17
Fall	0.01 (-0.05 — 0.07)	0.73	0.01 (-0.05 — 0.06)	0.82	0.04 (-0.05 — 0.12)	0.40	0.03 (-0.05 — 0.12)	0.45
Winter	**0.10 (0.04 — 0.15)**	**<0.01**	**0.10 (0.04 — 0.15)**	**<0.01**	0.01 (-0.08 — 0.10)	0.81	0.01 (-0.08 — 0.79)	0.83

Table 4. β coefficients for the number of patients with acute ethanol intoxication from univariate and multivariate GARCH model by age

*GARCH stands for generalized autoregressive conditional heteroskedasticity; †CI represents confidence interval; §Daytime earthquake means that the earthquake was observed between 9 a.m. and 5 p.m.; ‡Nighttime earthquake means that the earthquake was observed between 5 p.m. and 12 p.m. Numbers in bold indicate that the p value is less than 0.05.

Figure legend:

Figure 1. Number of earthquakes per day.

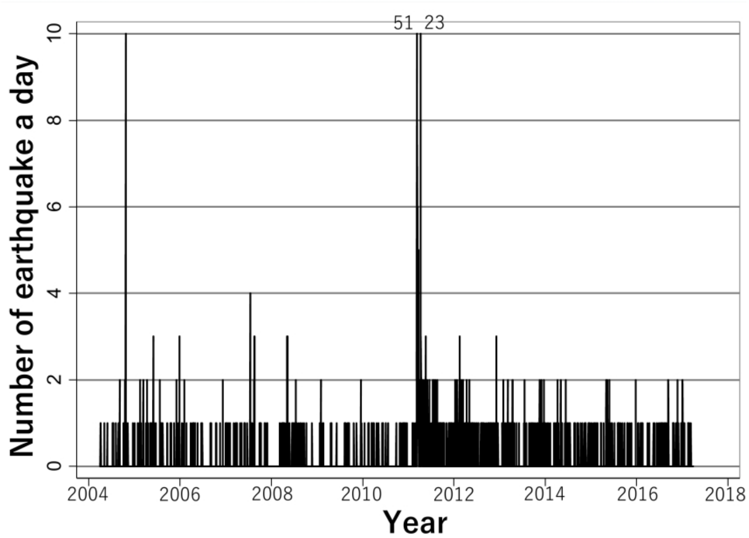

Figure 1. Daily number of earthquake.

279x215mm (300 x 300 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

Check	Page, session		Item No	Recommendation
X	Page1. Title	**Title and abstract**	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
X	Page2-3, abstract			(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
		Introduction		
X	Page4-5, introduction	Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
X	Page5, last in Introduction	Objectives	3	State specific objectives, including any prespecified hypotheses
		Methods		
X	Page6, first paragraph in Methods	Study design	4	Present key elements of study design early in the paper
X	Page6, first paragraph in Methods	Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
X	Page6, first paragraph in Methods	Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
X	Page6, first and second paragraph in Methods			(*b*) For matched studies, give matching criteria and number of exposed and unexposed
X	Page7-8, third paragraph in Methods	Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
X	Page7-8, third paragraph in Methods	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
X	Page7-8, third paragraph in Methods	Bias	9	Describe any efforts to address potential sources of bias
X	Page9, third paragraph in statistical analyses	Study size	10	Explain how the study size was arrived at
X	Page8, first and second paragraph in statistical analyses	Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why

X	Page8, first and second paragraph in statistical analyses	Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
X	Page8, first and second paragraph in statistical analyses			(*b*) Describe any methods used to examine subgroups and interactions
X	Page8, first and second paragraph in statistical analyses			(*c*) Explain how missing data were addressed
X	N/A			(*d*) If applicable, explain how loss to follow-up was addressed
X	Page8, first and second paragraph in statistical analyses			(*e*) Describe any sensitivity analyses
		Results		
X	Page10, result session	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
X	Page10, result session			(b) Give reasons for non-participation at each stage
X	N/A			(c) Consider use of a flow diagram
X	Page10, result session	Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
X	Page10, result session			(b) Indicate number of participants with missing data for each variable of interest
X	Page10, result session			(c) Summarise follow-up time (eg, average and total amount)
X	Page10, result session, table1	Outcome data	15*	Report numbers of outcome events or summary measures over time
X	Page10-11, result session	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
X	Page10-11, result session			(*b*) Report category boundaries when continuous variables were categorized
X	Page10-11, result session			(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
X	Page10-11, result session, Table2.	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
		Discussion		
X	Page12, first	Key results	18	Summarise key results with reference to

	paragraph in discussion			study objectives
X	Page 12-14 in discussion	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
X	Page 14	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
X	Page 14	Generalisability	21	Discuss the generalisability (external validity) of the study results
		Other information		
X	Page1	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

*Give information separately for exposed and unexposed groups.

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 http://www.strobe-statement.org.

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Alcohol Consumption Behaviors in the Immediate Aftermath of Earthquakes: Time series study

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Alcohol Consumption Behaviors in the Immediate Aftermath of Earthquakes: Time series study

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Abstract

Objectives: Earthquakes are a distressing natural phenomenon that can disrupt normal health-related behaviors. The aim of this study was to investigate changes in alcohol consumption behaviors in the immediate aftermath of mild to moderate earthquakes.

Setting: This retrospective cohort study was conducted at a large academic hospital in Tokyo, Japan from April 2004 to March 2017.

Participants: We included all adult patients presenting with acute alcohol intoxication in the emergency room.

Primary and secondary outcome measures: Our outcome was the number of such patients per 24 hour period comparing days with and without earthquake activity. We mainly focused on mild to moderate earthquakes (Sindo scale of less than 3). We conducted a simple generalized autoregressive conditional heteroscedasticity (GARCH) analysis, followed by a multivariate GARCH, including year-fixed effects and secular changes in alcohol taxation. Subanalyses were conducted by gender and age group.

Results: During the study period, 706 earthquakes were observed with a median Shindo scale of 2 (IQR: 1). During this period, 6,395 patients were admitted with acute ethanol intoxication; the mean age was 42.6 (SD: 16.9) years, and 4,592 (71.8%) patients were male. In univariate analyses, the occurrence of daytime earthquakes was marginally inversely related to the number of acutely intoxicated patients (β coefficient: -0.19, 95% CI: -0.40 - 0.01). This finding remained similar in multivariate analyses after adjustment for covariates. In analyses stratified by gender, the inverse association between daytime earthquakes and alcohol intoxication was only observed among men ($p<0.03$ for males and $p=0.99$ for females). In subanalyses by age, older people were less likely to be admitted to the hospital due to acute alcohol intoxication on days with daytime earthquakes (p=0.11), but this was not the case for younger people (p=0.36).

Conclusion: On days when a mild to moderate daytime earthquake occurred, the number of patients with acute alcohol intoxication was lower compared to days without earthquakes. Even milder forms of potentially catastrophic events appear to influence social behavior; mild to moderate earthquake activity is associated with the avoidance of excessive alcohol consumption.

Article summary

Strengths and limitations of this study

・This unique study is the first to evaluate alcohol consumption behavior in the immediate aftermath of earthquakes.

・Robust analyses supported the findings in this study.

・The limitation of this study was its analysis of a single center with a single ethnicity.

Introduction

Catastrophic earthquake activity has been reported to exert a variety of effects on both physical and mental health [1]. A previous study reported that approximately 42.6% of victims exhibited moderate to serious mental health problems after the Great East Japan earthquake, which occurred in March 2011 [1]. Acute health effects associated with earthquake activity include acute stress disorders [2], delirium, [3] and acute and transient psychotic disorders. Longer-term effects on victims' well-being have also been reported, including post-traumatic stress disorder and exacerbation of bipolar disorder [4-6]. Although most previous research has been limited to the health impacts of rare catastrophic earthquakes, very few studies have focused on the health effects associated with substantially more common mild to moderate earthquakes.

Substance abuse is a common disorder reported in the setting of catastrophic disasters [7,8]. Several studies have explored this relationship with regard to alcohol use behaviors [9,10], with several previous studies reporting an increased prevalence of alcohol abuse after major earthquakes. [11,12] However, in the larger context of catastrophic phenomena, this association remains unclear, with one report showing only a 2% increase in prevalence after a major hurricane [13] and other studies reporting a slight decrease in alcohol abuse after instances of terrorism [9,14]. Moreover, some suggested that disasters have rarely increased the prevalence of substance use disorders. Instead, increased alcohol abuse after disaster can often reflect an exacerbation of existing abuse rather than new onset disorders [15]. As such, the effect of disasters on alcohol abuse remains controversial. Previous studies have suggested that gender, age, education, and even cultural background modify these associations. [16,17]

Japan is a tectonically active country where earthquakes are observed frequently. The Japan Meteorological Agency observed 2,025 earthquakes in 2017, and more than 6,500 earthquakes were observed in 2016 in Japan [18]. Among the 76 earthquakes in 2017 and 123 events in 2016, 3.8% and 1.9%, respectively, were greater than a magnitude of 5. In addition to the incidence of earthquakes, the Japan Meteorological Agency recorded the date, time, magnitude, location, and seismic intensity [19]. Thus, the aim of this study was to evaluate the same-day association between mild to moderate earthquakes and unhealthy alcohol use behavior in Japan.

Methods

Study design and cohort description

We conducted a retrospective daily time series study using medical record data from St. Luke's International Hospital in Tokyo, Japan from April 2004 to March 2017.

Patient and Public Involvement

We included all patients who were 20 or older and presented to the hospital emergency room with acute alcohol intoxication. We excluded all patients who signed opt-out agreements for their anonymized data to be used in research. In addition, patients presenting with an altered mental status of uncertain origin were excluded. Our outcome was a patient volume of acutely intoxicated patients per 24-hour period. Outcomes were compared between days with and without earthquakes, as observed by the Japan Meteorological Agency. The ethical committee at St. Luke's International Hospital approved this study (approval number: 17-R025).

Research ethics application

In terms of data sharing, no additional patient data were available, although data about earthquakes were available on the Japan Meteorological Agency website [18]. This study was entirely the authors' own work, and no funding supported this study. The results of this study will be disseminated through publication, and individual participants will not be alerted because this was a retrospective design.

Acute alcohol intoxication

Emergency physicians at the hospital clinically diagnosed acute alcohol intoxication based on testimonies by patients or their companions. A blood ethanol level of 100 mg/dl or higher was used to support the diagnosis for those whose testimonies could not be elicited directly [20].

Earthquake

All earthquake data were obtained from the Japan Meteorological Agency [18]. The recorded data contain the time and date of occurrence, the Richter magnitude, the depth of epicenter, and Shindo scale data for any earthquake detected. With a range of 0 to 7, Shindo is the unique measurement scale used in Japan for seismic intensities in a specific area [19]. Unlike the Richter scale, which represents the size of the earthquake itself and is unique for each earthquake, Shindo scaling reflects the intensity of the observed shaking in a given area and is based on the distance from the epicenter at which the seismic activity was observed. Generally speaking, the further the observed area is from the epicenter, the lower the Shindo measurement is for that area. A Shindo score of 1 is comparable to mild shaking observed only when sitting quietly in a structure, while a Shindo score of 4 is defined as observable shaking that is intense enough to startle, awaken people from sleep, and can be detected while walking. A Shindo score of 7 equates to severe shaking in which it is impossible to remain standing or move without crawling. In terms of the severity of the earthquake, we defined earthquakes with a Shindo score of 1 – 3 as mild to moderate earthquakes and those with a Shindo score of 4 or more as severe earthquakes. We defined a daytime earthquake as one observed between 9 a.m. and 5 p.m., while a nighttime earthquake was defined as occurring between 5 p.m. and 12 a.m. The reason why we divided earthquakes as above is that a daytime earthquake was believed to affect the subsequent drinking behavior on the same night. In contrast, a nighttime earthquake that may have occurred while drinking alcohol was believed to have a different effect on drinking behavior. The remaining time period, from 12am to 9am, was considered as having little effect on alcohol behavior.

Study site

St. Luke's International Hospital is located in Chuo-ku, Tokyo, Japan. The hospital, a 520-bed tertiary-level community teaching hospital, accepts more than 10,000 ambulance admissions a year. Located close to Ginza, a major entertainment district popular for bars and restaurants serving alcohol, St. Luke`s receives the largest number of ambulances per year, including approximately 50% of ambulances dispatched from the Ginza area. We included only earthquakes that were observed in this metropolitan Tokyo area in the analyses.

Category of day in relation to work week and seasonality

Because the incidence of acute alcohol intoxication is considered to vary substantially by the day of the week, we divided the days into three categories: weekdays, days prior to a non-working day, and non-working days (generally understood in Japan to be Saturday, Sunday, and designated national holidays). For days overlapping categories, we considered days prior to a non-working day the most dominant. For instance, because December 31, January 1st, 2nd, and 3rd are designated national holidays in Japan, we categorized December 31, January 1st and 2nd as "days prior to a non-working day", and 3rd as a "non-working day".

As the incidence of acute alcohol intoxication is also considered to be related to seasonality, we categorized March, April and May as spring; June, July and August as summer; September, October and November as fall; December, January and February as winter.

Statistical analyses

Because the occurrence of earthquakes on a certain day was considered to be autocorrelated and have an autoregressive conditional heteroscedasticity (ARCH) effect (Figure), we applied a multivariate generalized autoregressive conditional heteroscedasticity (GARCH) approach with dynamic conditional correlation to investigate the association between patient presentation in the ER and acute alcohol intoxication and occurrence of earthquakes [21-23]. In terms of the primary outcome, we first applied a simple GARCH model with each variable examining the relationship between hospital admission for acute alcohol intoxication and earthquake activity, category of day, and seasonality. This was followed by a multivariate GARCH(1,1) model with variables found to have a *p* value of 0.2 or lower in the simple GARCH model, as well as a year-fixed effect and changes in alcohol taxation. Alcohol taxation had changed five times during study periods, and it is included the model as a categorical variable. Because the taxation rates were similar during the study periods (e.g., 45.1%- 46.6% for beer, 16.2%-18.1% for sake), the impact of alcohol taxation change on the results was considered to be limited. The β coefficient and 95% confidence intervals (CI) were calculated. In addition, we stratified the analyses by both gender and age (50 years or older versus less than 50 years). Moreover, we separately analyzed data before the Great East Japan earthquake on March 11, 2011 and after the earthquake. We also conducted sensitivity analyses to check robustness with the following three methods: using the Richter scale magnitude as a covariate to evaluate whether the results differ according to the magnitude of the earthquake; introducing different lag times between the earthquake and hospital visits (e.g., 1, 3 or 7 days after the earthquakes), excluding days in which severe earthquakes (Shindo scale ≥4) occurred; and having the data stratified by day of the week. All analyses were performed using Stata 14.0 (Stata Corp, TX, USA).

Results

During the study period, earthquakes were observed 706 times with a median Shindo score in the catchment area of 2 (interquartile range 1). During the 4,747 days in the study period, earthquakes were observed on 500 days. During this period, 6,571 patients were extracted from the electronic medical record. Among them, 99 were excluded because they were younger than 20 years old, and 77 were excluded based on the blood alcohol level. Finally, 6,395 patients with a mean age of 42.6 (*SD* 16.9) were treated for acute ethanol intoxication; 4,592 (71.8%) were male (Table 1).

Table 2 shows the results for the number of patients with acute ethanol intoxication from the simple and multivariate GRACH models. In univariate analyses, the daytime earthquake figure was marginally and inversely related to the number of acutely intoxicated patients (β coefficient: -0.19, 95% CI: -0.40 - 0.01). The number of days prior to a non-working day (β coefficient: 0.26, 95%CI: 0.15 - 0.37) was significantly related and the number of non-working days (β coefficient: 0.08, 95%CI: -0.01 - 0.14) was marginally significantly related to acute intoxication. These findings remained similar in multivariate analyses after adjusting for both occurrences of a daytime earthquake, category of day, seasonality, year-fixed effect and change in alcohol taxation.

In a sensitivity analysis, including Richter scale magnitude as a covariate to evaluate whether the results differ according to the magnitude of the earthquake, the daytime earthquake number was still marginally related to decreased patient volume (β coefficient: -0.23, 95% CI: -0.47 - 0.01). However, the magnitude of the earthquake itself had no relationship with patient volume (β coefficient: 0.01, 95% CI: -0.02 - 0.04). When we introduced different lag times between the earthquake and hospital visits, the number of daytime earthquakes was also marginally significantly related to decreased patient volume (β coefficient:

-0.18, 95% CI: -0.38 - 0.01 for 1 day after an earthquake; β coefficient: -0.18, 95% CI: -0.38 - 0.02 for 3 days after an earthquake; and β coefficient: -0.18, 95% CI: -0.38 - 0.02 for 7 days after an earthquake), while different lag times themselves were not associated with patient volume. When we excluded days in which severe earthquakes (Shindo scale ≥4) occurred, the findings were similar [daytime earthquake (β coefficient: -0.18, 95% CI: -0.38 - 0.02)]. In the analyses by stratification of day of the week, the number of daytime earthquakes was not related to patient volume on weekdays (β coefficient: 0.01, 95% CI: -0.28 - 0.30) but tend to be negatively related to patient volume on days off (β coefficient: -0.15, 95% CI: -0.49 - 0.19). The analysis was not concaved in the days prior to days off.

Table 3 shows the result of the number of patients with alcohol intoxication from univariate and multivariate analyses stratified by gender. The inverse association between daytime earthquake and alcohol intoxication seen in a pooled analysis was only observed among men ($p<0.03$ for males and $p=0.99$ for females). Although a positive association between the day before non-working days and acute alcohol intoxication were observed in both males ($p<0.01$) and females ($p<0.01$), higher rates of intoxication on non-working days were only observed in women ($p=0.02$ for females and $p=0.35$ for males). Among male patients, the number of patients with acute alcohol intoxication rose in the winter compared to spring ($p=0.01$), but not among females ($p=0.42$).

Table 4 shows the result for the number of patients with alcohol intoxication from univariate and multivariate analyses stratified by age group. Older people were less likely to be admitted to the ER due to acute alcohol intoxication on days when daytime earthquakes occurred ($p=0.11$), but the same pattern was not seen among younger people ($p=0.36$). Both older and younger patients with acute alcohol intoxication were more likely to be admitted on days before non-working days as well as on non-working days compared to weekdays. However, in terms of seasonality, older people were significantly more likely to be admitted to the ER with acute alcohol intoxication in the winter (p<0.01), but not younger people (p=0.83)

In terms of stratification by the date of the Great East Japan earthquake, the number of daytime earthquakes was inversely related to the number of acutely intoxicated patients after the Great East Japan earthquake (β coefficient: -0.28, 95% CI: -0.55 - -0.02), while the number of daytime earthquakes was not related to the number before the Great East Japan earthquake (β coefficient: -0.02, 95% CI: -0.32 - 0.29).

Discussion

Our study found several predictors of the number of intoxicated patients presenting in the ER of a major urban hospital in Japan. Notably, there was an inverse relationship between the number of intoxicated patients and daytime earthquakes observed in older patients and men.

Although previous studies that evaluated drinking behavior after catastrophic earthquakes reported both positive and negative effects, we found that non-catastrophic earthquakes may exert a dampening (i.e., a health-favorable) effect on excess alcohol consumption. This finding was considered to be a type of stress-related growth, which is the theory that people develop from negative events [24]. We speculate that people may avoid risky behaviors, such as going out with companions after work, to indulge in excessive amounts of drinking immediately after an earthquake. When people experience earthquakes, many may suspect additional tectonic activity; multiple earthquakes in a single day are common and were observed on 83 (16.7%) days in our study. As a result, we suspect that many people choose to go home rather than go out, as has been documented in reports about catastrophic earthquakes [25]. People may avoid social activities, such as after-work gatherings, on days in which even mild but nevertheless frightening natural phenomena have occurred, thereby reducing the opportunities for excessive drinking and other risky social behaviors. Lower blood alcohol levels noted on earthquake days also suggest that even imbibers may limit the amount of alcohol consumed on such days. Similar social behaviors have been observed after the Great East Japan earthquake in 2011, although whether these behavioral changes are conscious or unconscious remains unclear [26].

We found both age and gender differences in the relationship between daytime earthquakes and acute alcohol intoxication. There were statistically fewer male patients with acute alcohol intoxication on days when a daytime earthquake occurred compared to days without seismic activity. Interestingly, this relationship was not found for female patients. A previous systematic review reported that differing patterns of alcohol use between men and women are driven by both biological and psycho-socio-cultural factors [27]. As a result, men are more likely to seek sensations, including hazardous drinking, than women in ordinary settings [28,29]. However, it is possible that mild earthquakes may affect these psycho-socio-cultural factors more for men than women. Social capital may play an important role in this [30]. Because most Japanese male workers drink with colleagues after work [31], some may suggest that others not go out to drink after work on days with earthquakes.

In terms of age, fewer older patients with acute alcohol intoxication were observed on days with earthquakes, despite an unchanged number of younger patients presenting with acute alcohol intoxication on these days. A previous survey about alcohol use reported that younger people tended to indulge in more binge drinking and heavy episodic drinking in Japan [32] and other countries [33]. Psychologically disturbing natural phenomena, however mild, may also exert specific inhibitory psycho-socio-cultural effects on risky behaviors of younger people. Further research is needed to evaluate the potential mechanisms for these differences.

Significantly fewer patients with acute alcohol intoxication were observed on days with daytime earthquakes compared to those on days without daytime earthquakes after the Great East Japan earthquake, while the finding was not observed before the Great East Japan earthquake. This suggests that people still have catastrophic earthquakes in mind and avoid sensation seeking from stress-related growth.

Our study has some limitations. First, not all potential patients with acute alcohol intoxication were transferred to our hospital, resulting in a measure of selection bias. However, because our hospital has the largest number and highest rate of ambulance acceptances in Tokyo, with more than 50% of ambulances dispatched to the local entertainment area were transferred to us, and we assume that this bias is neither large nor differential. In addition, the findings may not be applicable to other countries because ethnicity and cultural diversity could exist [34]. Second, because we were unable to accurately record information about when patients started to consume alcohol, precise knowledge of the temporal relationship between alcohol consumption, intoxication, and earthquakes is difficult to assess. Similarly, because qualitative data concerning patients` physical and emotional perception of seismic activity is not available, further studies are warranted in this area. In addition, an evaluation for acute stress disorder may be useful to explain the gender and age difference of findings. Finally, an earthquake itself may somewhat impact hospital operations. However, the emergency department of hospitals had operated as usual on and after the Great East Japan earthquake. Therefore, the impact is considered to be limited.

Conclusion

On days when mild to moderate daytime earthquakes occurred, our hospital had fewer patients with acute alcohol intoxication presenting in the emergency room. This pattern was also seen for men and elderly patients. Even mild natural phenomena may lead to changes in social behavior that result in avoidance of excessive alcohol use.

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References

1. Yokoyama Y, Otsuka K, Kawakami N, et al. Mental health and related factors after the Great East Japan earthquake and tsunami. *PLoS One.* 2014;9(7):e102497.
2. Zhou P, Zhang Y, Wei C, Liu Z, Hannak W. Acute stress disorder as a predictor of posttraumatic stress: A longitudinal study of Chinese children exposed to the Lushan earthquake. *Psych J.* 2016;5(3):206-214.
3. Awata S. [Disaster psychiatry in late life]. *Nihon Rinsho.* 2013;71(10):1864-1869.
4. Navarro-Mateu F, Salmeron D, Vilagut G, et al. Post-Traumatic Stress Disorder and other mental disorders in the general population after Lorca's earthquakes, 2011 (Murcia, Spain): A cross-sectional study. *PLoS One.* 2017;12(7):e0179690.
5. Cai D, Zhu Z, Sun H, et al. Maternal PTSD following Exposure to the Wenchuan Earthquake Is Associated with Impaired Mental Development of Children. *PLoS One.* 2017;12(4):e0168747.
6. Derivois D, Cenat JM, Joseph NE, Karray A, Chahraoui K. Prevalence and determinants of post-traumatic stress disorder, anxiety and depression symptoms in street children survivors of the 2010 earthquake in Haiti, four years after. *Child Abuse Negl.* 2017;67:174-181.
7. Seligman J, Felder SS, Robinson ME. Substance Abuse and Mental Health Services Administration (SAMHSA) Behavioral Health Disaster Response App. *Disaster Med Public Health Prep.* 2015;9(5):516-518.
8. Moise IK, Ruiz MO. Hospitalizations for Substance Abuse Disorders Before and After Hurricane Katrina: Spatial Clustering and Area-Level Predictors, New Orleans, 2004 and 2008. *Prev Chronic Dis.* 2016;13:E145.
9. North CS, Pfefferbaum B. Mental health response to community disasters: a systematic review. *JAMA.* 2013;310(5):507-518.
10. Vlahov D, Galea S, Resnick H, et al. Increased use of cigarettes, alcohol, and marijuana among Manhattan, New York, residents after the September 11th terrorist attacks. *Am J Epidemiol.* 2002;155(11):988-996.
11. Pollice R, Bianchini V, Roncone R, Casacchia M. Marked increase in substance use among young people after L'Aquila earthquake. *Eur Child Adolesc Psychiatry.* 2011;20(8):429-430.
12. Keyes KM, Hatzenbuehler ML, Hasin DS. Stressful life experiences, alcohol consumption, and alcohol use disorders: the epidemiologic evidence for four main types of stressors. *Psychopharmacology (Berl).* 2011;218(1):1-17.
13. David D, Mellman TA, Mendoza LM, Kulick-Bell R, Ironson G, Schneiderman N. Psychiatric morbidity following Hurricane Andrew. *J Trauma Stress.* 1996;9(3):607-612.
14. Knudsen HK, Roman PM, Johnson JA, Ducharme LJ. A changed America? The effects of September 11th on depressive symptoms and alcohol consumption. *J Health Soc Behav.* 2005;46(3):260-273.
15. *Yuval Neria; Sandro Galea; Fran H. Norris. Mental Health and Disasters.* Cambridge University Press; 2009.
16. Cepeda A, Saint Onge JM, Kaplan C, Valdez A. The association between disaster-related experiences and mental health outcomes among drug using African American Hurricane Katrina evacuees. *Community Ment Health J.* 2010;46(6):612-620.

17. Bianchini V, Roncone R, Giusti L, Casacchia M, Cifone MG, Pollice R. PTSD Growth and Substance Abuse Among a College Student Community: Coping Strategies after 2009 L'aquila Earthquake. *Clin Pract Epidemiol Ment Health.* 2015;11:140-143.

18. Japan Meteorological Agency. Shindo database. 2018; http://www.jma.go.jp/jma/indexe.html. Accessed April 10, 2018.

19. Ruckinger S, von Kries R, Toschke AM. An illustration of and programs estimating attributable fractions in large scale surveys considering multiple risk factors. *BMC Med Res Methodol.* 2009;9:7.

20. Vonghia L, Leggio L, Ferrulli A, et al. Acute alcohol intoxication. *Eur J Intern Med.* 2008;19(8):561-567.

21. Bollerslev T. Generalized autoregressive conditional heteroskedasticity. *Journal of econometrics.* 1986;31(3):307-327.

22. Engle RF. Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica: Journal of the Econometric Society.* 1982:987-1007.

23. Engle R. Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business & Economic Statistics.* 2002;20(3):339-350.

24. Park CL, Cohen LH, Murch RL. Assessment and prediction of stress-related growth. *J Pers.* 1996;64(1):71-105.

25. Ito K, Aono A, and Ohmori N. Empirical Study on Stop-Offs en Route Home in the Aftermath of an Earthquake Disaster in the Tokyo Metropolitan Area – Analyses Based on an Online Questionnaire Survey about the Great East Japan Earthquake. Journal of the City Planning Institute of Japan, Vol.48, No.3, pp. 873-878, 2013.

26. Zare M, Afrouz SG. Crisis management of tohoku; Japan earthquake and tsunami, 11 march 2011. *Iran J Public Health.* 2012;41(6):12-20.

27. Erol A, Karpyak VM. Sex and gender-related differences in alcohol use and its consequences: Contemporary knowledge and future research considerations. *Drug Alcohol Depend.* 2015;156:1-13.

28. Bosque-Prous M, Espelt A, Borrell C, et al. Gender differences in hazardous drinking among middle-aged in Europe: the role of social context and women's empowerment. *Eur J Public Health.* 2015;25(4):698-705.

29. Holmila M, Raitasalo K. Gender differences in drinking: why do they still exist? *Addiction.* 2005;100(12):1763-1769.

30. Zarzar PM, Jorge KO, Oksanen T, Vale MP, Ferreira EF, Kawachi I. Association between binge drinking, type of friends and gender: a cross-sectional study among Brazilian adolescents. *BMC Public Health.* 2012;12:257.

31. Hagihara A, Tarumi K, Nobutomo K. Work stressors, drinking with colleagues after work, and job satisfaction among white-collar workers in Japan. *Subst Use Misuse.* 2000;35(5):737-756.

32. Osaki Y, Kinjo A, Higuchi S, et al. Prevalence and Trends in Alcohol Dependence and Alcohol Use Disorders in Japanese Adults; Results from Periodical Nationwide Surveys. *Alcohol Alcohol.* 2016;51(4):465-473.

33. Quinn PD, Harden KP. Differential changes in impulsivity and sensation seeking and the escalation of substance use from adolescence to early adulthood. *Dev Psychopathol.* 2013;25(1):223-239.

34. Betsy T. Risk-taking behaviour in men. Substance use and gender. 2003; https://pdfs.semanticscholar.org/2067/3ca32192d2577058acc9430f2ae6ad988d31.pdf. Accessed August 4, 2018.

	Patients (n=6,395)
Age, year, mean (SD)	42.6 (16.9)
Male, n (%)	4,592 (71.8)
Blood alcohol level, mg/dl, mean (SD)	225.4 (87.2)
Type of day when the patient visited the hospital	
Weekdays, n (%)	3,125 (48.9)
Days prior to day off, n (%)	1,220 (19.1)
Day off, n (%)	2,050 (32.1)
Season in which the patient visited the hospital	
Spring, n (%)	1,562 (24.4)
Summer, n (%)	1,558 (24.4)
Fall, n (%)	1,617 (25.3)
Winter, n (%)	1,658 (25.9)
Occurrence of earthquake when the patient visited the hospital	
Whole day, n (%)	657 (10.3)
Daytime earthquake, n (%)	197 (3.1)
Nighttime earthquake, n (%)	188 (2.94)

Table 1. Patient's characteristics

Variable	Univariate GARCH* model			Multivariate GARCH* model		
	β coefficient	95%CI†	*p* value	β coefficient	95%CI†	*p* value
Earthquake factors						
Incidence of earthquake	0.00	(-0.12 — 0.12)	0.95			
Number of earthquakes a day, times	-0.02	(-0.06 — 0.03)	0.46			
The depth of the epicenter, km	0.00	(-0.01 — 0.01)	0.85			
The highest magnitude in a day	0.00	(-0.02 — 0.02)	0.98			
The highest Shindo in a day	0.00	(-0.08 — 0.07)	0.92			
Daytime earthquake§	-0.19	(-0.40 — 0.01)	0.06	-0.18	(-0.38 — 0.02)	0.07
Nighttime earthquake‡	0.12	(-0.12 — 0.35)	0.34			
Date						
Categories of day						
Weekday		Reference			Reference	
The day before non-working day	**0.26**	**(0.15 — 0.37)**	**<0.01**	**0.25**	**(0.15 — 0.36)**	**<0.01**
Non-working day	0.08	(-0.01 — 0.17)	0.05	0.08	(-0.01 — 0.16)	0.08
Season						
Spring		Reference			Reference	
Summer	0.02	(-0.09 — 0.13)	0.73	0.02	(-0.09 — 0.12)	0.78
Fall	0.05	(-0.06 — 0.17)	0.35	0.03	(-0.76 — 0.14)	0.55
Winter	0.10	(-0.01 — 0.22)	0.07	**0.12**	**(0.02 — 0.23)**	**0.02**

Table 2. β coefficients for the number of patients with acute ethanol intoxication from the univariate and multivariate GARCH model

*GARCH stands for generalized autoregressive conditional heteroskedasticity. The multivariate GARCH model was adjusted for variables found to have a *p* value of 0.2 or less in a simple GARCH model as well as year-fixed effect and changes in alcohol taxation.; †CI represents confidence interval; §Daytime earthquake means that an earthquake was observed between 9 a.m. and 5 p.m.; ‡Nighttime earthquake means that earthquake was observed between 5 p.m. and 12 p.m.

Numbers in bold indicate that the p value is less than 0.05.

	Male (n = 4,646)				Female (n = 1,826)			
	Univariate GARCH*		Multivariate GARCH*		Univariate GARCH*		Multivariate GARCH*	
Variable	β coefficient (95%CI†)	p value	β coefficient (95%CI†)	p value	β coefficient (95%CI†)	p value	β coefficient (95%CI†)	p value
Earthquake factors								
Incidence of earthquake	0.00 (-0.11 — 0.10)	0.98			-0.01 (-0.07 — 0.05)	0.86		
Number of earthquakes per day, times	-0.01 (-0.05 — 0.02)	0.39			0.00 (-0.02 — 0.02)	0.79		
The depth of the epicenter, km	0.00 (-0.00 — 0.00)	0.98			0.00 (-0.01 — 0.01)	0.78		
The highest magnitude in a day	0.00 (-0.02 — 0.02)	0.98			0.00 (-0.01 — 0.01)	0.98		
The highest Shindo in a day	-0.01 (-0.07 — 0.05)	0.81			0.00 (-0.03 — 0.04)	0.94		
Daytime earthquake§	**-0.19 (-0.36 — -0.02)**	**0.02**	**-0.19 (-0.36 — -0.02)**	**0.03**	0.00 (-0.09 — 0.10)	0.95	0.00 (-0.10 — 0.10)	0.99
Nighttime earthquake‡	0.05 (-0.14 — 0.25)	0.59			0.05 (-0.07 — 0.16)	0.41		
Date								
Categories of day								
Weekday	Reference				Reference			
The day before a non-working day	**0.19** (0.10 — 0.28)	**<0.01**	**0.19** (0.10 — 0.28)	**<0.01**	**0.08 (0.03 — 0.13)**	**<0.01**	**0.08 (0.03 — 0.13)**	**<0.01**
Non-working day	0.04 (-0.04 — 0.11)	0.34	0.04 (-0.04 — 0.11)	0.35	**0.05 (0.01 — 0.09)**	**0.02**	**0.05 (0.01 — 0.09)**	**0.02**
Season								

Spring	Reference				Reference			
Summer	-0.00 (-0.10 — 0.09)	0.93	-0.00 (-0.10 — 0.09)	0.93	0.02 (-0.03 — 0.07)	0.42	0.02 (-0.03 — 0.08)	0.37
Fall	0.02 (-0.07 — 0.12)	0.63	0.02 (-0.08 — 0.11)	0.74	0.02 (-0.04 — 0.07)	0.55	0.01 (-0.04 — 0.07)	0.58
Winter	**0.12 (0.02 — 0.21)**	**0.01**	**0.12 (0.02 — 0.21)**	**0.01**	-0.02 (-0.07 — 0.03)	0.43	-0.02 (-0.07 — 0.03)	0.42

Table 3. β coefficients for the number of patients with acute ethanol intoxication from the univariate and multivariate GARCH model by gender

*GARCH represents generalized autoregressive conditional heteroskedasticity. The multivariate GARCH model was adjusted for variables found to have *p* value of 0.2 or less in a simple GARCH model as well as year-fixed effect and changes in alcohol taxation; †CI represents confidence interval; §Daytime earthquake means that earthquake was observed between 9 a.m. and 5 p.m.; ‡Nighttime earthquake means that earthquake was observed between 5 p.m. and 12 p.m.

Numbers in bold indicate that the p value is less than 0.05.

Variable	50 years or older (*n* = 2,202) Univariate GARCH* β coefficient (95%CI†)	p value	50 years or older Multivariate GARCH* β coefficient (95%CI†)	p value	Younger than 50 years (*n* = 4,270) Univariate GARCH* β coefficient (95%CI†)	p value	Younger than 50 years Multivariate GARCH* β coefficient (95%CI†)	p value
Earthquake factors								
Incidence of earthquake	-0.03 (-0.10 — 0.04)	0.37			0.03 (-0.07 — 0.13)	0.54		
Number of earthquakes per day, times	-0.01 (-0.03 — 0.01)	0.35			0.00 (-0.04 — 0.03)	0.82		
The depth of the epicenter, km	0.00 (-0.00 — 0.00)	0.67			0.00 (-0.01 — 0.01)	0.98		
The highest magnitude in a day	-0.01 (-0.02 — 0.01)	0.39			0.01 (-0.01 — 0.03)	0.54		
The highest Shindo in a day	-0.02 (-0.06 — 0.02)	0.35			0.02 (-0.04 — 0.08)	0.58		
Daytime earthquake§	-0.09 (-0.20 — 0.01)	0.09	-0.09 (-0.19 — 0.02)	0.11	-0.07 (-0.23 — 0.10)	0.39	-0.08 (-0.24 — 0.09)	0.36
Nighttime earthquake‡	0.03 (-0.09 — 0.15)	0.65			0.09 (-0.09 — 0.28)	0.32		
Date								
Categories of day								
Weekday	Reference				Reference			
The day before the non-working day	**0.06** (0.01 — 0.12)	**0.02**	**0.06** (0.01 — 0.12)	**0.03**	**0.19 (0.11 — 0.28)**	**<0.01**	**0.19 (0.11 — 0.28)**	**<0.01**
Non-working day	-0.04 (-0.08 — 0.01)	0.09	-0.04 (-0.09 — 0.01)	0.08	**0.11 (0.04 — 0.18)**	**<0.01**	**0.11 (0.05 — 0.18)**	**<0.01**
Season								

Spring		Reference				Reference		
Summer	-0.03 (-0.09 — 0.02)	0.26	-0.03 (-0.09 — 0.02)	023	0.06 (-0.03 — 0.14)	0.20	0.06 (-0.03 — 0.15)	0.17
Fall	0.01 (-0.05 — 0.07)	0.73	0.01 (-0.05 — 0.06)	0.82	0.04 (-0.05 — 0.12)	0.40	0.03 (-0.05 — 0.12)	0.45
Winter	**0.10 (0.04 — 0.15)**	**<0.01**	**0.10 (0.04 — 0.15)**	**<0.01**	0.01 (-0.08 — 0.10)	0.81	0.01 (-0.08 — 0.79)	0.83

Table 4. β coefficients for the number of patients with acute ethanol intoxication from univariate and multivariate GARCH model by age

*GARCH stands for generalized autoregressive conditional heteroskedasticity; †CI represents confidence interval; §Daytime earthquake means that the earthquake was observed between 9 a.m. and 5 p.m.; ‡Nighttime earthquake means that the earthquake was observed between 5 p.m. and 12 p.m. Numbers in bold indicate that the p value is less than 0.05.

Figure legend:

Figure 1. Number of earthquakes per day.

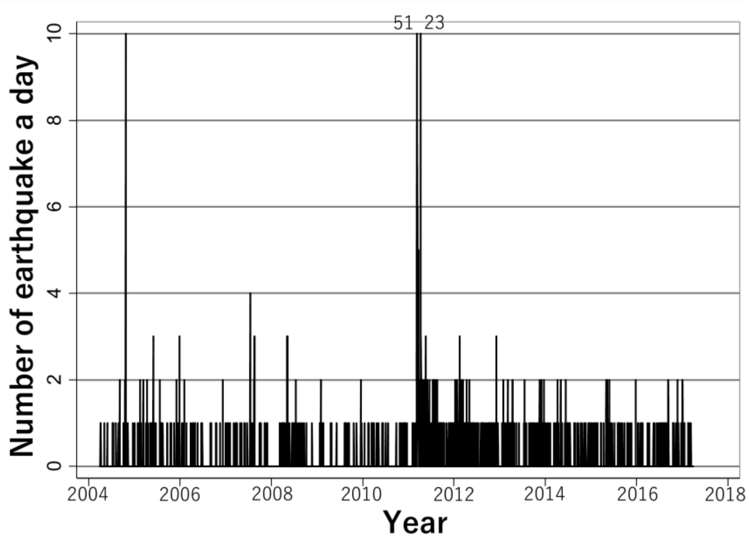

Figure 1. Daily number of earthquake.

279x215mm (300 x 300 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

Check	Page, session		Item No	Recommendation
X	Page1. Title	**Title and abstract**	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
X	Page2-3, abstract			(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
		Introduction		
X	Page4-5, introduction	Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
X	Page5, last in Introduction	Objectives	3	State specific objectives, including any prespecified hypotheses
		Methods		
X	Page6, first paragraph in Methods	Study design	4	Present key elements of study design early in the paper
X	Page6, first paragraph in Methods	Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
X	Page6, first paragraph in Methods	Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
X	Page6, first and second paragraph in Methods			(*b*) For matched studies, give matching criteria and number of exposed and unexposed
X	Page7-8, third paragraph in Methods	Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
X	Page7-8, third paragraph in Methods	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
X	Page7-8, third paragraph in Methods	Bias	9	Describe any efforts to address potential sources of bias
X	Page9, third paragraph in statistical analyses	Study size	10	Explain how the study size was arrived at
X	Page8, first and second paragraph in statistical analyses	Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why

X	Page8, first and second paragraph in statistical analyses	Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
X	Page8, first and second paragraph in statistical analyses			(*b*) Describe any methods used to examine subgroups and interactions
X	Page8, first and second paragraph in statistical analyses			(*c*) Explain how missing data were addressed
X	N/A			(*d*) If applicable, explain how loss to follow-up was addressed
X	Page8, first and second paragraph in statistical analyses			(*e*) Describe any sensitivity analyses
		Results		
X	Page10, result session	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
X	Page10, result session			(b) Give reasons for non-participation at each stage
X	N/A			(c) Consider use of a flow diagram
X	Page10, result session	Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
X	Page10, result session			(b) Indicate number of participants with missing data for each variable of interest
X	Page10, result session			(c) Summarise follow-up time (eg, average and total amount)
X	Page10, result session, table1	Outcome data	15*	Report numbers of outcome events or summary measures over time
X	Page10-11, result session	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
X	Page10-11, result session			(*b*) Report category boundaries when continuous variables were categorized
X	Page10-11, result session			(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
X	Page10-11, result session, Table2.	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
		Discussion		
X	Page12, first	Key results	18	Summarise key results with reference to

	paragraph in discussion			study objectives
X	Page 12-14 in discussion	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
X	Page 14	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
X	Page 14	Generalisability	21	Discuss the generalisability (external validity) of the study results
		Other information		
X	Page1	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

*Give information separately for exposed and unexposed groups.

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 http://www.strobe-statement.org.

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Alcohol Consumption Behaviors in the Immediate Aftermath of Earthquakes: Time series study

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Alcohol Consumption Behaviors in the Immediate Aftermath of Earthquakes: Time series study

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Abstract

Objectives: Earthquakes are a distressing natural phenomenon that can disrupt normal health-related behaviors. The aim of this study was to investigate changes in alcohol consumption behaviors in the immediate aftermath of mild to moderate earthquakes.

Setting: This retrospective cohort study was conducted at a large academic hospital in Tokyo, Japan from April 2004 to March 2017.

Participants: We included all adult patients presenting with acute alcohol intoxication in the emergency room.

Primary and secondary outcome measures: Our outcome was the number of such patients per 24 hour period comparing days with and without earthquake activity. We mainly focused on mild to moderate earthquakes (Sindo scale of less than 3). We conducted a simple generalized autoregressive conditional heteroscedasticity (GARCH) analysis, followed by a multivariate GARCH, including year-fixed effects and secular changes in alcohol taxation. Subanalyses were conducted by gender and age group.

Results: During the study period, 706 earthquakes were observed with a median Shindo scale of 2 (IQR: 1). During this period, 6,395 patients were admitted with acute ethanol intoxication; the mean age was 42.6 (SD: 16.9) years, and 4,592 (71.8%) patients were male. In univariate analyses, the occurrence of daytime earthquakes was marginally inversely related to the number of acutely intoxicated patients (β coefficient: -0.19, 95% CI: -0.40 - 0.01). This finding remained similar in multivariate analyses after adjustment for covariates. In analyses stratified by gender, the inverse association between daytime earthquakes and alcohol intoxication was only observed among men (*p*<0.03 for males and *p*=0.99 for females). In subanalyses by age, older people were less likely to be admitted to the hospital due to acute alcohol intoxication on days with daytime earthquakes (p=0.11), but this was not the case for younger people (p=0.36).

Conclusion: On days when a mild to moderate daytime earthquake occurred, the number of patients with acute alcohol intoxication was lower compared to days without earthquakes. Even milder forms of potentially catastrophic events appear to influence social behavior; mild to moderate earthquake activity is associated with the avoidance of excessive alcohol consumption.

Article summary

Strengths and limitations of this study

・This unique study is the first to evaluate alcohol consumption behavior in the immediate aftermath of earthquakes.

・Robust analyses, by sensitivity analyses with three methods in addition to the main analysis by multivariate generalized autoregressive conditional heteroscedasticity (GARCH) approach, supported the findings in this study.

・The limitation of this study was its analysis of a single center with a single ethnicity.

Introduction

Catastrophic earthquake activity has been reported to exert a variety of effects on both physical and mental health [1]. A previous study reported that approximately 42.6% of victims exhibited moderate to serious mental health problems after the Great East Japan earthquake, which occurred in March 2011 [1]. Acute health effects associated with earthquake activity include acute stress disorders [2], delirium, [3] and acute and transient psychotic disorders. Longer-term effects on victims' well-being have also been reported, including post-traumatic stress disorder and exacerbation of bipolar disorder [4-6]. Although most previous research has been limited to the health impacts of rare catastrophic earthquakes, very few studies have focused on the health effects associated with substantially more common mild to moderate earthquakes.

Substance abuse is a common disorder reported in the setting of catastrophic disasters [7,8]. Several studies have explored this relationship with regard to alcohol use behaviors [9,10], with several previous studies reporting an increased prevalence of alcohol abuse after major earthquakes. [11,12] However, in the larger context of catastrophic phenomena, this association remains unclear, with one report showing only a 2% increase in prevalence after a major hurricane [13] and other studies reporting a slight decrease in alcohol abuse after instances of terrorism [9,14]. Moreover, some suggested that disasters have rarely increased the prevalence of substance use disorders. Instead, increased alcohol abuse after disaster can often reflect an exacerbation of existing abuse rather than new-onset disorders [15]. As such, the effect of disasters on alcohol abuse remains controversial. Previous studies have suggested that gender, age, education, and even cultural background modify these associations. [16,17]

Japan is a tectonically active country where earthquakes are observed frequently. The Japan Meteorological Agency observed 2,025 earthquakes in 2017, and more than 6,500 earthquakes were observed in 2016 in Japan [18]. Among the 76 earthquakes in 2017 and 123 events in 2016, 3.8% and 1.9%, respectively, were greater than a magnitude of 5. In addition to the incidence of earthquakes, the Japan Meteorological Agency recorded the date, time, magnitude, location, and seismic intensity [19]. Thus, the aim of this study was to evaluate the same-day association between mild to moderate earthquakes and unhealthy alcohol use behavior in Japan.

Methods

Study design and cohort description

We conducted a retrospective daily time series study using medical record data from St. Luke's International Hospital in Tokyo, Japan from April 2004 to March 2017. We included all patients who were 20 or older and presented to the hospital emergency room with acute alcohol intoxication. We excluded all patients who signed opt-out agreements for their anonymized data to be used in research. In addition, patients presenting with an altered mental status of uncertain origin were excluded. Our outcome was a patient volume of acutely intoxicated patients per 24-hour period. Outcomes were compared between days with and without earthquakes, as observed by the Japan Meteorological Agency.

Patient and Public Involvement

There was no involvement of patients other than this data and the public.

Research ethics application

The ethical committee at St. Luke's International Hospital approved this study (approval number: 17-R025).

Data availability statement

No additional data available.

Acute alcohol intoxication

Emergency physicians at the hospital clinically diagnosed with acute alcohol intoxication based on testimonies by patients or their companions. A blood ethanol level of 100 mg/dl or higher was used to support the diagnosis for those whose testimonies could not be elicited directly [20].

Earthquake

All earthquake data were obtained from the Japan Meteorological Agency [18]. The recorded data contain the time and date of occurrence, the Richter magnitude, the depth of epicenter, and Shindo scale data for any earthquake detected. With a range of 0 to 7, Shindo is the unique measurement scale used in Japan for seismic intensities in a specific area [19]. Unlike the Richter scale, which represents the size of the earthquake itself and is unique for each earthquake, Shindo scaling reflects the intensity of the observed shaking in a given area and is based on the distance from the epicenter at which the seismic activity was observed. Generally speaking, the further the observed area is from the epicenter, the lower the Shindo measurement is for that area. A Shindo score of 1 is comparable to mild shaking observed only when sitting quietly in a structure, while a Shindo score of 4 is defined as observable shaking that is intense enough to startle, awaken people from sleep, and can be detected while walking. A Shindo score of 7 equates to severe shaking in which it is impossible to remain standing or move without crawling. In terms of the severity of the earthquake, we defined earthquakes with a Shindo score of 1 – 3 as mild to moderate earthquakes and those with a Shindo score of 4 or more as severe earthquakes. We defined a daytime earthquake as one observed between 9 a.m. and 5 p.m., while a nighttime earthquake was defined as occurring between 5 p.m. and 12 a.m. The reason why we divided earthquakes as above is that a daytime earthquake was believed to affect the subsequent drinking behavior on the same night. In contrast, a nighttime earthquake that may have occurred while drinking alcohol was believed to have a different effect on drinking behavior. The remaining time period, from 12 a.m. to 9 a.m., was considered as having little effect on alcohol behavior.

Study site

St. Luke’s International Hospital is located in Chuo-ku, Tokyo, Japan. The hospital, a 520-bed tertiary-level community teaching hospital, accepts more than 10,000 ambulance admissions a year. Located close to Ginza, a major entertainment district popular for bars and restaurants serving alcohol, St. Luke`s receives the largest number of ambulances per year, including approximately 50% of ambulances dispatched from the Ginza area. We included only earthquakes that were observed in this metropolitan Tokyo area in the analyses.

Category of the day in relation to work week and seasonality

Because the incidence of acute alcohol intoxication is considered to vary substantially by the day of the week, we divided the days into three categories: weekdays, days prior to a non-working day, and non-working days (generally understood in Japan to be Saturday, Sunday, and designated national holidays). For days overlapping categories, we considered days prior to a non-working day the most dominant. For instance, because December 31, January 1st, 2nd, and 3rd are designated national holidays in Japan, we categorized December 31, January 1st and 2nd as “days prior to a non-working day”, and 3rd as a “non-working day”.

As the incidence of acute alcohol intoxication is also considered to be related to seasonality, we categorized March, April and May as spring; June, July and August as summer; September, October and November as fall; December, January and February as winter.

Statistical analyses

Because the occurrence of earthquakes on a certain day was considered to be autocorrelated and have an autoregressive conditional heteroscedasticity (ARCH) effect (Figure), we applied a multivariate generalized autoregressive conditional heteroscedasticity (GARCH) approach with dynamic conditional correlation to investigate the association between patients' presentation in the ER and acute alcohol intoxication and occurrence of earthquakes [21-23]. In terms of the primary outcome, we first applied a simple GARCH model with each variable examining the relationship between hospital admission for acute alcohol intoxication and earthquake activity, the category of day, and seasonality. This was followed by a multivariate GARCH(1,1) model with variables found to have a p value of 0.2 or lower in the simple GARCH model, as well as a year-fixed effect and changes in alcohol taxation. Alcohol taxation had changed five times during study periods, and it is included the model as a categorical variable. Because the taxation rates were similar during the study periods (e.g., 45.1%- 46.6% for beer, 16.2%-18.1% for sake), the impact of alcohol taxation change on the results was considered to be limited. The β coefficient and 95% confidence intervals (CI) were calculated. In addition, we stratified the analyses by both gender and age (50 years or older versus less than 50 years). Moreover, we separately analyzed data before the Great East Japan earthquake on March 11, 2011 and after the earthquake. We also conducted sensitivity analyses to check robustness with the following three methods: using the Richter scale magnitude as a covariate to evaluate whether the results differ according to the magnitude of the earthquake; introducing different lag times between the earthquake and hospital visits (e.g., 1, 3 or 7 days after the earthquakes), excluding days in which severe earthquakes (Shindo scale ≥4) occurred; and having the data stratified by day of the week. All analyses were performed using Stata 14.0 (Stata Corp, TX, USA).

Results

During the study period, earthquakes were observed 706 times with a median Shindo score in the catchment area of 2 (interquartile range 1). During the 4,747 days in the study period, earthquakes were observed on 500 days. During this period, 6,571 patients were extracted from the electronic medical record. Among them, 99 were excluded because they were younger than 20 years old, and 77 were excluded based on the blood alcohol level. Finally, 6,395 patients with a mean age of 42.6 (*SD* 16.9) were treated for acute ethanol intoxication; 4,592 (71.8%) were male (Table 1).

Table 2 shows the results for the number of patients with acute ethanol intoxication from the simple and multivariate GRACH models. In univariate analyses, the daytime earthquake figure was marginally and inversely related to the number of acutely intoxicated patients (β coefficient: -0.19, 95% CI: -0.40 - 0.01). The number of days prior to a non-working day (β coefficient: 0.26, 95%CI: 0.15 - 0.37) was significantly related and the number of non-working days (β coefficient: 0.08, 95%CI: -0.01 - 0.14) was marginally significantly related to acute intoxication. These findings remained similar in multivariate analyses after adjusting for both occurrences of a daytime earthquake, the category of day, seasonality, year-fixed effect and change in alcohol taxation.

In a sensitivity analysis, including Richter scale magnitude as a covariate to evaluate whether the results differ according to the magnitude of the earthquake, the daytime earthquake number was still marginally related to decreased patient volume (β coefficient: -0.23, 95% CI: -0.47 - 0.01). However, the magnitude of the earthquake itself had no relationship with patient volume (β coefficient: 0.01, 95% CI: -0.02 - 0.04). When we introduced different lag times between the earthquake and hospital visits, the number of daytime earthquakes was also marginally significantly related to decreased patient volume (β coefficient:

-0.18, 95% CI: -0.38 - 0.01 for 1 day after an earthquake; β coefficient: -0.18, 95% CI: -0.38 - 0.02 for 3 days after an earthquake; and β coefficient: -0.18, 95% CI: -0.38 - 0.02 for 7 days after an earthquake), while different lag times themselves were not associated with patient volume. When we excluded days in which severe earthquakes (Shindo scale ≥4) occurred, the findings were similar [daytime earthquake (β coefficient: -0.18, 95% CI: -0.38 - 0.02)]. In the analyses by stratification of day of the week, the number of daytime earthquakes was not related to patient volume on weekdays (β coefficient: 0.01, 95% CI: -0.28 - 0.30) but tend to be negatively related to patient volume on days off (β coefficient: -0.15, 95% CI: -0.49 - 0.19). The analysis was not concaved in the days prior to days off.

Table 3 shows the result of the number of patients with alcohol intoxication from univariate and multivariate analyses stratified by gender. The inverse association between daytime earthquake and alcohol intoxication seen in a pooled analysis was only observed among men ($p<0.03$ for males and $p=0.99$ for females). Although a positive association between the day before non-working days and acute alcohol intoxication were observed in both males ($p<0.01$) and females ($p<0.01$), higher rates of intoxication on non-working days were only observed in women ($p=0.02$ for females and $p=0.35$ for males). Among male patients, the number of patients with acute alcohol intoxication rose in the winter compared to spring ($p=0.01$), but not among females ($p=0.42$).

Table 4 shows the result for the number of patients with alcohol intoxication from univariate and multivariate analyses stratified by age group. Older people were less likely to be admitted to the ER due to acute alcohol intoxication on days when daytime earthquakes occurred ($p=0.11$), but the same pattern was not seen among younger people ($p=0.36$). Both older and younger patients with acute alcohol intoxication were more likely to be admitted on days before non-working days as well as on non-working days compared to weekdays. However, in terms of seasonality, older people were significantly more likely to be admitted to the ER with acute alcohol intoxication in the winter (*p*<0.01), but not younger people (*p*=0.83)

In terms of stratification by the date of the Great East Japan earthquake, the number of daytime earthquakes was inversely related to the number of acutely intoxicated patients after the Great East Japan earthquake (β coefficient: -0.28, 95% CI: -0.55 - -0.02), while the number of daytime earthquakes was not related to the number before the Great East Japan earthquake (β coefficient: -0.02, 95% CI: -0.32 - 0.29).

Discussion

Our study found several predictors of the number of intoxicated patients presenting in the ER of a major urban hospital in Japan. Notably, there was an inverse relationship between the number of intoxicated patients and daytime earthquakes observed in older patients and men.

Although previous studies that evaluated drinking behavior after catastrophic earthquakes reported both positive and negative effects, we found that non-catastrophic earthquakes may exert a dampening (i.e., a health-favorable) effect on excess alcohol consumption. This finding was considered to be a type of stress-related growth, which is the theory that people develop from negative events [24]. We speculate that people may avoid risky behaviors, such as going out with companions after work, to indulge in excessive amounts of drinking immediately after an earthquake. When people experience earthquakes, many may suspect additional tectonic activity; multiple earthquakes in a single day are common and were observed on 83 (16.7%) days in our study. As a result, we suspect that many people choose to go home rather than go out, as has been documented in reports about catastrophic earthquakes [25]. People may avoid social activities, such as after-work gatherings, on days in which even mild but nevertheless frightening natural phenomena have occurred, thereby reducing the opportunities for excessive drinking and other risky social behaviors. Lower blood alcohol levels noted on earthquake days also suggest that even imbibers may limit the amount of alcohol consumed on such days. Similar social behaviors have been observed after the Great East Japan earthquake in 2011, although whether these behavioral changes are conscious or unconscious remains unclear [26].

We found both age and gender differences in the relationship between daytime earthquakes and acute alcohol intoxication. There were statistically fewer male patients with acute alcohol intoxication on days when a daytime earthquake occurred compared to days without seismic activity. Interestingly, this relationship was not found for female patients. A previous systematic review reported that differing patterns of alcohol use between men and women are driven by both biological and psycho-socio-cultural factors [27]. As a result, men are more likely to seek sensations, including hazardous drinking, than women in ordinary settings [28,29]. However, it is possible that mild earthquakes may affect these psycho-socio-cultural factors more for men than women. Social capital may play an important role in this [30]. Because most Japanese male workers drink with colleagues after work [31], some may suggest that others not go out to drink after work on days with earthquakes.

In terms of age, fewer older patients with acute alcohol intoxication were observed on days with earthquakes, despite an unchanged number of younger patients presenting with acute alcohol intoxication on these days. A previous survey about alcohol use reported that younger people tended to indulge in more binge drinking and heavy episodic drinking in Japan [32] and other countries [33]. Psychologically disturbing natural phenomena, however mild, may also exert specific inhibitory psycho-socio-cultural effects on risky behaviors of younger people. Further research is needed to evaluate the potential mechanisms for these differences.

Significantly fewer patients with acute alcohol intoxication were observed on days with daytime earthquakes compared to those on days without daytime earthquakes after the Great East Japan earthquake, while the finding was not observed before the Great East Japan earthquake. This suggests that people still have catastrophic earthquakes in mind and avoid sensation seeking from stress-related growth.

Our study has some limitations. First, not all potential patients with acute alcohol intoxication were transferred to our hospital, resulting in a measure of selection bias. However, because our hospital has the largest number and highest rate of ambulance acceptances in Tokyo, with more than 50% of ambulances dispatched to the local entertainment area were transferred to us, and we assume that this bias is neither large nor differential. In addition, the findings may not be applicable to other countries because ethnicity and cultural diversity could exist [34]. Second, because we were unable to accurately record information about when patients started to consume alcohol, precise knowledge of the temporal relationship between alcohol consumption, intoxication, and earthquakes are difficult to assess. Similarly, because qualitative data concerning patients` physical and emotional perception of seismic activity is not available, further studies are warranted in this area. In addition, evaluation for acute stress disorder may be useful to explain the gender and age difference of findings. Finally, an earthquake itself may somewhat impact hospital operations. However, the emergency department of hospitals had operated as usual on and after the Great East Japan earthquake. Therefore, the impact is considered to be limited.

Conclusion

On days when mild to moderate daytime earthquakes occurred, our hospital had fewer patients with acute alcohol intoxication presenting in the emergency room. This pattern was also seen for men and elderly patients. Even mild natural phenomena may lead to changes in social behavior that result in avoidance of excessive alcohol use.

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References

1. Yokoyama Y, Otsuka K, Kawakami N, et al. Mental health and related factors after the Great East Japan earthquake and tsunami. *PLoS One.* 2014;9(7):e102497.
2. Zhou P, Zhang Y, Wei C, Liu Z, Hannak W. Acute stress disorder as a predictor of posttraumatic stress: A longitudinal study of Chinese children exposed to the Lushan earthquake. *Psych J.* 2016;5(3):206-214.
3. Awata S. [Disaster psychiatry in late life]. *Nihon Rinsho.* 2013;71(10):1864-1869.
4. Navarro-Mateu F, Salmeron D, Vilagut G, et al. Post-Traumatic Stress Disorder and other mental disorders in the general population after Lorca's earthquakes, 2011 (Murcia, Spain): A cross-sectional study. *PLoS One.* 2017;12(7):e0179690.
5. Cai D, Zhu Z, Sun H, et al. Maternal PTSD following Exposure to the Wenchuan Earthquake Is Associated with Impaired Mental Development of Children. *PLoS One.* 2017;12(4):e0168747.
6. Derivois D, Cenat JM, Joseph NE, Karray A, Chahraoui K. Prevalence and determinants of post-traumatic stress disorder, anxiety and depression symptoms in street children survivors of the 2010 earthquake in Haiti, four years after. *Child Abuse Negl.* 2017;67:174-181.
7. Seligman J, Felder SS, Robinson ME. Substance Abuse and Mental Health Services Administration (SAMHSA) Behavioral Health Disaster Response App. *Disaster Med Public Health Prep.* 2015;9(5):516-518.
8. Moise IK, Ruiz MO. Hospitalizations for Substance Abuse Disorders Before and After Hurricane Katrina: Spatial Clustering and Area-Level Predictors, New Orleans, 2004 and 2008. *Prev Chronic Dis.* 2016;13:E145.
9. North CS, Pfefferbaum B. Mental health response to community disasters: a systematic review. *JAMA.* 2013;310(5):507-518.
10. Vlahov D, Galea S, Resnick H, et al. Increased use of cigarettes, alcohol, and marijuana among Manhattan, New York, residents after the September 11th terrorist attacks. *Am J Epidemiol.* 2002;155(11):988-996.
11. Pollice R, Bianchini V, Roncone R, Casacchia M. Marked increase in substance use among young people after L'Aquila earthquake. *Eur Child Adolesc Psychiatry.* 2011;20(8):429-430.
12. Keyes KM, Hatzenbuehler ML, Hasin DS. Stressful life experiences, alcohol consumption, and alcohol use disorders: the epidemiologic evidence for four main types of stressors. *Psychopharmacology (Berl).* 2011;218(1):1-17.
13. David D, Mellman TA, Mendoza LM, Kulick-Bell R, Ironson G, Schneiderman N. Psychiatric morbidity following Hurricane Andrew. *J Trauma Stress.* 1996;9(3):607-612.
14. Knudsen HK, Roman PM, Johnson JA, Ducharme LJ. A changed America? The effects of September 11th on depressive symptoms and alcohol consumption. *J Health Soc Behav.* 2005;46(3):260-273.
15. *Yuval Neria; Sandro Galea; Fran H. Norris. Mental Health and Disasters.* Cambridge University Press; 2009.
16. Cepeda A, Saint Onge JM, Kaplan C, Valdez A. The association between disaster-related experiences and mental health outcomes among drug using African American Hurricane Katrina evacuees. *Community Ment Health J.* 2010;46(6):612-620.

17. Bianchini V, Roncone R, Giusti L, Casacchia M, Cifone MG, Pollice R. PTSD Growth and Substance Abuse Among a College Student Community: Coping Strategies after 2009 L'aquila Earthquake. *Clin Pract Epidemiol Ment Health.* 2015;11:140-143.
18. Japan Meteorological Agency. Shindo database. 2018; http://www.jma.go.jp/jma/indexe.html. Accessed April 10, 2018.
19. Ruckinger S, von Kries R, Toschke AM. An illustration of and programs estimating attributable fractions in large scale surveys considering multiple risk factors. *BMC Med Res Methodol.* 2009;9:7.
20. Vonghia L, Leggio L, Ferrulli A, et al. Acute alcohol intoxication. *Eur J Intern Med.* 2008;19(8):561-567.
21. Bollerslev T. Generalized autoregressive conditional heteroskedasticity. *Journal of econometrics.* 1986;31(3):307-327.
22. Engle RF. Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica: Journal of the Econometric Society.* 1982:987-1007.
23. Engle R. Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business & Economic Statistics.* 2002;20(3):339-350.
24. Park CL, Cohen LH, Murch RL. Assessment and prediction of stress-related growth. *J Pers.* 1996;64(1):71-105.
25. Ito K, Aono A, and Ohmori N. Empirical Study on Stop-Offs en Route Home in the Aftermath of an Earthquake Disaster in the Tokyo Metropolitan Area – Analyses Based on an Online Questionnaire Survey about the Great East Japan Earthquake. Journal of the City Planning Institute of Japan, Vol.48, No.3, pp. 873-878, 2013.
26. Zare M, Afrouz SG. Crisis management of tohoku; Japan earthquake and tsunami, 11 march 2011. *Iran J Public Health.* 2012;41(6):12-20.
27. Erol A, Karpyak VM. Sex and gender-related differences in alcohol use and its consequences: Contemporary knowledge and future research considerations. *Drug Alcohol Depend.* 2015;156:1-13.
28. Bosque-Prous M, Espelt A, Borrell C, et al. Gender differences in hazardous drinking among middle-aged in Europe: the role of social context and women's empowerment. *Eur J Public Health.* 2015;25(4):698-705.
29. Holmila M, Raitasalo K. Gender differences in drinking: why do they still exist? *Addiction.* 2005;100(12):1763-1769.
30. Zarzar PM, Jorge KO, Oksanen T, Vale MP, Ferreira EF, Kawachi I. Association between binge drinking, type of friends and gender: a cross-sectional study among Brazilian adolescents. *BMC Public Health.* 2012;12:257.
31. Hagihara A, Tarumi K, Nobutomo K. Work stressors, drinking with colleagues after work, and job satisfaction among white-collar workers in Japan. *Subst Use Misuse.* 2000;35(5):737-756.
32. Osaki Y, Kinjo A, Higuchi S, et al. Prevalence and Trends in Alcohol Dependence and Alcohol Use Disorders in Japanese Adults; Results from Periodical Nationwide Surveys. *Alcohol Alcohol.* 2016;51(4):465-473.
33. Quinn PD, Harden KP. Differential changes in impulsivity and sensation seeking and the escalation of substance use from adolescence to early adulthood. *Dev Psychopathol.* 2013;25(1):223-239.

34. Betsy T. Risk-taking behaviour in men. Substance use and gender. 2003; https://pdfs.semanticscholar.org/2067/3ca32192d2577058acc9430f2ae6ad988d31.pdf. Accessed August 4, 2018.

	Patients (n=6,395)
Age, year, mean (SD)	42.6 (16.9)
Male, n (%)	4,592 (71.8)
Blood alcohol level, mg/dl, mean (SD)	225.4 (87.2)
Type of day when the patient visited the hospital	
Weekdays, n (%)	3,125 (48.9)
Days prior to day off, n (%)	1,220 (19.1)
Day off, n (%)	2,050 (32.1)
Season in which the patient visited the hospital	
Spring, n (%)	1,562 (24.4)
Summer, n (%)	1,558 (24.4)
Fall, n (%)	1,617 (25.3)
Winter, n (%)	1,658 (25.9)
The occurrence of earthquake when the patient visited the hospital	
A whole day, n (%)	657 (10.3)
Daytime earthquake, n (%)	197 (3.1)
Nighttime earthquake, n (%)	188 (2.94)

Table 1. Patients' characteristics

Variable	Univariate GARCH* model			Multivariate GARCH* model		
	β coefficient	95%CI†	*p* value	β coefficient	95%CI†	*p* value
Earthquake factors						
Incidence of earthquake	0.00	(-0.12 — 0.12)	0.95			
Number of earthquakes a day, times	-0.02	(-0.06 — 0.03)	0.46			
The depth of the epicenter, km	0.00	(-0.01 — 0.01)	0.85			
The highest magnitude in a day	0.00	(-0.02 — 0.02)	0.98			
The highest Shindo in a day	0.00	(-0.08 — 0.07)	0.92			
Daytime earthquake§	-0.19	(-0.40 — 0.01)	0.06	-0.18	(-0.38 — 0.02)	0.07
Nighttime earthquake‡	0.12	(-0.12 — 0.35)	0.34			
Date						
Categories of day						
Weekday		Reference			Reference	
The day before non-working day	**0.26**	**(0.15 — 0.37)**	**<0.01**	**0.25**	**(0.15 — 0.36)**	**<0.01**
Non-working day	0.08	(-0.01 — 0.17)	0.05	0.08	(-0.01 — 0.16)	0.08
Season						
Spring		Reference			Reference	
Summer	0.02	(-0.09 — 0.13)	0.73	0.02	(-0.09 — 0.12)	0.78
Fall	0.05	(-0.06 — 0.17)	0.35	0.03	(-0.76 — 0.14)	0.55
Winter	0.10	(-0.01 — 0.22)	0.07	**0.12**	**(0.02 — 0.23)**	**0.02**

Table 2. β coefficients for the number of patients with acute ethanol intoxication from the univariate and multivariate GARCH model

*GARCH stands for generalized autoregressive conditional heteroskedasticity. The multivariate GARCH model was adjusted for variables found to have a *p* value of 0.2 or less in a simple GARCH model as well as year-fixed effect and changes in alcohol taxation.; †CI represents confidence interval; §Daytime earthquake means that an earthquake was observed between 9 a.m. and 5 p.m.; ‡Nighttime earthquake means that earthquake was observed between 5 p.m. and 12 p.m.

Numbers in bold indicate that the p value is less than 0.05.

	Male (n = 4,646)				Female (n = 1,826)			
	Univariate GARCH*		Multivariate GARCH*		Univariate GARCH*		Multivariate GARCH*	
Variable	β coefficient (95%CI†)	p value	β coefficient (95%CI†)	p value	β coefficient (95%CI†)	p value	β coefficient (95%CI†)	p value
Earthquake factors								
Incidence of earthquake	0.00 (-0.11 — 0.10)	0.98			-0.01 (-0.07 — 0.05)	0.86		
Number of earthquakes per day, times	-0.01 (-0.05 — 0.02)	0.39			0.00 (-0.02 — 0.02)	0.79		
The depth of the epicenter, km	0.00 (-0.00 — 0.00)	0.98			0.00 (-0.01 — 0.01)	0.78		
The highest magnitude in a day	0.00 (-0.02 — 0.02)	0.98			0.00 (-0.01 — 0.01)	0.98		
The highest Shindo in a day	-0.01 (-0.07 — 0.05)	0.81			0.00 (-0.03 — 0.04)	0.94		
Daytime earthquake§	**-0.19 (-0.36 — -0.02)**	**0.02**	**-0.19 (-0.36 — -0.02)**	**0.03**	0.00 (-0.09 — 0.10)	0.95	0.00 (-0.10 — 0.10)	0.99
Nighttime earthquake‡	0.05 (-0.14 — 0.25)	0.59			0.05 (-0.07 — 0.16)	0.41		
Date								
Categories of day								
Weekday	Reference				Reference			
The day before a non-working day	**0.19** (0.10 — 0.28)	**<0.01**	**0.19** (0.10 — 0.28)	**<0.01**	**0.08 (0.03 — 0.13)**	**<0.01**	**0.08 (0.03 — 0.13)**	**<0.01**
Non-working day	0.04 (-0.04 — 0.11)	0.34	0.04 (-0.04 — 0.11)	0.35	**0.05 (0.01 — 0.09)**	**0.02**	**0.05 (0.01 — 0.09)**	**0.02**
Season								

Spring	Reference				Reference			
Summer	-0.00 (-0.10 — 0.09)	0.93	-0.00 (-0.10 — 0.09)	0.93	0.02 (-0.03 — 0.07)	0.42	0.02 (-0.03 — 0.08)	0.37
Fall	0.02 (-0.07 — 0.12)	0.63	0.02 (-0.08 — 0.11)	0.74	0.02 (-0.04 — 0.07)	0.55	0.01 (-0.04 — 0.07)	0.58
Winter	**0.12 (0.02 — 0.21)**	**0.01**	**0.12 (0.02 — 0.21)**	**0.01**	-0.02 (-0.07 — 0.03)	0.43	-0.02 (-0.07 — 0.03)	0.42

Table 3. β coefficients for the number of patients with acute ethanol intoxication from the univariate and multivariate GARCH model by gender

*GARCH represents generalized autoregressive conditional heteroskedasticity. The multivariate GARCH model was adjusted for variables found to have *p* value of 0.2 or less in a simple GARCH model as well as year-fixed effect and changes in alcohol taxation; †CI represents confidence interval; §Daytime earthquake means that earthquake was observed between 9 a.m. and 5 p.m.; ‡Nighttime earthquake means that earthquake was observed between 5 p.m. and 12 p.m.

Numbers in bold indicate that the p value is less than 0.05.

	50 years or older (n = 2,202)				Younger than 50 years (n = 4,270)			
	Univariate GARCH*		Multivariate GARCH*		Univariate GARCH*		Multivariate GARCH*	
Variable	β coefficient (95%CI†)	p value	β coefficient (95%CI†)	p value	β coefficient (95%CI†)	p value	β coefficient (95%CI†)	p value
Earthquake factors								
Incidence of earthquake	-0.03 (-0.10 — 0.04)	0.37			0.03 (-0.07 — 0.13)	0.54		
Number of earthquakes per day, times	-0.01 (-0.03 — 0.01)	0.35			0.00 (-0.04 — 0.03)	0.82		
The depth of the epicenter, km	0.00 (-0.00 — 0.00)	0.67			0.00 (-0.01 — 0.01)	0.98		
The highest magnitude in a day	-0.01 (-0.02 — 0.01)	0.39			0.01 (-0.01 — 0.03)	0.54		
The highest Shindo in a day	-0.02 (-0.06 — 0.02)	0.35			0.02 (-0.04 — 0.08)	0.58		
Daytime earthquake§	-0.09 (-0.20 — 0.01)	0.09	-0.09 (-0.19 — 0.02)	0.11	-0.07 (-0.23 — 0.10)	0.39	-0.08 (-0.24 — 0.09)	0.36
Nighttime earthquake‡	0.03 (-0.09 — 0.15)	0.65			0.09 (-0.09 — 0.28)	0.32		
Date								
Categories of day								
Weekday	Reference				Reference			
The day before the non-working day	**0.06** (0.01 — 0.12)	**0.02**	**0.06** (0.01 — 0.12)	**0.03**	**0.19 (0.11 — 0.28)**	**<0.01**	**0.19 (0.11 — 0.28)**	**<0.01**
Non-working day	-0.04 (-0.08 — 0.01)	0.09	-0.04 (-0.09 — 0.01)	0.08	**0.11 (0.04 — 0.18)**	**<0.01**	**0.11 (0.05 — 0.18)**	**<0.01**
Season								

Spring	Reference				Reference			
Summer	-0.03 (-0.09 — 0.02)	0.26	-0.03 (-0.09 — 0.02)	023	0.06 (-0.03 — 0.14)	0.20	0.06 (-0.03 — 0.15)	0.17
Fall	0.01 (-0.05 — 0.07)	0.73	0.01 (-0.05 — 0.06)	0.82	0.04 (-0.05 — 0.12)	0.40	0.03 (-0.05 — 0.12)	0.45
Winter	**0.10 (0.04 — 0.15)**	**<0.01**	**0.10 (0.04 — 0.15)**	**<0.01**	0.01 (-0.08 — 0.10)	0.81	0.01 (-0.08 — 0.79)	0.83

Table 4. β coefficients for the number of patients with acute ethanol intoxication from univariate and multivariate GARCH model by age

*GARCH stands for generalized autoregressive conditional heteroskedasticity; †CI represents confidence interval; §Daytime earthquake means that the earthquake was observed between 9 a.m. and 5 p.m.; ‡Nighttime earthquake means that the earthquake was observed between 5 p.m. and 12 p.m.

Numbers in bold indicate that the p value is less than 0.05.

Figure legend:

Figure 1. The number of earthquakes per day.

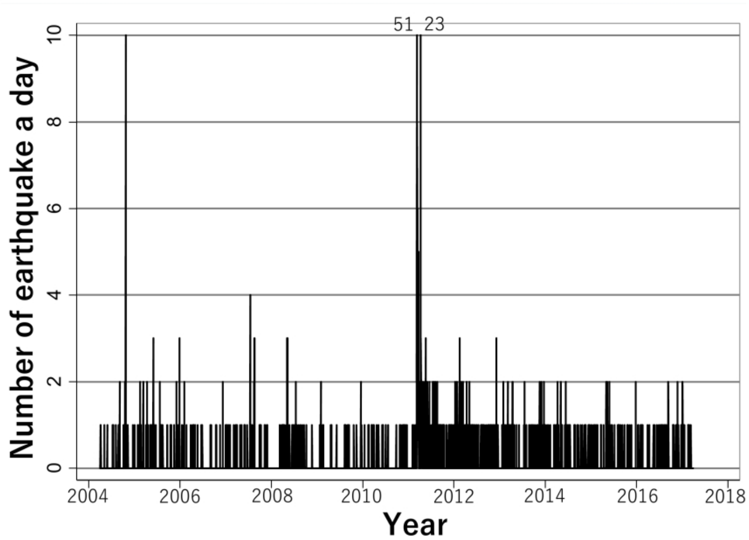

Figure 1. Daily number of earthquake.

279x215mm (300 x 300 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

Check	Page, session		Item No	Recommendation
X	Page1. Title	**Title and abstract**	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
X	Page2-3, abstract			(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
		Introduction		
X	Page4-5, introduction	Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
X	Page5, last in Introduction	Objectives	3	State specific objectives, including any prespecified hypotheses
		Methods		
X	Page6, first paragraph in Methods	Study design	4	Present key elements of study design early in the paper
X	Page6, first paragraph in Methods	Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
X	Page6, first paragraph in Methods	Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
X	Page6, first and second paragraph in Methods			(*b*) For matched studies, give matching criteria and number of exposed and unexposed
X	Page7-8, third paragraph in Methods	Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
X	Page7-8, third paragraph in Methods	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
X	Page7-8, third paragraph in Methods	Bias	9	Describe any efforts to address potential sources of bias
X	Page9, third paragraph in statistical analyses	Study size	10	Explain how the study size was arrived at
X	Page8, first and second paragraph in statistical analyses	Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why

X	Page8, first and second paragraph in statistical analyses	Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
X	Page8, first and second paragraph in statistical analyses			(*b*) Describe any methods used to examine subgroups and interactions
X	Page8, first and second paragraph in statistical analyses			(*c*) Explain how missing data were addressed
X	N/A			(*d*) If applicable, explain how loss to follow-up was addressed
X	Page8, first and second paragraph in statistical analyses			(*e*) Describe any sensitivity analyses
		Results		
X	Page10, result session	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
X	Page10, result session			(b) Give reasons for non-participation at each stage
X	N/A			(c) Consider use of a flow diagram
X	Page10, result session	Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
X	Page10, result session			(b) Indicate number of participants with missing data for each variable of interest
X	Page10, result session			(c) Summarise follow-up time (eg, average and total amount)
X	Page10, result session, table1	Outcome data	15*	Report numbers of outcome events or summary measures over time
X	Page10-11, result session	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
X	Page10-11, result session			(*b*) Report category boundaries when continuous variables were categorized
X	Page10-11, result session			(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
X	Page10-11, result session, Table2.	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
		Discussion		
X	Page12, first	Key results	18	Summarise key results with reference to

	paragraph in discussion			study objectives
X	Page 12-14 in discussion	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
X	Page 14	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
X	Page 14	Generalisability	21	Discuss the generalisability (external validity) of the study results
		Other information		
X	Page1	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

*Give information separately for exposed and unexposed groups.

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 http://www.strobe-statement.org.