# A 5-Year Longitudinal Study of Knee Pain Among Natural Disaster Survivors

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**Research Article**

**Keywords:** knee pain, longitudinal study, natural disaster, course

**Posted Date:** October 20th, 2021

**DOI:** https://doi.org/10.21203/rs.3.rs-959947/v1

# Abstract

**Background:** Knee pain is a common symptom among natural disaster survivors as well as general population. However, its long-term course is unclear. The purpose of this study was to clarify the course of knee pain, especially focusing on the association between prior and subsequent knee pain, among people living in disaster-stricken areas.

**Methods:** This was a 5-year longitudinal study of 1,821 participants. Knee pain was assessed at two, four, and seven years after the Great East Japan Earthquake. Multiple logistic regression analyses were examined to assess the association of knee pain at two and five years after the disaster and knee pain at seven years after the disaster.

**Results:** The prevalence of knee pain was 18.0%, 18.2%, and 19.7% at two, four, and seven years after the disaster, respectively. Throughout the 5-year period, 34.7% of the participants had knee pain at any time point and 6.2% had knee pain at all three time points. Knee pain at two and four years after the disaster was significantly associated with knee pain at seven years after the disaster (adjusted odds ratios (95% confidence intervals): 3.17 (2.32–4.34) for knee pain at either of the two time points and 12.49 (8.42–18.54) for knee pain at both time points (p for trend <0.001)).

**Conclusions:** In the present 5-year cohort study, the prevalence of knee pain was gradually increased. Among the people with knee pain at any time point, approximately one fifth of them had consistent pain. Prior knee pain was associated with subsequent knee pain, which was stronger in those with more prior knee pain episodes. Clinicians should pay attention to prior knee pain episodes to consider methods to treat knee pain.

# Background

Knee pain is a common musculoskeletal problem worldwide [1]. It arises from various disorders of the structures in and around the knee joint (e.g., inflammatory or degenerative arthritis) and cartilage or ligament injuries [2]. Knee pain restricts activities of daily living, and thus identifying its related factors and course is important. Some factors such as older age, being female, high body mass index (BMI), depression, and sleep disturbance have been reported to be associated with knee pain [3–5]. Further, knee pain is considered to be frequently associated with knee osteoarthritis (OA) [6], and some studies have reported the natural course of knee OA. Most of these studies mainly focused on radiographic changes [7–12] although knee pain is a subjective experience and is not always constant. Some studies also showed knee pain trajectories among people with knee OA [13, 14]. However, the course of knee pain has been rarely investigated [3, 15, 16] and not clarified.

Knee pain is also a major musculoskeletal problem after natural disasters [17]. A high incidence of knee pain was reported after the Great East Japan Earthquake (GEJE) that occurred in the northeast coastal areas of Japan on March 11, 2011 [4]. Further, knee pain caused a decline of physical function in elderly survivors after the GEJE [18]. Knowing the long-term course of knee pain is important in developing strategies to treat and prevent knee pain, which is beneficial for general population as well as natural disaster survivors. Thus, this study aimed to clarify the time course of knee pain, particularly the association between prior knee pain and subsequent knee pain, using a 5-year longitudinal data after the GEJE.

## Materials And Methods

# Study design and participants

A panel study was performed among people living in disaster-stricken areas in the north-east coastal areas in Japan to assess their health and social problems [19]. The initial survey was conducted 3 months after the GEJE among the residents registered in Ogatsu, Oshika, and Ajishima areas and people living in the temporary prefabricated housing in Wakabayashi ward. The survey was consecutively conducted every year. The current study used the data from that survey. Because the number of participants increased from the initial survey until the survey conducted approximately two years after the GEJE, this study used the data from three points at two, four, and seven years after the GEJE (designated as the first, second, and third time points, respectively) to evaluate the 5-year time course of knee pain. In each time point, residents aged over 18 years in Ogatsu, Oshika, and Ajishima areas and people who had participated in the previous survey in Wakabayashi ward were recruited. At the first time point, 7,007 people were contacted and 2,881 responded (41.1%). Among those, 2,254 responded at the second time point (78.2%). Further, 1,821 (80.8%) of these participants responded at the third time point and were enrolled (Fig. 1). This study was approved by the institutional review board of our institute (approval number: 201192) and was performed in accordance with the Declaration of Helsinki.

# Knee pain

Knee pain was assessed by a self-reported questionnaire [20]. The participants were asked if they had had knee pain in the last few days. Knee pain was assessed at each time point and the pain at the first and second time points was divided into three categories: absence of knee pain at neither time point, presence of knee pain at either of the time point, and presence of knee pain at both time points.

# Covariates

The following variables at the first time point were included in the analysis as covariates because they were considered as potential confounding factors: sex, age, BMI, living area and environment, smoking and drinking habits, comorbidities, working status, walking time/day, subjective economic, psychological, and sleep condition, and social network. Psychological condition was assessed by the Kessler Psychological Distress Scale, and a score of ≥ 10/24 was considered to have psychological distress [21]. Sleep condition was assessed by the Athens Insomnia Scale, and a score of ≥ 6/24 was considered to have sleep disturbance. Social network was assessed by the Lubben Social Network Scale, and a score of <12/30 was considered to have social isolation [19]. Variables were divided into categories as seen in Table 1 [22].

# Statistical analysis

A chi-square test was performed to compare the covariates according to the presence of knee pain at the first time point. Crude and multiple logistic regression analyses were used to assess the association between knee pain at the first and third time points and the odds ratios (ORs) and 95% confidence intervals (95% CIs) were calculated. Further, we divided the participants into subgroups by age (<65 and ≥65 years) and sex (male and female) and assess the association in the same manner. For the subgroup analysis, potential multiplicative interactions between knee pain at the first time point and age or sex were tested by the Walt test. In addition, the association of knee pain at the first and second time points with knee pain at the third time point was also assessed. SPSS 24.0 (IBM Corp., Armonk, NY, USA) was used for statistical analyses with statistical significance of <0.05 in a p value.

# Results

The variables divided due to the presence of knee pain at the first time point are shown in Table 1. At the first time point, knee pain was prevalent in 18.0% (328/1,821) of the participants. The participants with knee pain were more likely to be female, older, non-smoker, non-drinker, and unemployed. They also had higher BMI, number of comorbidities, shorter walking time, and worse subjective economic condition, psychological distress, and sleep disturbance (Table 1). At the second and third time points, knee pain was prevalent in 18.2% (331/1,821) and 19.7% (357/1,821) of the participants, respectively. Table 2 shows the 5-year time course of knee pain among the participants. Throughout the 5-year period, 65.3% of the participants had no knee pain at any time point, 19.6% had knee pain at one time point, 8.8% had knee pain at two time points, and 6.2% had knee pain at all three time points (Table 2). There was significant association between knee pain at the first and third time points in both crude and adjusted analyses, and the adjusted OR (95% CI) was 4.37 (3.28–5.82) (Table 3). In the subgroup analyses, the prevalence of knee pain was higher in the older participants than the younger ones (26.5% vs12.7%) and in females than males (24.5% vs. 13.6%). There was significant association between knee pain at the first and third time points in all categories. No significant multiplicative interaction was seen between knee pain and age or sex (Table 4). Furthermore, the number of prior knee pain episodes was significantly associated with knee pain at the third time point. The adjusted ORs (95% CIs) for knee pain at the third time point were 3.17 (2.32–4.34) in the presence of knee pain at either of the two time points and 12.49 (8.42–18.54) in the presence of knee pain at both time points (p for trend <0.001) (Table 5).

Table 1
Baseline characteristics of the participants at the first time point

| | | Knee pain at the first time point | | | |
|---|---|---|---|---|---|
| | | n (%) | Absent | Present | P value |
| | | n=1821 | n=1,493 | n=328 | |
| Sex | Male | 799 (43.9) | 699 (46.8) | 100 (30.5) | < 0.001 |
| | Female | 1,022 (56.1) | 794 (53.2) | 228 (69.5) | |
| Age, years | < 65 | 897 (49.3) | 793 (53.1) | 104 (31.7) | < 0.001 |
| | ≥65 | 924 (50.7) | 700 (46.9) | 224 (68.3) | |
| BMI | ≥18.5, <25 | 1,073 (58.9) | 911 (61.0) | 162 (49.4) | 0.001 |
| | <18.5 | 36 (2.0) | 31 (2.1) | 5 (1.5) | |
| | ≥25 | 628 (34.5) | 483 (32.4) | 145 (44.2) | |
| Area of residence | Ogatsu | 794 (43.6) | 651 (43.6) | 143 (43.6) | n.s. |
| | Oshika | 599 (32.9) | 500 (33.5) | 99 (30.2) | |
| | Ajishima | 102 (5.6) | 75 (5.0) | 27 (8.2) | |
| | Wakabayashi | 326 (17.9) | 267 (17.9) | 59 (18.0) | |
| Smoking habits | Non-smoker | 1,383 (75.9) | 1,115 (74.7) | 268 (81.7) | 0.001 |
| | Smoker | 320 (17.6) | 286 (19.2) | 34 (10.4) | |
| Drinking habits | Non-drinker | 1,055 (57.9) | 832 (55.7) | 223 (68.0) | < 0.001 |
| | <45.6 g of alcohol/day** | 383 (21.0) | 338 (22.6) | 45 (13.7) | |
| | ≥45.6 g of alcohol/day** | 189 (10.4) | 165 (11.1) | 24 (7.3) | |
| Comorbid conditions | Hypertension | 732 (40.2) | 556 (37.2) | 176 (53.7) | < 0.001 |

| | | Knee pain at the first time point | | | |
|---|---|---|---|---|---|
| | Diabetes mellitus | 167 (9.2) | 132 (8.8) | 35 (10.7) | n.s. |
| | Myocardial infarction | 114 (6.3) | 74 (5.0) | 40 (12.2) | < 0.001 |
| | Cerebral stroke | 22 (1.2) | 19 (1.3) | 3 (0.9) | n.s. |
| Working status | Unemployed | 944 (51.8) | 743 (49.8) | 201 (61.3) | < 0.001 |
| | Employed | 834 (45.8) | 716 (48.0) | 118 (36.0) | |
| Walking time/day | ≥ 1 h | 542 (29.8) | 461 (30.9) | 81 (24.7) | 0.02 |
| | 30 min to < 1 h | 644 (35.4) | 534 (35.8) | 110 (33.5) | |
| | < 30 min | 605 (33.2) | 473 (31.7) | 132 (40.2) | |
| Living environment | Same house as before the disaster | 533 (29.3) | 432 (28.9) | 101 (30.8) | n.s. |
| | Prefabricated house | 726 (39.9) | 594 (39.8) | 132 (40.2) | |
| | New house | 159 (8.7) | 134 (9.0) | 25 (7.6) | |
| | Other | 355 (19.5) | 294 (19.7) | 61 (18.6) | |
| Economic hardship | Normal | 796 (43.7) | 668 (44.7) | 128 (39.0) | 0.045 |
| | A little hard | 481 (26.4) | 394 (26.4) | 87 (26.5) | |
| | Hard | 343 (18.8) | 273 (18.3) | 70 (21.3) | |
| | Very hard | 172 (9.4) | 131 (8.8) | 41 (12.5) | |
| Psychological distress | Absent | 1,409 (77.4) | 1,188 (79.6) | 221 (67.4) | < 0.001 |
| | Present | 246 (13.5) | 184 (12.3) | 62 (18.9) | |
| Sleep disturbance | Absent | 1,042 (57.2) | 893 (59.8) | 149 (45.4) | < 0.001 |

| | | Knee pain at the first time point | | | |
|---|---|---|---|---|---|
| | Present | 591 (32.5) | 456 (30.5) | 135 (41.2) | |
| Social isolation* | Absent | 1,240 (68.1) | 1,027 (68.8) | 213 (64.9) | n.s. |
| | Present | 497 (27.3) | 397 (26.6) | 100 (30.5) | |

Table 2
Patterns of knee pain in the 5-year time course

| Presence of knee pain | | | | |
|---|---|---|---|---|
| First time point | Second time point | Third time point | Number of knee pain episodes | n (%) |
| No | No | No | 0 | 1,190 (65.3) |
| No | No | Yes | 1 | 141 (7.7) |
| No | Yes | No | 1 | 101 (5.5) |
| No | Yes | Yes | 2 | 61 (3.3) |
| Yes | No | No | 1 | 115 (6.3) |
| Yes | No | Yes | 2 | 44 (2.4) |
| Yes | Yes | No | 2 | 56 (3.1) |
| Yes | Yes | Yes | 3 | 113 (6.2) |

Table 3. Association between prior knee pain and knee pain 5 years later

| | Total | No knee pain at the first time point | Knee pain at the first time point | P value |
|---|---|---|---|---|
| Participants | 1,821 | 1,493 | 328 | |
| Knee pain at the third time point, n (%) | 359 (19.7) | 202 (13.5) | 157 (47.9) | |
| Crude OR (95% CI) | | 1.00 (Ref.) | 5.87 (4.51–7.63) | < 0.001 |
| Adjusted OR (95% CI) | | 1.00 (Ref.) | 4.37 (3.28–5.82) | < 0.001 |

Adjusted for sex, age, body mass index, living area and environment, smoking and drinking habits, comorbid conditions, working status, walking time, subjective economic, psychological, and sleep condition, and social network. OR: odds ratio; CI: confidence interval

Table 4. Association between prior knee pain and knee pain 5 years later: subgroup analysis by age and sex

| | | Total | No knee pain at the first time point | Knee pain at the first time point | P value |
|---|---|---|---|---|---|
| | Age | | | | |
| | < 65 years | | | | |
| Participants | | 897 | 793 | 104 | |
| Knee pain at the third time point, n (%) | | 114 (12.7) | 77 (9.7) | 37 (35.6) | |
| Adjusted OR (95% CI) | | | 1.00 (Ref.) | 4.35 (2.57–7.37) | <0.001 |
| | ≥ 65 years | | | | |
| Participants | | 924 | 700 | 224 | |
| Knee pain at the third time point, n (%) | | 245 (26.5) | 125 (17.9) | 120 (53.6) | |
| Adjusted OR (95% CI) | | | 1.00 (Ref.) | 4.48 (3.14–6.40) | <0.001 |
| | | | | P-interaction = 1.0 | |
| | Sex | | | | |
| | Male | | | | |
| Participants | | 799 | 699 | 100 | |
| Knee pain at the third time point, n (%) | | 109 (13.6) | 66 (9.4) | 43 (43.0) | |
| Adjusted OR (95% CI) | | | 1.00 (Ref.) | 6.60 (3.83–11.37) | < 0.001 |
| | Female | | | | |
| Participants | | 1,022 | 794 | 228 | |
| Knee pain at the third time point, n (%) | | 250 (24.5) | 136 (17.1) | 114 (50.0) | |
| Adjusted OR (95% CI) | | | 1.00 (Ref.) | 4.12 (2.88–5.90) | <0.001 |
| | | | | P-interaction = 0.18 | |

Adjusted for sex, age, body mass index, living area and environment, smoking and drinking habits, comorbid conditions, working status, walking time, subjective economic, psychological, and sleep condition, and social network. OR: odds ratio; CI: confidence interval

Table 5. Association between the number of prior knee pain episodes and subsequent knee pain

| | Total | No knee pain at the first and second time points | Knee pain at either the first or second time point | Knee pain at the first and second time points | P for trend |
|---|---|---|---|---|---|
| Participants | 1,821 | 1,331 | 321 | 169 | |
| Knee pain at the third time point, n (%) | 359 (19.7) | 141 (10.6) | 105 (32.7) | 113 (66.9) | |
| Crude OR (95% CI) | | 1 | 4.10 (3.07–5.49) | 17.03 (11.83–24.53) | <0.001 |
| Adjusted OR (95% CI) | | 1 | 3.17 (2.32–4.34) | 12.49 (8.42–18.54) | <0.001 |
| Adjusted for sex, age, body mass index, living area and environment, smoking and drinking habits, comorbid conditions, working status, walking time, subjective economic, psychological, and sleep condition, and social network. OR: odds ratio; CI: confidence interval | | | | | |

# Discussion

The long-term course of knee pain is unclear. The present study found that prior knee pain was significantly associated with knee pain five years later among the survivors of the GEJE. Further, the association was stronger in those with more episodes of prior knee pain. To our best knowledge, this study is the first to investigate the association of prior knee pain with subsequent episode of knee pain and to show that prior knee pain was significantly associated with knee pain five years later. Further, the association was significant irrespective of other potential confounding factors.

Some authors have reported the course of knee OA [9, 11, 12]. Most of these reports investigated new-onset or progressive changes of knee OA because OA changes are generally constant or advanced and not recovered. Felson et al. used an 8-year cohort study and showed that the prevalence of new-onset radiographic knee OA was 16.9% and progression of radiographic knee OA was 29.1%. Furthermore, the rate of new onset of symptomatic knee OA was 6.7%, which was lower than that of new-onset or progressive radiographic knee OA [11]. Muraki et al. also indicated that the correlation between knee pain and radiographic severity of knee OA is not as significant as expected [23]. Knee pain should be assessed with distinction from knee OA. However, in contrast with knee OA, the time course of knee pain has rarely been investigated. Miranda et al. investigated knee pain among the working population using a 1-year cohort study. The prevalence of knee pain was 23.4% at baseline and 24.3% 1 year later, and only 16.6% of the participants had knee pain at both points, indicating that knee pain was not always persistent [15]. In the current 5-year cohort study, the prevalence of knee pain gradually increased from 18.0%, 18.2%, and to 19.7%. However, only 6.2% of the participants had knee pain at all three time points. The results also indicated that knee pain in survivors after natural disasters was not consistent. As many as 34.7% of participants had knee pain at each time point, 19.6% had knee pain at one time point, and 8.8% had knee pain at two time points throughout the 5-year study period. Although pain was not consistent, knee pain was a common musculoskeletal symptom after the GEJE.

The present study showed that prior knee pain was associated with knee pain 5 years later. In a previous 1-year cohort study, 70.1% of the participants with knee pain at baseline had knee pain 1 year later [15]. Knee pain is frequently related to knee OA, especially in the elderly. It is often accompanied with pain and structural changes and is considered to be chronic [5, 24]. Further, OA changes are often seen in the bilateral knee, and these changes are related to lifestyle, indicating that mechanical stress on the knee depends on individuals [12]. The perception of pain severity is also subjective and varies among individuals [25]. Although the pain severity is rarely consistent, people who experience knee pain are presumed to have recurrent pain thereafter. In addition, our stratified analysis by age and sex showed a higher prevalence of knee pain among older and female individuals, consistent with previous studies [3, 5]. Furthermore, similar association between prior knee pain and knee pain 5 years later was seen among the groups, supporting the robustness of the results in this study. In addition, there have been no reports showing an association of the number of prior knee pain episodes with subsequent knee pain. This study demonstrated that higher episodes of prior knee pain had a stronger effect on subsequent knee pain. People with more knee pain episodes are considered to have a higher risk of knee pain thereafter. Although knee pain is associated with several factors, including psychosocial factors [24, 25], prior knee pain episodes are considered an important predictor of knee pain. Clinicians should pay attention to the risk of future knee pain when treating people with knee pain and consider preventive measures even if the present knee pain improves.

This study had some limitations. First, the response rate was not high. It was possible that responders were highly conscious of their health, which could have affected the results. Second, the intensity and cause of pain were not assessed. The recurrence rate of knee pain may depend on pain severity or the cause of pain, which should be considered in future studies. Finally, the participants of the present study lived in disaster-stricken areas. We did not compare them with those living in non-disaster areas and thus could not assess the effect of the natural disaster on knee pain.

In conclusion, prior knee pain was associated with subsequent knee pain. Further, the effect was stronger with more episodes of prior knee pain.

# List Of Abbreviations

GEJE: Great East Japan Earthquake, OA: osteoarthritis, BMI: body mass index, OR: odds ratio, 95% CI: 95% confidence interval

# Declarations

### Ethics approval and consent to participate:

This study was approved by the institutional review board of our institute (approval number: 201192). Written informed consent was obtained from all the participants.

### Consent to publish:

Not applicable

### Availability of data and materials:

All relevant data are contained in this article.

### Competing interests:

The authors declare no conflict of interest.


### Funding statement:

Not applicable


### Authors' contributions:

YY, YH, and IT designed the study. YS, MT, and SY contributed to data collection. TS and YY performed statistical analysis. YY and YH wrote the manuscript. YS, MT, and IT helped to analyze the data.


### Acknowledgements

This work was supported by the Health Sciences Research Grants (H24, 25-Kenki-Shintei-002 [Fukkou]) from the Ministry of Health, Labor, and Welfare of Japan.


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## Figures

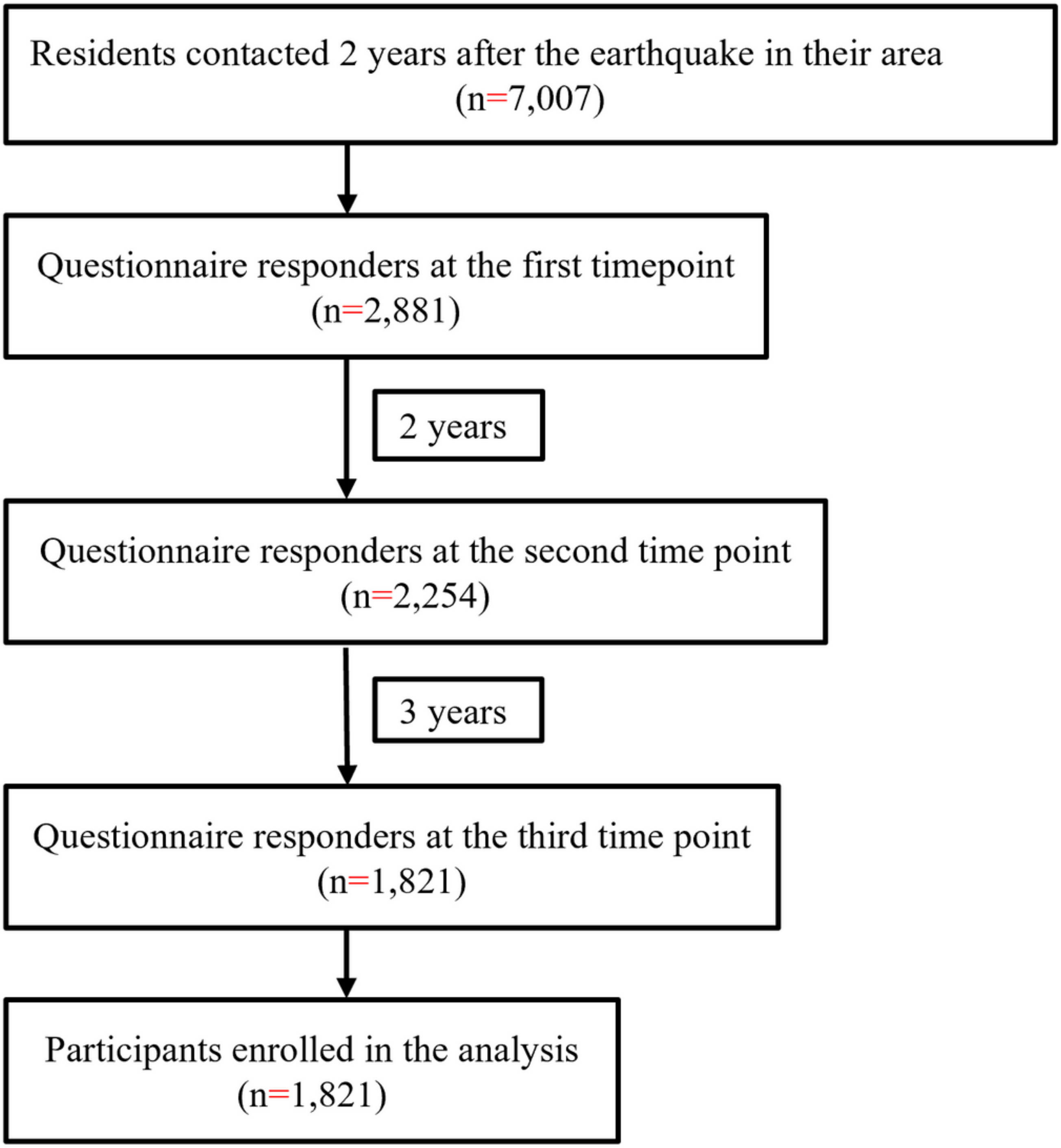


**Figure 1**

Participant inclusion flowchart.