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# IMPACT OF THE 2011 EARTHQUAKE ON MARRIAGES, BIRTHS AND THE SECONDARY SEX RATIO IN JAPAN

YURI HAMAMATSU[1], YOSUKE INOUE, CHIHO WATANABE AND MASAHIRO UMEZAKI

*Department of Human Ecology, Graduate School of Medicine, The University of Tokyo, Japan*

**Summary.** On 11th March 2011 a magnitude nine earthquake struck the Tohoku region of Japan. The earthquake resulted in a large tsunami and an accident at the Fukushima Nuclear Power Plant. Previous studies have suggested that demographic indices relating to reproduction and marriage change after such massive disasters (e.g. large earthquakes). The present study investigated whether the number of births, number of marriages and the secondary sex ratio (SSR) changed after the East Japan Earthquake. The monthly number of births (males and females, separately) and marriages in each prefecture in Japan from January 1997 to June 2012 were obtained from the Demographic Survey of Japan. An analysis was performed for three different geographic boundary units: the disaster-stricken area, the non-disaster-stricken area and the whole of Japan. In each unit, the numbers of births and marriages in a given month during the post-disaster period were predicted based on a regression equation estimated by the numbers of births and marriages in that month during the pre-disaster period. The numbers of observed monthly births and marriages during the post-disaster period were compared with the predicted figures. Differences between the observed and predicted numbers were determined by referring to the 95% confidence limits for the predicted mean number. The observed probability of a male birth in a given month during the post-disaster period was compared with a 95% confidence interval of a binominal distribution. In all three boundary units, the number of births was significantly lower than the predicted number by about 3–8% from nine months after the disaster, while the number of marriages in October 2011 was significantly lower than the predicted number by about 25–28%. In October 2011, the SSR in the whole of Japan had decreased from 104.8 (the predicted SSR) to 102.9. The number of births and marriages and the SSR decreased in Japan after the East Japan Earthquake irrespective of locality.

[1] Corresponding author. Email: yhama@humeco.m.u-tokyo.ac.jp

## Introduction

Disasters destroy infrastructure such as water and electricity supplies, transportation systems and administrative services, creating instability in people's daily lives for a long time. On 11th March 2011 a magnitude nine earthquake struck the Tohoku region of Japan. The earthquake was accompanied by a tsunami and an accident at the Fukushima Nuclear Power Plant (Japan Meteorological Agency, n.d.; Prime Minister of Japan and his Cabinet, n.d.). More than 15,000 people died, 120,000 people lost their homes and 80,000 people were evacuated (National Police Agency of Japan, n.d.). Residents of regions close to the Tohoku region were also affected, by insufficient supplies of electricity, food and bottled water, and fears of aftershocks and the potential health hazards of the radioactive leaks at the Fukushima Nuclear Power Plant. After the disaster, people inhabiting the disaster area had an increased level of psychological stress in comparison to before the disaster (Kotozaki & Kawashima, 2012).

The disaster not only affected the people living in the Tohoku region and the neighbouring regions but also those living much further away from the Tohoku region. Pictures of the disaster were broadcast daily on television and spread via the Internet. Economic activity (both production and consumption) worsened in the whole of Japan after the disaster (Cabinet Office, Government of Japan, 2012). In short, all of the Japanese population experienced a difficult post-disaster period.

During post-disaster periods, demographic variables such as the fertility rate, marriage rate and secondary sex ratio (SSR: number of male births per 100 female births) have been reported to change. For example, Finlay (2009) reported a positive fertility response following large earthquakes in Turkey in 1999, India in 2001 and Pakistan in 2005. Cohan & Cole (2002) found that both fertility and marriage rates increased in South Carolina, USA, following hurricane Hugo. In addition, SSRs decreased after a severe flood in Brisbane, Australia (Lyster, 1974) and an earthquake in Chile (Torche & Kleinhaus, 2012). A similar phenomenon has also been reported in Japan, as after the destructive Kobe earthquake in Hyogo Prefecture in 1995 the SSR declined significantly (Fukuda *et al*., 1998).

The following motivations have been proposed to explain the changes in demographic behaviour that have been observed after large-scale disasters. As regards the increases in fertility and marriage rates, one hypothesis states that people are motivated to produce more children in order to replace the work force that is lost during a disaster (Finlay, 2009). Another explanation is based on psychology. Cohan & Cole (2002) stated that the increased fertility and marriage rates observed after hurricane Hugo could be explained by attachment theory (Bowlby, 1969). Specifically, that humans' attachment to family members or lovers intensifies in extremely stressful conditions as witnessed by their increased efforts to reproduce. In contrast, other researchers have suggested that the number of births and marriages would decrease during post-disaster periods because psychological stress suppresses the motivation for reproduction (McLeod, 1994), while vulnerable daily life circumstances would further restrict the opportunities for reproduction (White & Rogers, 2004), although no direct evidence for such a scenario has been reported to date.

The sex ratio of fetuses declines steadily from the stages of conception to delivery because fetal death occurs more frequently in males than in females (Davis *et al*., 2007).

The reported SSR is about 105 (i.e. about 105 male births per 100 female births) in most human populations. It is speculated that under conditions of strong psychological stress, fetus mortality increases more in males than in females, which consequently lowers the SSR. For example, Hansen *et al*. (1999) reported that the SSRs of mothers who had experienced severe life events such as the death of family members or the hospitalization of a partner or child were lower than those of their peers.

The present study examined the demographic impact of the East Japan Earthquake, which struck the Tohoku region of Japan in 2011. The earthquake and tsunami caused massive death and destruction in the region. A resulting accident at the Fukushima Nuclear Power Plant has since posed an ongoing health threat to people living both in and outside of the Tohoku region. To the best of our knowledge, no previous study has examined whether the earthquake and accompanying disasters affected demographic indices in Japan.

The authors analysed the number of births and marriages as demographic indices, rather than birth and marriage rates, because many pregnant mothers were evacuated from the disaster-stricken area for delivery during the post-disaster period. In these cases, newborn babies were registered in the municipality where the mothers had their residence cards. By focusing on the number of births/marriages, the authors judged that it was possible to evaluate the demographic impact of the disaster.

## Methods

The monthly numbers of male and female births, and marriages in each prefecture in Japan ($n = 47$) were available for the period from January 1997 from the website of the Demographic Survey of Japan (Statistic Bureau of Japan, n.d.). Monthly statistics are reported five months after birth/marriage events occur. The authors collected data on births and marriages that occurred between January 1997 and June 2012. The analysis was performed using monthly data because there are seasonal variations in the number of births and marriages and in the SSR (Miura, 1987; Matsuda & Kahyo, 1994). The number of births and marriages in the month of February in leap years (i.e. 2000, 2004, 2008 and 2012) was multiplied by 28/29.

The period when birth/marriage events were predicted to be influenced by the East Japan Earthquake ('the disaster-impact period') and the period before the disaster ('the pre-disaster-impact period') were defined for births, marriages and the SSR, separately. Considering that the gestational period is about nine months (Takagi, 2011), the authors determined the beginning of the disaster-impact period for births as being in December 2011. For marriages, the authors considered that the disaster-impact period began in March 2011. Making use of recent research by Torche & Kleinhaus (2012), which showed that the SSR started to decrease from six months after an earthquake in Chile, the authors set September 2011 as the start of the disaster-impact period for the SSR. Further, issues of data availability meant that the length of the disaster-impact period for births, marriages and the SSR varied, i.e. December 2011 to June 2012 (births), March 2011 to February 2012 (marriages) and September 2011 to June 2012 (SSR).

The impact of the disaster on the number of births was evaluated by comparing the observed number of births in a target area (e.g. the whole of Japan) with the predicted number of births during the disaster-impact period (i.e. 2011/2012). Specifically,

a quadratic regression equation was estimated for each month of the consecutive years in the target region using data during the pre-disaster-impact period (i.e. 1997 to 2010/2011). For example, for the analysis of the number of births in May in the whole of Japan, a quadratic regression equation was estimated on the basis of the number of births in May from 1997 to 2011 ($n = 15$). Using the equation, the number of births in May 2012 in the whole of Japan was predicted. A quadratic regression model was used because it best fitted the longitudinal trend observed in the number of births/marriages during the pre-disaster-impact period in Japan. The pre-disaster-impact period was defined as starting in 1997 because of data availability.

The 95% confidence limits were calculated for the predicted mean number during the disaster-impact period on the basis of a quadratic regression equation estimated by using data from the pre-disaster-impact period. For example, on the basis of a quadratic regression analysis applied to the number of births in May from 1997 to 2011 (the pre-disaster-impact period) in the whole of Japan, the 95% confidence limits for the predicted mean number in May 2012 were estimated to range from 81,634 to 89,847 births. If the observed number of births in May 2012 was higher/lower than this predicted range, it was judged that the number of births during the disaster-impact period was significantly higher/lower. The impact of the disaster on the number of marriages was also assessed using the same methodology.

The probability of a male birth ($p$) was used to evaluate the impact of the disaster on the SSR where for simplicity the SSR $= 100 \times p/[1 - p]$. The probability of a male birth follows a binomial distribution. Thus, the 95% confidence interval (CI) of $p$ can be estimated as a function of the total number of births ($n$):

$$p \pm 1.96\sqrt{p(1-p)/n}.$$

Although Mizuno (2000) showed that the sex ratio at birth declined in Japan from 1970 to 1996, the authors did not find such a trend during the pre-disaster-impact period (i.e. 1997–2010/2011). It is known that the SSR varies by season/month in Japan (Takahashi & Nagai, 2008). For example, the average SSR of each month during the pre-disaster-impact period varied from 104.1 (in March) to 106.3 (in June) in the whole of Japan. Thus, the expected probability of a male birth in a given month in area $Z$ was empirically estimated by averaging the proportion of male births in that month during the pre-disaster-impact period in that area. The 95% CI for the probability of a male birth in a given month in area $Z$ during the disaster-impact period was estimated by using the expected probability of a male birth and the number of total births in that month in area $Z$ during the disaster-impact period. The observed proportion of male births in area $Z$ in that month during the disaster-impact period was then compared with the 95% CI to determine if the SSR in the disaster-impact period was significantly higher or lower.

The authors investigated the impact of the disaster on demographic variables in three different geographical boundary units: the whole of Japan ($n = 47$ prefectures), the disaster-stricken area ($n = 13$ prefectures) and the non-disaster-stricken area ($n = 34$ prefectures). The disaster-stricken area consisted of thirteen prefectures in the Kanto and Tohoku regions. A score of 'upper 5' or more on the Japan Meteorological Agency seismic activity intensity scale was used to determine which prefectures should be in this area. A 'upper 5' severity means that the strength of the seismic activity was sufficient to

destroy a reinforced concrete building (Japan Meteorological Agency, n.d.). The appropriateness of this classification scheme is supported by the fact that 13,391 people died and 59,806 buildings were totally destroyed in the disaster-stricken area, whereas only one person died and no buildings were totally destroyed in the non-disaster-stricken area (Okada *et al*., 2011). The confusion after the disaster (relating to evacuation, insufficient supplies of electricity, food and bottled water, and the reporting of the disaster) affected both the disaster-stricken area and the non-disaster-stricken area, although to a different extent.

## Results

Table 1 shows the results of the impact of the disaster on the number of births in the whole of Japan, the disaster-stricken area and the non-disaster-stricken area. The numbers of births in Japan in December 2011, January 2012, April 2012 and June 2012 (during the disaster-impact period) were lower than the 95% confidence limits. In the disaster-stricken area, the numbers of births in December 2011, January 2012, March to April 2012 and June 2012 were lower than the 95% confidence limits. The numbers of births were also lower in the non-disaster-stricken area in April 2012 and June 2012.

Table 2 shows the results of the impact of the disaster on the number of marriages in the whole of Japan, the disaster-stricken area and the non-disaster-stricken area. The number of marriages in the whole of Japan in one of the main marriage months, October (2011), was below the lower bound of the 95% confidence limits. Marriage numbers were also lower than the 95% confidence limits both in the disaster-stricken and non-disaster-stricken areas in October 2011. In contrast, the number of marriages in the disaster-stricken area was higher than the 95% confidence limits in November 2011.

Table 3 shows the results of the SSR analysis. The observed probability of a male birth in the total number of births for all of Japan in October 2011 (SSR = 102.9, $n = 89{,}180$) was lower than the empirically estimated 95% CI. In the non-disaster-stricken area, the observed probability of a male birth in October 2011 was lower than the empirically estimated 95% CI (SSR = 102.6, $n = 53{,}761$). The observed probability of a male birth in the disaster-stricken area also decreased from 104.8 (the expected SSR) to 103.4 ($n = 35{,}410$) during the disaster-impact period, although it remained within the empirically estimated 95% CI.

## Discussion

The number of births and marriages in Japan decreased after the East Japan Earthquake. Depending on the particular area, the number of births significantly decreased in two to five months, while the number of marriages significantly decreased in October 2011 in all three boundary units. These findings contrast with those from most previous studies, which have reported an increase in demographic indices of reproduction and marriage after serious disasters such as earthquakes (Finlay, 2009) and hurricanes (Cohan & Cole, 2002). As mentioned previously, Finlay (2009) suggested that a large-scale disaster motivates people to engage in greater reproductive activity in order to replenish the labour resources that are lost during the disaster. Cohan & Cole (2002) postulated

**Table 1.** Comparison between the observed number of births and the 95% confidence limits for the predicted mean number of births in each month in the whole of Japan, the disaster-stricken area and the non-disaster-stricken area during the disaster-impact period

| | Whole of Japan[a] | | | Disaster-stricken area[a] | | | Non-disaster-stricken area[a] | | |
|---|---|---|---|---|---|---|---|---|---|
| Month/year | Observed number of births | Predicted value and 95% CL | | Observed number of births | Predicted value and 95% CL | | Observed number of births | Predicted value and 95% CL | |
| Dec/2011 | 85,243[b] | 90,750 | 87,314–94,187 | 32,078[b] | 35,727 | 34,318–37,137 | 53,150 | 55,003 | 52,794–57,211 |
| Jan/2012 | 83,990[b] | 87,615 | 84,836–90,394 | 32,843[b] | 34,753 | 33,694–35,811 | 51,142 | 52,848 | 51,071–54,626 |
| Feb/2012 | 78,676 | 78,884 | 75,767–82,002 | 30,452 | 31,097 | 30,170–32,025 | 48,214 | 47,775 | 45,559–49,992 |
| Mar/2012 | 83,618 | 85,896 | 83,192–88,600 | 32,689[b] | 33,764 | 32,719–34,809 | 50,926 | 52,124 | 50,311–53,937 |
| Apr/2012 | 80,533[b] | 85,261 | 82,176–88,345 | 31,287[b] | 33,905 | 32,756–35,053 | 49,242[b] | 51,345 | 49,318–53,371 |
| May/2012 | 87,094 | 85,740 | 81,634–89,847 | 34,033 | 34,047 | 32,512–35,581 | 53,053 | 51,690 | 49,029–54,350 |
| Jun/2012 | 82,982[b] | 88,459 | 86,111–90,807 | 32,469[b] | 35,409 | 34,627–36,192 | 50,505[b] | 53,041 | 51,373–54,710 |

CL: confidence limits.

[a] The disaster-stricken area includes thirteen prefectures in the Tohoku and Kanto regions; the non-disaster-stricken area includes the rest of the prefectures ($n = 34$) in Japan. The data for the whole of Japan include those births that occurred in foreign countries but which were registered as Japanese.

[b] The observed number of births in these months was lower than the 95% confidence limits. See text for the method used to estimate the 95% confidence limits.

**Table 2.** Comparison between the observed number of marriages and the 95% confidence limits for the predicted mean number of marriages in each month in the whole of Japan, the disaster-stricken area and the non-disaster-stricken area during the disaster-impact period

| | Whole of Japan[a] | | | Disaster-stricken area[a] | | | Non-disaster-stricken area[a] | | |
|---|---|---|---|---|---|---|---|---|---|
| Month/year | Observed number of marriages | Predicted value and 95% CL | | Observed number of marriages | Predicted value and 95% CL | | Observed number of marriages | Predicted value and 95% CL | |
| Mar/2011 | 69,795 | 71,021 | 65,856–76,186 | 27,622 | 29,155 | 27,075–31,235 | 42,173 | 41,866 | 38,720–45,012 |
| Apr/2011 | 57,083 | 56,690 | 50,907–62,473 | 23,287 | 23,368 | 20,887–25,848 | 33,796 | 33,323 | 29,977–36,669 |
| May/2011 | 56,775 | 56,157 | 50,235–62,079 | 24,067 | 23,750 | 21,161–26,338 | 32,708 | 32,407 | 29,060–35,755 |
| Jun/2011 | 49,897 | 53,238 | 47,521–58,955 | 21,268 | 22,772 | 20,186–25,357 | 28,629 | 30,466 | 27,281–33,651 |
| July/2011 | 57,656 | 57,011 | 49,275–64,747 | 25,296 | 25,416 | 21,417–29,415 | 32,360 | 31,595 | 27,828–35,362 |
| Aug/2011 | 47,855 | 49,491 | 42,168–56,814 | 20,483 | 21,217 | 17,765–24,669 | 27,372 | 28,274 | 24,374–32,174 |
| Sep/2011 | 45,424 | 45,963 | 43,462–48,463 | 18,752 | 19,268 | 18,180–20,357 | 26,672 | 26,694 | 25,130–28,259 |
| Oct/2011 | 49,377[b] | 66,972 | 55,500–78,443 | 20,286[b] | 28,312 | 23,162–33,463 | 29,091[b] | 38,660 | 32,292–45,027 |
| Nov/2011 | 78,592 | 68,591 | 56,594–80,588 | 34,215[c] | 28,899 | 23,790–34,008 | 44,377 | 39,692 | 32,740–46,644 |
| Dec/2011 | 53,072 | 59,053 | 46,919–71,186 | 22,991 | 25,331 | 19,979–30,684 | 30,081 | 33,721 | 26,921–40,522 |
| Jan/2012 | 46,062 | 43,093 | 26,139–60,047 | 18,931 | 18,349 | 10,246–26,453 | 24,930 | 24,744 | 15,870–33,617 |
| Feb/2012 | 47,941 | 57,428 | 47,139–67,718 | 23,543 | 24,041 | 19,708–28,373 | 31,417 | 33,388 | 27,411–39,364 |

CL: confidence limits.

[a] The disaster-stricken area includes thirteen prefectures in the Tohoku and Kanto regions; the non-disaster-stricken area includes the rest of the prefectures ($n = 34$) in Japan.

[b,c] The observed number of marriages in these months was lower/higher than the 95% confidence limits. See text for the method used to estimate the 95% confidence limits.

**Table 3.** Comparison between the observed probability of a male birth and the 95% CI for the predicted probability of a male birth in each month in the whole of Japan, the disaster-stricken area and the non-disaster-stricken area during the post-disaster period

| | Whole of Japan[a] | | | Disaster-stricken area[a] | | | Non-disaster-stricken area[a] | | |
|---|---|---|---|---|---|---|---|---|---|
| Month/year | Observed probability | Predicted value and 95% CI | | Observed probability | Predicted value and 95% CI | | Observed probability | Predicted value and 95% CI | |
| Sep/2011 | 0.513 | 0.514 | 0.511–0.518 | 0.518 | 0.515 | 0.510–0.520 | 0.510 | 0.514 | 0.510–0.518 |
| Oct/2011 | 0.507[b] | 0.512 | 0.508–0.515 | 0.508 | 0.512 | 0.507–0.517 | 0.506[b] | 0.512 | 0.508–0.516 |
| Nov/2011 | 0.511 | 0.512 | 0.508–0.515 | 0.514 | 0.511 | 0.506–0.517 | 0.509 | 0.512 | 0.508–0.516 |
| Dec/2011 | 0.510 | 0.513 | 0.509–0.516 | 0.511 | 0.514 | 0.509–0.520 | 0.510 | 0.512 | 0.507–0.516 |
| Jan/2012 | 0.511 | 0.513 | 0.509–0.516 | 0.512 | 0.513 | 0.508–0.519 | 0.510 | 0.512 | 0.508–0.517 |
| Feb/2012 | 0.512 | 0.512 | 0.509–0.516 | 0.513 | 0.512 | 0.507–0.518 | 0.512 | 0.512 | 0.508–0.517 |
| Mar/2012 | 0.508 | 0.510 | 0.507–0.514 | 0.509 | 0.511 | 0.505–0.516 | 0.507 | 0.510 | 0.506–0.514 |
| Apr/2012 | 0.516 | 0.515 | 0.512–0.518 | 0.515 | 0.515 | 0.509–0.520 | 0.517 | 0.515 | 0.511–0.520 |
| May/2012 | 0.516 | 0.515 | 0.511–0.518 | 0.516 | 0.515 | 0.509–0.520 | 0.516 | 0.515 | 0.510–0.519 |
| Jun/2012 | 0.518 | 0.515 | 0.512–0.519 | 0.518 | 0.515 | 0.509–0.520 | 0.519 | 0.516 | 0.511–0.520 |

CI: confidence interval.

[a] The disaster-stricken area includes thirteen prefectures in the Tohoku and Kanto regions; the non-disaster-stricken area includes the rest of the prefectures ($n = 34$) in Japan. The data for the whole of Japan include those births that occurred in foreign countries but which were registered as Japanese.

[b] The observed SSR in these months was outside the predicted 95% CI. See text for the method used to predict the 95% CI.

that an increase in fertility and marriage rates occurred after hurricane Hugo because in conditions of high stress people feel a stronger attachment to family members or lovers. As regards the demographic impact of man-made disasters and events, Ruther (2010) reported that there was increased fertility after the terror attack in New York on 11th September 2001, although a non-significant change in fertility was observed after a blackout occurred in New York in 1965 (Udry, 1970).

The Japanese response to the recent disaster seems to have differed from what has occurred in many previous situations. Although the goal of this study was not to determine the reasons for this discrepancy, the following factors might have contributed to this difference and may therefore be worth considering in future research. First, as indirectly evidenced by the low birth rate, the rising trend in maternal childbearing age, and the declining marriage rate (Bongaarts, 2001), most Japanese couples do not regard children as either labour or economic resources; rather, children may be considered costly because of the large amount of money that is required to raise and educate a child (Retherford *et al*., 1996). Although Finley (2009) reported increased fertility in India, Pakistan and Turkey after earthquakes, the role of children in households in those countries differs from that of children in Japan.

Second, the East Japan Earthquake resulted in a nuclear leak from the Fukushima Nuclear Power Plant. The accident raised questions regarding the safety of nuclear power plants nationwide. All of Japan's nuclear power plants suspended operations, which forced people to reduce electricity consumption, while companies had to lower electricity use in their business operations. As a result, the Japanese economy subsequently worsened in terms of both production and consumption (Cabinet Office, Government of Japan, 2012). This might have been an important factor in changing demographic behaviour as previous research has highlighted how since the 1990s fertility and marriage rates have decreased in parallel with the worsening economic conditions in Japan (Yamada, 2007). The decrease in terms of births and marriages after the disaster can therefore be interpreted as being associated with the economic problems that occurred in the post-disaster period.

Third, it can be argued that the events in Japan have been unique: not only was the country struck by a triple disaster but the crisis at the Fukushima Nuclear Power Plant is still ongoing with the potential to have a long-lasting and widespread impact on the environment and people's health. It is known that the fetal period is the period of life most sensitive to the health risks associated with nuclear radiation, which may have influenced the decision not to conceive immediately after the disaster. Furthermore, 120,000 people lost their homes, and more than 80,000 people were evacuated because of the disaster (National Police Agency of Japan, n.d.). Given this, it is possible that family separation and the cost of relocation caused by the disaster (Asian Development Bank, 2012), as well as uncertainty about whether and how the crisis would be successfully resolved, could have affected both marital and reproductive behaviour.

The number of marriages in October 2011 decreased in all three boundary units, but increased in November 2011 in the disaster-stricken area. These changes occurred in the months of the year (October and November) when more marriages usually take place in Japan (Matsuda & Kahyo, 1994). The significant decreases in October 2011 could be due to the effect of the disaster. Japanese couples usually decide to get married a few months to a year before their marriage registrations occur. Couples seem to have postponed or

cancelled their marriage registrations in October because of the unstable economic environment and insecurity regarding the social situation in March and the following months. The reason for the increased number of marriages in the disaster-stricken area in November and for a non-significant increase in the number of marriages elsewhere in Japan may be related to a trend where Japanese couples wed on dates with corresponding numbers, e.g. 2009/09/09, 2010/10/10 and 2011/11/11. This social phenomenon termed 'the date of the matching dice' has been commented on by Japanese academics in recent years (Iwasawa *et al*., 2012).

Seven months after the disaster, in the disaster-stricken area, the SSR was 103.4 instead of the expected 104.8. This result accords with those from several previous studies: the SSR decreased to 100.4 nine months after the Kobe earthquake in Japan (Fukuda *et al*., 1998) and to 101.6 in Slovenia after a short period of war in 1991 (Zorn *et al*., 2002). In the whole of Japan and the non-disaster-stricken area, the SSR also decreased seven months after the disaster. This finding accords with the results from a study about the impact of the 11th September 2001 terror attack on New York (Catalano *et al*., 2005), where it was shown that the SSR decreased in California nearly 2500 miles away from New York. After the East Japan Earthquake, pictures of the disaster were broadcast daily on television and spread via the Internet. Moreover, the accident at the Fukushima Nuclear Power Plant could have the potential to affect the health of those living both in and outside of the disaster-stricken area. Even people living far from the disaster-stricken area were repeatedly exposed to the shocking scenes of devastation caused by the earthquake and tsunami as well as to the reports of the ongoing disaster at the Fukushima, which might have induced psychological stress and a lowered SSR even in those areas not directly affected by the disaster.

These findings suggest that the demographic impact of this disaster cannot be fully evaluated by simply counting the number of deaths and migrants; attention should also be paid to the disaster-induced reduction in the number of births and marriages, which will have a demographic impact on the future population of Japan.

The present study has one main limitation. The authors could only evaluate the immediate demographic impact of the disaster, i.e. relating to seven, ten and twelve months of the post-disaster period for births, marriages and the SSR, respectively. Further studies are needed to determine whether the numbers of births and marriages and the SSR have been affected over a longer period of time.

In conclusion, the number of births decreased after the East Japan Earthquake, not only in the disaster-stricken area but also in other parts of Japan. The number of marriages also decreased although the possibility exists that these marriages may have been merely postponed due to the disaster. The SSR decreased in the whole of Japan during the disaster-impact period.

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