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Gender Disparities in First Authorship at Three Medical Universities in an Area Affected by the Great East Japan Earthquake

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The Great East Japan Earthquake that occurred on March 11, 2011, was one of the largest natural disasters in modern times. Publication in medical journals is important aspects of the academic promotion process, and is thus important for all scientists. However, little is known about whether and how substantial natural disasters affect gender disparities in academic productivity in disaster-affected areas. We hypothesized that the Great East Japan Earthquake widened the existing disparities in scientific publishing between male and female researchers. To test this hypothesis, this retrospective observational study using existing databases was conducted. We extracted from the MEDLINE database all types of biomedical articles published from March 11, 2007, to March 11, 2015, by three medical universities in a disaster-affected area of Japan. Differences in the proportion of female first authorship during the 4 years before and after the Great East Japan Earthquake were compared. A total of 5,873 papers were analyzed. The proportion of female first authors significantly declined after the Great East Japan Earthquake (20.5% vs. 14.1%; odds ratio 0.64; 95% confidence interval 0.56–0.73). A similar trend was identified across all prespecified subgroups, including clinical department; original article; public medical university; and prestigious journal with impact factor >6. Reference data from two medical universities minimally affected by the Great East Japan Earthquake showed the opposite trend. These results collectively suggest that large natural disasters can reinforce existing gender disparities in first authorship in biomedicine.

INTRODUCTION

The Great East Japan Earthquake that occurred on March 11, 2011, was one of the largest natural disasters in modern times (1, 2). This magnitude 9.0 earthquake, and the subsequent tsunamis and nuclear power plant accident in Fukushima, caused substantial damage to the Pacific coast of northeastern Japan (3, 4). According to a recent estimate, this complex disaster resulted in more than 19,000 deaths, 6,000 injuries, and 1,150,000 collapsed buildings (5). Therefore, this unprecedented event had both acute and chronic detrimental health effects on the inhabitants of areas affected by the disaster (6, 7). To address these disaster-related healthcare problems, the workload of medical professionals in areas affected by the Great East Japan Earthquake considerably increased following the earthquake. Researchers were responsible for recording and disseminating what they had learned from the earthquake, tsunamis, and nuclear power plant accident; applying their experience of the disaster to scientific developments; and training professionals who specialize in disaster and emergency radiation. The disaster destroyed a large amount of laboratory equipment, stock agents, and experimental animal cages, which considerably disrupted normal research activities. As frontline physicians and biomedical researchers working at medical universities in a disaster-affected area, the authors have firsthand experience of these huge changes.

It is well known that women, children, older people, and people in poverty are disproportionately affected by natural disasters. For example, women are more likely to die or be injured during disasters, and more likely to experience negative effects of a disaster (e.g., loss of livelihood, longer recovery time, greater recovery effort

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burden) than men (8–12). Large disasters therefore have discriminatory health and economic effects. However, little is known about whether and how natural disasters affect gender disparities in academic productivity in disaster-affected areas. Previous studies have shown that work-life conflicts are more prevalent in female healthcare professionals (especially those with children) than in their male counterparts (13, 14). In Japan, female healthcare professionals often spend more time than their male counterparts engaging in unpaid domestic work (e.g., childrearing and housekeeping) (15), and tend to experience more difficulty finding time for their research and balancing their work and personal lives (14). The considerable changes to personal lives, disruption of normal research activities, and increased workload and responsibilities caused by the Great East Japan Earthquake may have made it even harder for female healthcare professionals and scientists to balance their research activity and family responsibilities. We hypothesized that this major disaster widened the existing gap in academic productivity (e.g., scientific publishing and grant acquisition) between male and female researchers. Both publication in medical journals and grant acquisition are important aspects of the academic promotion process and academic employment retention, especially in the field of medicine, and are thus important for all scientists (16–22). Rigorous testing of this research hypothesis is therefore warranted.

The goal of this study was to clarify the effects of the Great East Japan Earthquake on gender differences in first authorship and public funding acquisition at three medical universities in a disaster-affected area.

MATERIALS AND METHODS

Study design, setting, participants, data source, search strategy, and measured variables

This retrospective observational study using existing databases was conducted from August 2021 to February 2022 at three medical universities in an area affected by the Great East Japan Earthquake. We identified relevant studies that similarly assessed the prevalence of female first authorship in selected journals (17–21) or evaluated the effect of the COVID-19 pandemic on female academic output (23–26). The search strategy was determined a priori by the survey team, which comprised clinicians (YO, NY, KaS, YI, SI, and JK), basic scientists (MS and KeS), and a librarian (MJ, listed in the Acknowledgments). All types of biomedical articles published from March 11, 2007, to March 11, 2015, from Fukushima Medical University, Iwate Medical University, and Tohoku University School of Medicine and Graduate School of Medicine were included in the analysis. Biomedical articles were acquired from the MEDLINE database; no language restrictions were applied. The following search terms were used: Fukushima medical university [ad] OR Fukushima medical university hospital [ad] OR Iwate medical university [ad] OR Iwate medical university hospital [ad] OR Tohoku university graduate school of medicine [ad] OR Tohoku university school of medicine [ad] OR Tohoku university hospital [ad]. PubMed® (https://pubmed.ncbi.nlm.nih.gov/) was used to search the MEDLINE database. Articles were excluded from the analysis if the gender of the first author could not be determined; the first author did not belong to the three study facilities; or the article had been retracted after publication.

The following data were extracted from this systematic PubMed® search: article type, disaster-related topic, first author's department, number of authors, and first author's affiliation type. Journal impact factors were obtained using InCites Journal Citation Reports® (Clarivate Analytics, Philadelphia, PA, USA) and categorized into three levels: 0–3, 3–6, and >6. Type of article was categorized as original article, case report, review, and others (e.g., letter, commentary, editorial). Papers on the Great East Japan Earthquake and similar topics were identified using a set of disaster-related keywords (e.g., the Great East Japan Earthquake, the Tohoku-Oki earthquake, tsunamis, nuclear power plant accident) that appeared in the article titles or abstracts. First author's department was dichotomized into clinical and preclinical departments. The total number of authors was defined as the number of named authors listed in an article. If a group author [e.g., the Fukushima Health Management Survey Group (27)] was listed at the end of a list of named authors, the group was not included in the total count (18). Fukushima Medical University and Tohoku University are public medical universities. Iwate Medical University is a private medical university. All three institutions were substantially affected by the Great East Japan Earthquake. Therefore, if the first author belonged to the two former universities, their affiliation type was categorized as "public medical university." If the first author belonged to the latter university, their affiliation type was categorized as "private medical university."

Outcome measures

The primary outcome measure was female first authorship in articles in the biomedical journals included in the MEDLINE database. The other outcomes of interest were female corresponding authorship and last authorship in published articles. Publication in medical journals is an important measure of academic productivity. First authorship usually indicates the researcher who made the greatest contribution to the work; corresponding authorship and last authorship indicate successful group leadership (21, 28). Most previous studies that have assessed female authorship in biomedical literature have used similar measures (17, 19–21, 23–25, 28).

Differences in these outcomes during the 4 years before and after the Great East Japan Earthquake (March 11, 2007, to March 10, 2011, and March 11, 2011, to March 11, 2015) were compared. Four years was deemed a reasonable time for publication because most biomedical articles tend to be published within this period (29). In addition, most doctoral courses in Japan, including those at the three study facilities, specify 4 years as a reasonable time in which to complete a doctoral dissertation. For single-author articles, the author was categorized as both the first and last author.

All eligible articles were initially evaluated by the first author (YO) between August 2021 and December 2021 using a standardized recording format. To identify the author's gender, we used a modified version of the method previously reported by Jagsi et al. and Filardo et al. (17, 18). In brief, the author's gender was initially determined using his or her first name. If an author's gender was unclear, attempts were made to confirm it by checking with the coauthors who belonged to Fukushima Medical University (KeS), Iwate Medical University (NY), and Tohoku University (YI); by consulting institutional websites or social media accounts (e.g., Resarchmap®, Resarchgate®, LinkedIn®); and by performing Internet searches using search engines (e.g., Google Image®). If the first author's gender remained unclear after these sources were exhausted, the article was classified as "gender of first author could not be determined" and excluded from the analysis.

Primary analysis and subgroup analysis

All analyses were performed according to an a priori statistical analysis plan. Initially, all survey items were evaluated using descriptive statistics. Predisaster and postdisaster differences in categorical variables were assessed using chi-square followed by residual analysis. Differences in continuous variables between the two groups (predisaster and postdisaster) were compared using Student's t-test or the Mann-Whitney U test for normally and non-normally distributed data, respectively, after application of the Shapiro-Wilk test for normality. Univariable logistic regression models were fitted to produce a crude odds ratio (OR) and 95% confidence interval (CI) for female first and last authorship after the occurrence of the Great East Japan Earthquake. To further clarify the transition in female first authorship, the percentage and simple moving average of female first authorship were calculated for 6 months from 11 March 11, 2007, to March 11, 2015. A simple moving average is an arithmetic average of data points divided by the number of time periods. We calculated the simple moving average of female first authorship using two consecutive data points. For instance, if the proportion of female first authorship was calculated at the two consecutive data points of P1 and P2, the simple moving average equals P1 + P2 divided by 2. A simple moving average was computed using the trendline function in Microsoft Excel®.

To evaluate the robustness of the primary analysis described above, the logistic regression analysis was repeated for prespecified subgroups of original articles, articles from clinical departments, articles from public universities, and articles in prestigious journals with impact factors >6. All statistical analyses were performed using SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA). A P value of <0.05 was considered to indicate statistical significance.

Subanalyses

It is likely that determining the factors associated with female first authorship would increase understanding of gender disparities in research output before and after the occurrence of the Great East Japan Earthquake. Thus, differences in characteristics of female and male first authors at three medical universities in a disaster-affected area were also compared.

Funding acquisition plays a fundamental role in supporting the publication cycle and is an important marker of scientific productivity (30, 31). Therefore, we also compared gender disparities in the number and amount of grants obtained during the 4 years before and after the occurrence of the Great East Japan Earthquake. To assess this, all research projects at Fukushima Medical University, Iwate Medical University, and Tohoku University School of Medicine from March 11, 2007, to March 11, 2015, were searched using the Grants-in-Aid for Scientific Research database (Japan Society for the Promotion of Science [JSPS] KAKEN database: https://kaken.nii.ac.jp/en/). The JSPS is the largest public funder of academic research in Japan.

Reference dataset

To further confirm the effect of the Great East Japan Earthquake on the gender gap in first authorship, all types of biomedical articles in the MEDLINE database published from March 11, 2007, to March 11, 2015, by Kobe University School of Medicine and Hyogo Medical University were acquired as a reference. Kobe University School of Medicine is a public medical university and Hyogo Medical University is a private medical university; both institutions were minimally affected by the Great East Japan Earthquake. These universities were chosen as a reference because several of the present coauthors (YO, SI, and JK) belong to or used to belong to these institutions and thus were able to confirm the gender of the researchers. PubMed® was searched using the

following search terms: Kobe university graduate school of medicine [ad] OR Kobe university school of medicine [ad] OR Kobe university hospital [ad] OR Hyogo college of medicine [ad] OR Hyogo college of medicine hospital [ad] OR Hyogo medical university [ad] OR Hyogo medical university hospital. The same primary analysis was used to determine the gender gap in academic productivity before and after the Great East Japan Earthquake.

Power analysis

The retrospective nature of the study predetermined the sample size. Therefore, a priori estimation of statistical power was not possible. The observed power was computed posthoc using G*Power 3 for Windows (Heinrich Heine University, Dusseldorf, Germany).

Ethics approval and consent to participate

Current Japanese ethical guidelines do not mandate ethical review for studies involving analysis of publicly available data. This study was therefore exempt from ethical evaluation by the institutional review boards of the authors' institutions. Because this study did not involve human participants, the need for informed consent was waived. All methods were carried out in accordance with the relevant guidelines and regulations, such as SAGER guidelines (32) and STROBE statement (33).

RESULTS

Study flow

The initial MEDLINE search detected 6,504 eligible biomedical articles from three study sites for March 11, 2007, to March 11, 2015 (Figure 1). Of these, 145 (2.2%) articles for which the first author's gender could not be determined, 484 articles (7.4%) for which the first author did not belong to the study site, and 2 articles (0.03%) that were retracted after publication were excluded from the analysis. The remaining 5,873 articles were included in the final analysis. Of these, 2,317 (39.5%) articles were published during the 4 years before the Great East Japan Earthquake, and 3,556 (60.5%) articles were published during the 4 years after the disaster. Complete records were available for all articles, and no data were missing from the analyses.

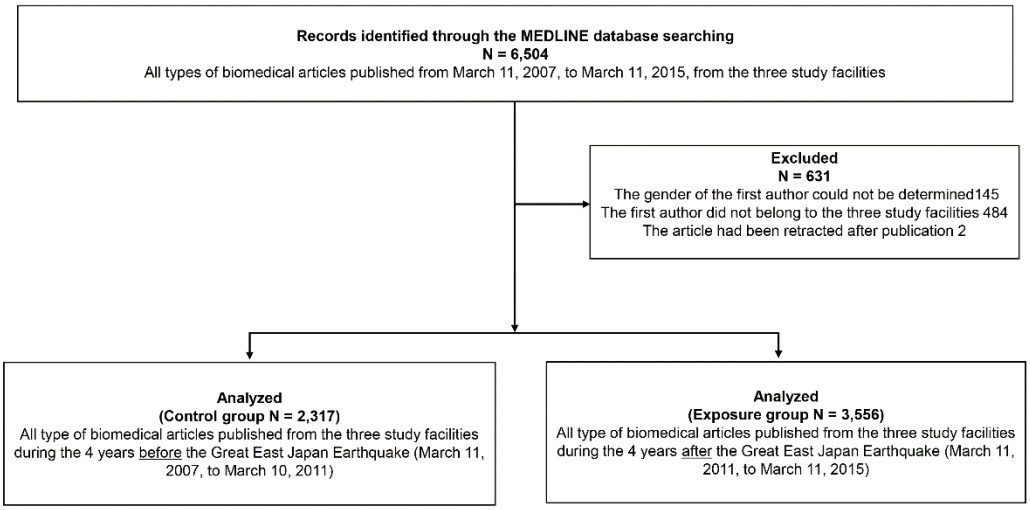


Figure 1. Study flow diagram

Differences in research output before versus after the occurrence of the Great East Japan Earthquake

Although there were significant differences in type of article, first author's department, and number of authors before versus after the Great East Japan Earthquake, these differences were small (Table I). Other characteristics, including journal impact factor and first author's affiliation type, were similar between the two groups.

Table I. Differences in biomedical articles published from three medical universities in a disaster-affected area: before versus after the Great East Japan Earthquake

	All (n = 5,873)	Before disaster (n = 2,317)[a]	After disaster (n = 3,556)[b]	P
Journal impact factor				0.143
0–3	3,261 (55.5)	1,253 (54.1)	2,008 (56.5)	
3–6	1,997 (34.0)	805 (34.7)	1,192 (33.5)	
>6	615 (10.5)	259 (11.2)	356 (10.0)	
Type of article				<0.001
Original article	4,340 (73.9)	1,741 (75.1)	2,599 (73.1)	
Case report	818 (13.9)	301 (13.0)	517 (14.5)	
Review	596 (10.1)	249 (10.7)	347 (9.8)	
Others[c]	119 (2.0)	26 (1.1)*	93 (2.6)**	
Disaster-related topic[d]				
Yes	96 (1.6)	0 (0)	96 (2.7)	
No	5,777 (98.4)	2,317 (100)	3,460 (97.3)	
First author's department				<0.001
Clinical department	4,176 (71.1)	1,588 (68.5)	2,588 (72.8)	
Preclinical department	1,697 (28.9)	729 (31.5)	968 (27.2)	
Number of authors	7 (4–10)	6 (4–9)	7 (4–10)	<0.001
First author's affiliation type				0.094
Public university	4,712 (80.2)	1,834 (79.2)	2,878 (80.9)	
Private university	1,161 (19.8)	483 (20.8)	678 (19.1)	

Data are expressed as n (%) or median (interquartile range). [a]Biomedical articles published during the 4 years before the Great East Japan Earthquake (March 11, 2007, to March 10, 2011). [b]Biomedical articles published during the 4 years after the Great East Japan Earthquake (March 11, 2011, to March 11, 2015). [c]Letter, commentary, editorial, etc. [d]Papers on the Great East Japan Earthquake and related topics. Identified by a set of keywords (e.g., Great East Japan Earthquake, tsunamis, nuclear power plant accident) that appeared in their titles or abstracts. **Adjusted standardized residual >1.96. *Adjusted standardized residual ≤1.96.

Primary and subgroup analysis

As shown in Figure 2a, the proportion of female first authors significantly declined after the Great East Japan Earthquake (20.5% vs. 14.1%; OR 0.64; 95% CI 0.56–0.73). The proportion of female corresponding authors also declined (12.2% vs. 8.8%; OR 0.69; 95% CI 0.59–0.82), whereas the proportion of female last authors was similar before and after the disaster (3.4% vs. 3.3%; OR 0.96; 95% CI 0.71–1.28). A decline in female first authorship was particularly pronounced in the first 2 years after the disaster (Figure 2b).

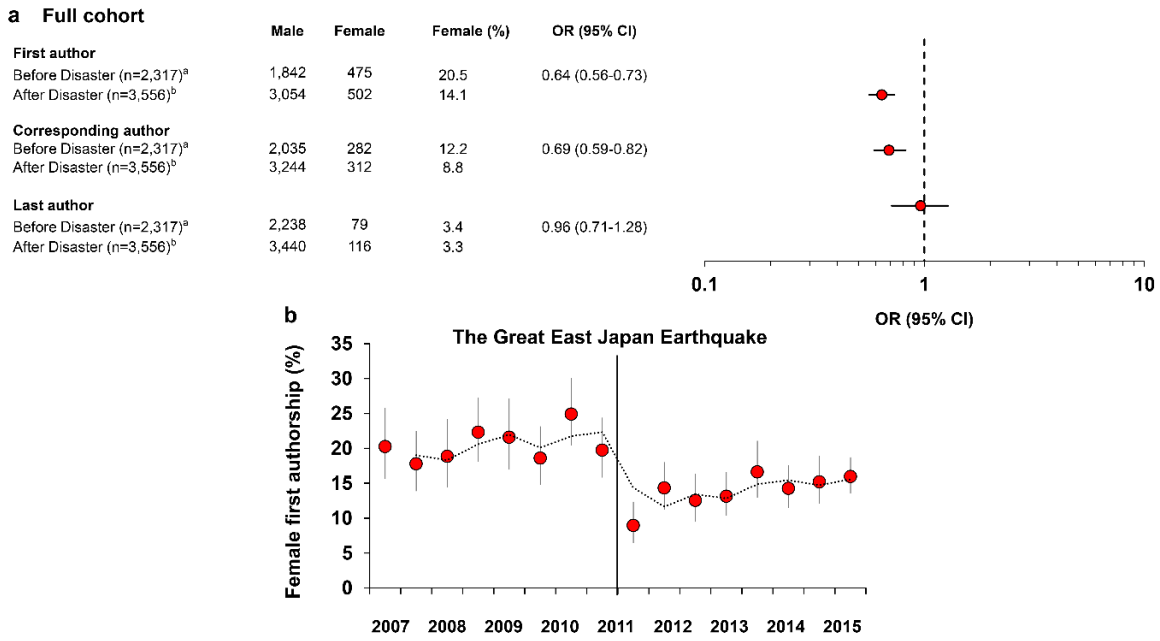


Figure 2. Female authorship at three medical universities in a disaster-affected area: before versus after the Great East Japan Earthquake

(a) Odds ratios for female first, corresponding, and last authorships: before versus after the Great East Japan Earthquake.

(b) Percentage of female first authorship over 6 months. Red points represent the percentage of female first authors; vertical lines represent 95% CI; the dotted line represents the simple moving average (2 consecutive points to average). [a]Biomedical articles published during the 4 years before the Great East Japan Earthquake (March 11, 2007, to March 10, 2011). This group is the reference set. [b]Biomedical articles published during the 4 years after the Great East Japan Earthquake (March 11, 2011, to March 11, 2015). CI, confidence interval; OR, odds ratio.

There was a similar trend in all prespecified subgroups (Figure 3): clinical department (OR 0.71; 95% CI 0.58–0.84); original article (OR 0.60; 95% CI 0.51–0.70); public medical university (OR 0.64; 95% CI 0.55–0.75); and prestigious journal with impact factor >6 (OR 0.65; 95% CI 0.41–1.05).

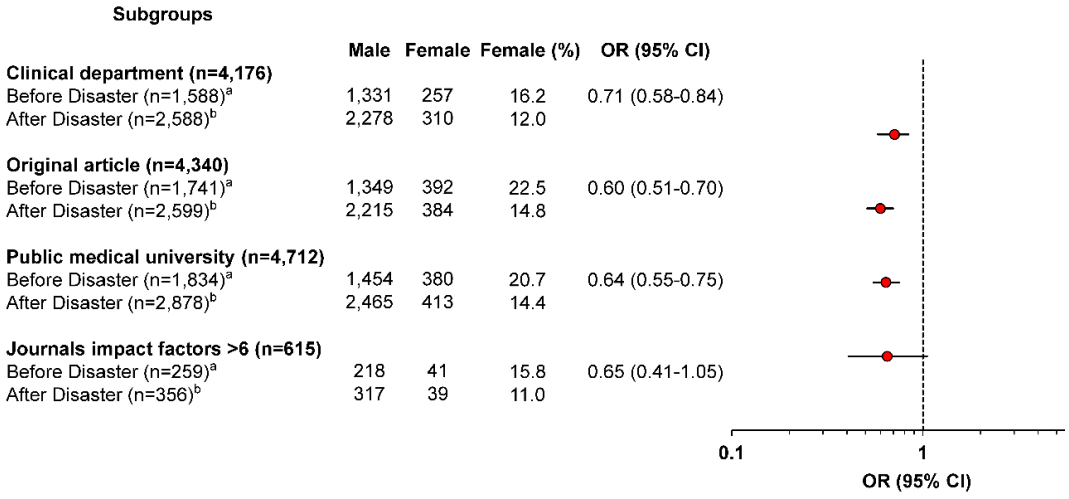


Figure 3. Subgroup analysis of female first authorship at three medical universities in a disaster-affected area: before versus after the Great East Japan Earthquake

[a]Biomedical articles published during the 4 years before the occurrence of the Great East Japan Earthquake (March 11, 2007, to March 10, 2011). This group is the reference set. [b]Biomedical articles published during the 4 years after the occurrence of the Great East Japan Earthquake (March 11, 2011, to March 11, 2015). CI, confidence interval; OR, odds ratio.

Subanalyses

There were substantial differences between female and male first authors (Table II): male first authors were more likely to publish papers in journals with impact factors >6; more likely to write reviews and other types of papers such as letters, commentaries, and editorials; and wrote more articles on disaster-related topics than female first authors. In particular, 553 of 596 (92.8%) review papers and 91 of 96 (94.8%) disaster-related papers were written by male first authors. Female first authors were more likely to belong to preclinical departments. Consistent with previous studies (20, 28), first authors were more likely to be women for articles with female corresponding authors and last authors.

Table II. Factors associated with female first authorship on biomedical articles published by three medical universities

	All (n = 5,873)	Male first author (n = 4,896)	Female first author (n = 977)	P
Journal impact factor				
0–3	3,261 (55.5)	2,729 (55.7)	532 (54.5)	0.007
3–6	1,997 (34.0)	1,632 (33.3)*	365 (37.4)**	
>6	615 (10.5)	535 (10.9)**	80 (8.2)*	
Type of article				<0.001
Original article	4,340 (73.9)	3,564 (72.8)*	776 (79.4)**	
Case report	818 (13.9)	668 (13.6)	150 (15.4)	
Review	596 (10.1)	553 (11.3)**	43 (4.4)*	
Others[a]	119 (2.0)	111 (2.3)**	8 (0.8)*	
Disaster-related topic[b]				0.002
Yes	96 (1.6)	91 (1.9)	5 (0.5)	
No	5,777 (98.4)	4,805 (98.1)	972 (99.5)	
First author's department				<0.001
Clinical department	1,697 (28.9)	1,287 (26.3)	410 (42.0)	
Preclinical department	4,176 (71.1)	3,609 (73.7)	567 (58.0)	
Corresponding author's gender				<0.001
Male	4,896 (83.4)	4,785 (97.7)	494 (50.6)	
Female	977 (16.6)	111 (2.3)	483 (49.4)	
Last author's gender				<0.001
Male	5,678 (96.7)	4,760 (97.2)	918 (94.0)	
Female	195 (3.3)	136 (2.8)	59 (6.0)	
Number of author(s)	7 (4–10)	7 (4–10)	7 (4–9)	0.275
First author's affiliation type				0.421
Public university	4,712 (80.2)	3,919 (80.0)	793 (81.2)	
Private university	1,161 (19.8)	977 (20.0)	184 (18.8)	

Data are expressed as n (%) or median (interquartile range). [a]Letter, commentary, editorial, etc. [b]Papers on the Great East Japan Earthquake and related topics. Identified by a set of keywords (e.g., Great East Japan Earthquake, tsunamis, nuclear power plant accident) that appeared in their titles or abstracts. **Adjusted standardized residual >1.96. *Adjusted standardized residual ≤1.96.

Regarding JSPS KAKEN grants obtained, the Great East Japan Earthquake seems not to have widened the existing gender gap (Figure 4).

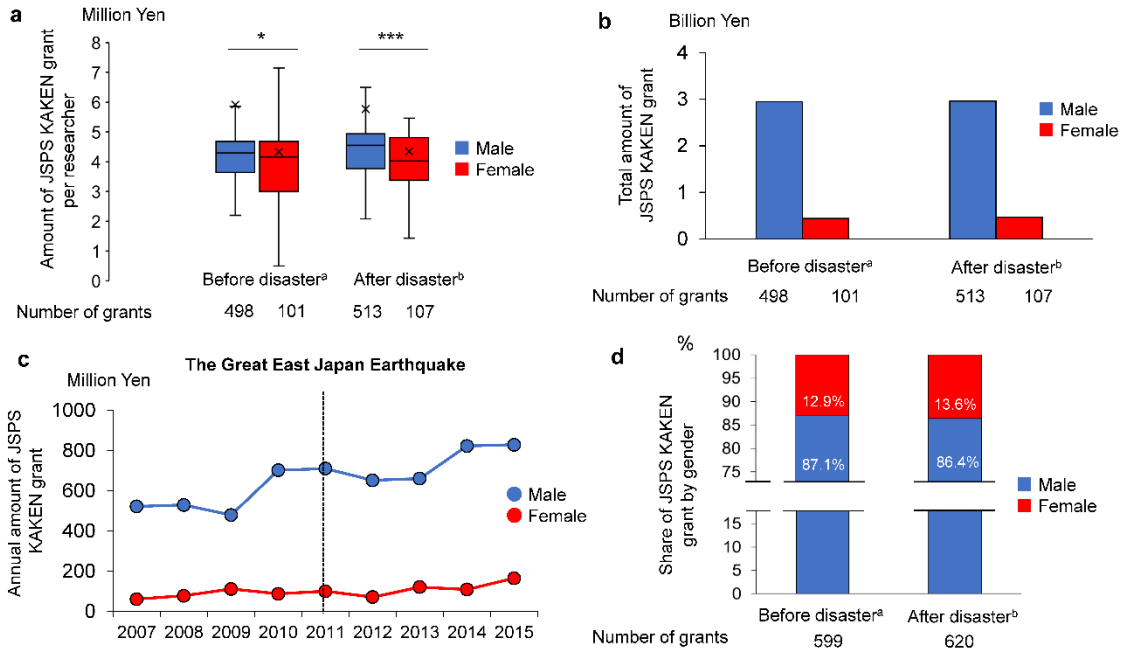


Figure 4. Gender disparities in the number and amount of public grants obtained at three medical universities in a disaster-affected area: before versus after the Great East Japan Earthquake

(a) Comparison of the median JSPS KAKEN grant between male and female researchers. Solid line inside the box represents the median, x represents the mean, the box represents the 25th and 75th percentiles, the whiskers represent the lower and upper extremes. ***$p < 0.001$, *$p < 0.05$. P-values were derived from Mann-Whitney U test.

(b) Comparison of the sum of JSPS KAKEN grant between male and female researchers.

(c) Comparison of the annual amount of JSPS KAKEN grant between male and female researchers.

(d) Gender proportion in total amount of JSPS KAKEN grant. [a]During the 4 years before the Great East Japan Earthquake (March 11, 2007, to March 10, 2011). [b]During the 4 years after the Great East Japan Earthquake (March 11, 2011, to March 11, 2015). JSPS: Japan Society for the Promotion of Science.

Reference dataset

As a reference, we obtained all types of biomedical articles published by Kobe University School of Medicine and Hyogo Medical University, Japanese medical universities minimally affected by the disaster (Figure 5 and Table III).

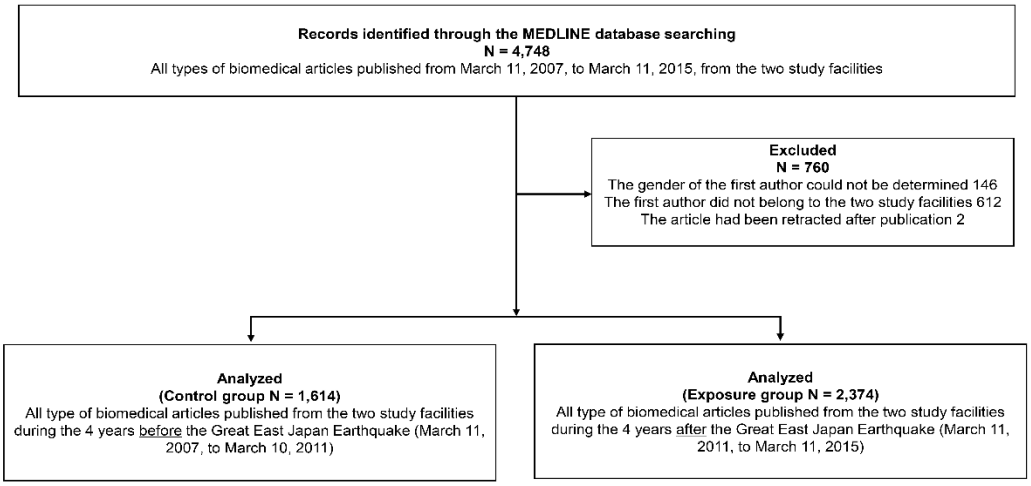


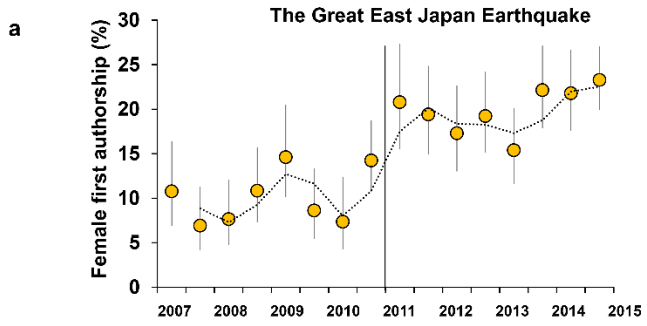
Figure 5. Study flow diagram (reference dataset)

Table III. Differences in biomedical articles published from two medical universities minimally affected by the disaster: before versus after the Great East Japan Earthquake

	All (n = 3,988)	Before disaster (n = 1,614)[a]	After disaster (n = 2,374)[b]	P
Journal impact factor				0.009
0–3	1,953 (49.0)	761 (47.1)	1,192 (50.2)	
3–6	1,589 (39.8)	644 (39.9)	945 (39.8)	
> 6	446 (11.2)	209 (12.9)**	237 (10.0)*	
Type of article				0.001
Original article	3,012 (75.5)	1,181 (73.2)*	1,831 (77.1)**	
Case report	588 (14.7)	250 (15.5)	338 (14.2)	
Review	345 (8.7)	171 (10.6)**	174 (7.3)*	
Others[c]	43 (1.1)	12 (0.7)	31 (1.3)	
Disaster–related topic[d]				
Yes	0 (0)	0 (0)	0 (0)	
No	0 (0)	0 (0)	0 (0)	
First author's department				<0.001
Clinical department	3,151 (79.0)	1,217 (75.4)	1,934 (81.5)	
Preclinical department	837 (21.0)	397 (24.6)	440 (18.5)	
Number of authors	6 (3–9)	5 (3–8)	7 (5–10)	<0.001
First author's affiliation type				0.206
Public university	2,523 (63.2)	1,040 (64.4)	1,483 (62.5)	
Private university	1,465 (36.7)	574 (35.6)	891 (37.5)	

Data are expressed as n (%) or median (interquartile range). [a]Biomedical articles published during the 4 years before the Great East Japan Earthquake (March 11, 2007, to March 10, 2011). [b]Biomedical articles published during the 4 years after the Great East Japan Earthquake (March 11, 2011, to March 11, 2015). [c]Letter, commentary, editorial, etc. [d]Papers on the Great East Japan Earthquake and related topics. Identified by a set of keywords (e.g., Great East Japan Earthquake, tsunamis, nuclear power plant accident) that appeared in their titles or abstracts. **Adjusted standardized residual >1.96. *Adjusted standardized residual ≤1.96.

In contrast with the primary analysis, the proportion of female first authorship increased over time (Figure 6a). As shown in Figure 6b, the ORs for female first authorships; corresponding authorships; and last authorships all increased after the Great East Japan Earthquake (First author: OR 2.19; 95% CI 1.82–2.65; corresponding author: OR 2.11; 95% CI 1.56–2.86; and last author: OR 2.04; 95% CI 1.36–3.06).



b Full cohort

	Male	Female	% Female	OR (95% CI)
First author				
Before Disaster (n=1,614)[a]	1,446	168	10.4	2.19 (1.82-2.65)
After Disaster (n=2,374)[b]	1,892	482	20.3	
Corresponding author				
Before Disaster (n=1,614)[a]	1,556	58	3.6	2.11 (1.56-2.86)
After Disaster (n=2,374)[b]	2,201	173	7.3	
Last author				
Before Disaster (n=1,614)[a]	1,582	32	2.0	2.04 (1.36-3.06)
After Disasters (n=2,374)[b]	2,280	94	4.0	

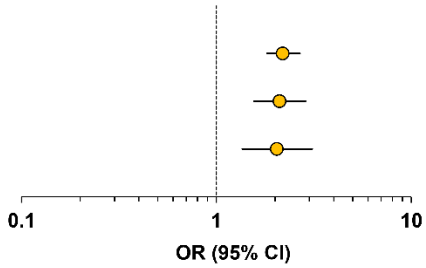


Figure 6. Female authorship at two medical universities minimally affected by the disaster: before versus after the Great East Japan Earthquake

(a) Percentage of female first authorship over 6 months. Orange points represent the percentage of female first authors; vertical lines represent 95% CI; the dotted line represents the simple moving average (2 consecutive points to average).

(b) ORs for female first, corresponding, and last authorships: before versus after the Great East Japan Earthquake. [a]Biomedical articles published during the 4 years before the Great East Japan Earthquake (March 11, 2007, to March 10, 2011). This group is the reference set. [b]Biomedical articles published during the 4 years after the Great East Japan Earthquake (March 11, 2011, to March 11, 2015). CI, confidence interval; OR, odds ratio.

As shown in Figure 7, there was a similar trend for the subgroups of clinical department (OR 2.35; 95% CI 1.86–2.97); original article (OR 1.98; 95% CI 1.62–2.43); public medical university (OR 1.44; 95% CI 1.16–1.78); and prestigious journal with impact factor >6 (OR 2.16; 95% CI 1.25–3.72). Both these results and those of the primary analysis described above demonstrate an effect of the Great East Japan Earthquake on female first authorship in the biomedical field.

Subgroups

	Male	Female	% Female	OR (95% CI)
Clinical department (n=3,151)				
Before Diaster (n=1,217)[a]	1,116	101	8.3	2.35 (1.86-2.97)
After Disaster (n=1,934)[b]	1,595	339	17.5	
Original paper (n=3,012)				
Before Diaster (n=1,181)[a]	1,033	148	12.5	1.98 (1.62-2.43)
After Disaster (n=1,831)[b]	1,426	405	22.1	
Public medical university (n=2,523)				
Before Diaster (n=1,040)[a]	890	150	14.4	1.44 (1.16-1.78)
After Disaster (n=1,483)[b]	1,194	289	19.5	
Journal with IF>6 (n=446)				
Before Diaster (n=209)[a]	187	22	10.5	2.16 (1.25-3.72)
After Diaster (n=237)[b]	189	48	20.3	

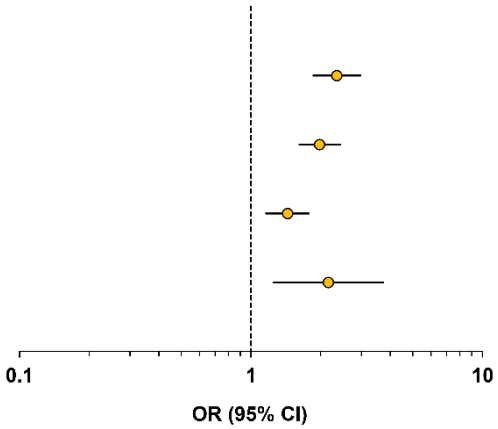


Figure 7. Subgroup analysis of female first authorship at two medical universities minimally affected by the disaster: before versus after the Great East Japan Earthquake

[a]Biomedical articles published during the 4 years before the occurrence of the Great East Japan Earthquake (March 11, 2007, to March 10, 2011). This group is the reference set. [b]Biomedical articles published during the 4 years after the occurrence of the Great East Japan Earthquake (March 11, 2011, to March 11, 2015). CI, confidence interval; OR, odds ratio.

DISCUSSION

This study showed that the proportion of publications by women after the Great East Japan Earthquake declined significantly, and this trend was apparent in all predetermined subgroups (clinical department, original article, public medical university, and journal impact factor >6). The most significant reduction in the proportion of female first authors occurred in the first 2 years after the disaster. Female researchers also produced fewer publications related to the Great East Japan Earthquake than their male counterparts. The reference data from two medical universities minimally affected by the Great East Japan Earthquake showed the opposite trend. Collectively, these results suggest that large natural disasters enforce the existing disparities in academic productivity between male and female researchers. Advancements in academic medicine are largely contingent on publication in medical journals (17). Therefore, the worrying trend identified by this study may increase the existing gender gap in academic promotion. Our results should be used to encourage the scientific community, institutional administrators, funding bodies, and policymakers to address these problems.

For the last few decades, there has been increased participation by women in various scientific disciplines, including medicine (22, 34–36). The representation of women among first authors of articles in biomedical journals has also substantially increased, suggesting that the gender gap is shrinking (17–21). Consistent with these observations, the presents findings show that the proportion of female first authorship increased over time at two Japanese medical universities that were minimally affected by the Great East Japan Earthquake. A recent study in Japan also identified a consistent increase in the proportion of female faculty in medicine since 1995 (36). Thus, a sudden reduction in female biomedical research output after the Great East Japan Earthquake is an unusual reverse trend. There are several plausible explanations for the observed findings.

First, female healthcare professionals working at the study sites may have had less time to spend on research in the aftermath of the Great East Japan Earthquake. In this study, the decline in female first authorship was particularly pronounced in the first 2 years after the disaster. In the acute phase of a large natural disaster, there is increasing need to care for children or other family members. Women often actively care for the family and spend more time per day on unpaid domestic work than men, roles they are expected to fulfil during disaster situations (37–39). As healthcare professionals and researchers working at the three study sites, the authors have direct experience of how workloads substantially increased following the disaster to address disaster-related healthcare problems and meet increasing educational needs. Following disasters, women tend to be "doubly burdened" (39, 40); they may struggle more with integrating work and family life, which reduces their academic productivity. Greater attention should be paid to this pattern, and future policies should address this problem appropriately.

Second, most research related to the Great East Japan Earthquake, which comprised approximately 3% of all academic output from the three study sites, was conducted by male researchers. The Great East Japan Earthquake and subsequent nuclear power plant accident is a high-profile dynamic research topic. There is a general trend for this type of research to be conducted by those in research leadership positions (12, 37), who are more often men. A relatively large number of review papers were commissioned articles, which are generally written by researchers in leadership positions. We found that 553 of 596 (92.8%) review articles were written by male researchers. In the aftermath of a major disaster, masculine traits (e.g., being aggressive, competitive, and dominant) tend to be valued more, and men are expected to adopt leadership and decision-making roles (12, 37, 38). Previous studies indicate that women are praised when they followed traditional norms (e.g., assisting men in relief and recovery efforts, caring for family members and disaster victims, and taking care of people's emotional and mental health) but are denigrated when they perform what are viewed as male-oriented tasks (12, 39). These social norms may prevent women from adopting leadership roles, which in turn may prevent them from conducting disaster-related research. We must be aware of the existence of such bias (39), particularly in the aftermath of major natural disasters.

Our findings are consistent with those of previous related studies. Stay-at-home orders, lockdowns, and school closures during the COVID-19 pandemic have also disproportionately affected scientists in the biomedical field (23–26). Female scientists, particularly those caring for children or other family members during the pandemic, have reported a substantial reduction in the time they have available for research (41–43). Consequently, the academic productivity of female scientists has declined (23–26). These results, together with our own findings, collectively suggest that major disasters reinforce existing disparities in academic productivity between male and female researchers.

Science and innovation benefit greatly from gender diversity (44). Therefore, we need to identify ways to reduce gender inequalities and support women in academia during and after disasters. Both organizational efforts and political commitment are needed to address disaster-related gender disparities (45, 46). The academic promotion process places high value on publication in medical journals (16–22). When assessing team members for promotion, institutional administrators and academic departments should recognize that disasters can exacerbate the gender gap in academic productivity. Formal disaster response agencies and funding bodies may

need to consider gender quotas, as these can help to rectify the underrepresentation of women in prominent positions (e.g., in political, economic, and academic systems) (23, 47). We believe that concerted organizational and political efforts could help to prevent the loss of women's scientific expertise from the scientific publication realm in the aftermath of disasters.

This study had several limitations. First, as with any observational study, the observed associations between the occurrence of the Great East Japan Earthquake and gender disparities in first authorship may have been confounded by other unmeasured factors. For example, authors' job titles, academic degrees, marital status, and number and age of children may have affected the publication rate. During the COVID-19 pandemic, female scientists with young children have reported a greater reduction in research time than their male colleagues (41–43). Further analyses that include such in-depth personal information are required to further clarify how the Great East Japan Earthquake affected gender disparities in scientific output, and to identify vulnerable individuals within academia who may need assistance. Another important variable that was not measured was the change in the proportion of male and female researchers after the Great East Japan Earthquake compared with before. Consistent with a recent study in Japan (36), the proportion of female faculty and researchers at Tohoku University consistently increased rather than decreased during the study period (48). In addition, the proportion of female faculty at Iwate Medical University during 2011–2015 (part of the study period) also increased (49). This may have biased our results toward the null hypothesis. Data on the proportion of male and female researchers in the other study facilities during the study period were not available.

Second, as with previous studies that similarly assessed female first authorship (17–21, 23–26), some misclassification may have occurred when determining the gender of a publication's author or grant winner. However, in addition to using previously applied gender-detection methods (17, 18), we tried to minimize this potential error by consulting scientists who belong to the study sites during the gender determination process, and by excluding low-confidence results. We believe that our data are the best available, and that the proportion of authors whose gender was categorized incorrectly was small and would not have altered the main conclusions of this study.

Third, because we searched for published articles in a single database (MEDLINE) using a single search engine (PubMed®), some peer-reviewed papers may have been overlooked. However, we believe that our search strategy was appropriate and clinically relevant because most biomedical researchers use MEDLINE as the first and most reliable source of medical information. It is also unlikely that the results would have substantially differed if other databases (e.g., Embase® and Google Scholar®) had been included. For example, Berry et al. (50) found their MEDLINE search for articles included in systematic reviews of medical imaging identified 94% of target references.

Fourth, the use of biomedical articles published by Kobe University School of Medicine and Hyogo Medical University may be insufficient. These two medical universities were chosen as a reference because several of the present coauthors (YO, SI, and JK) belong to or used to belong to these institutions and thus were able to confirm the gender of the researchers. The use of other medical universities as a reference would have made it more difficult to determine the gender of the authors of publications because Asian names (particularly Japanese names) can be ambiguous and are not gender specific (22, 24). In this study, we prioritized the accuracy of the data. Our reference data were consistent with previous observations suggesting that the gender gap in academic research is shrinking over time (17–21, 36).

Finally, we did not use an a priori estimate of sample size. As described in the Methods, the retrospective nature of the study predetermined the sample size. However, a posthoc power calculation demonstrated that the study had sufficient power (>0.80) for all primary outcomes examined.

Despite these limitations, to the best of our knowledge this is the first study to document increased gender disparities in academic productivity following a major natural disaster. In addition to examining the proportion of female first authors, we assessed the number and amount of grants obtained by female researchers before and after the Great East Japan Earthquake. We also obtained reference data from a university minimally affected by the earthquake to improve our understanding of this phenomenon. This is the first study to conduct this type of multifaceted analysis. Major earthquakes and tsunamis occur repeatedly (51), and disasters like the Great East Japan Earthquake can happen at any time and in many locations. It is therefore important that the scientific community, institutional administrators, funding bodies, and policymakers take into consideration the present findings that major natural disasters may disproportionately disadvantage some groups of scientists and worsen existing disparities. Further research should be informed by our findings and seek to identify objective ways to assist female researchers in the aftermath of major disasters.

In conclusion, at three medical universities severely affected by the Great East Japan Earthquake, the representation of women among first authors of biomedical research articles significantly declined in the aftermath of the disaster. This effect was particularly evident in the first 2 years following the disaster and for papers related to the Great East Japan Earthquake. Data from two medical universities minimally affected by the Great East Japan

Earthquake showed the opposite trend. Taken together, these findings suggest that major natural disasters reinforce existing disparities in academic productivity between male and female researchers. This may have important short- and longer-term effects on the academic careers of women, which policymakers, institution leaders, and research funders need to address appropriately.

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