Appendix 1. Seismic Intensity Scale

Seismic intensity scale defined by the Japan Meteorological Agency (JMA) is an indicator for the scale of ground motion at a particular location. It varies with the distance from the epicenter and the surface geology at each point. Table A1 summarizes the JMA’s seismic intensity and has 10 degrees: 0 (imperceptible), 1, 2, 3, 4, 5 lower (5-), 5 upper (5+), 6 lower (6-), 6 upper (6+), and 7.

Table A1. Seismic Intensity, Human Perception, and Reaction and Indoor and Outdoor Situations

|  |  |  |  |
| --- | --- | --- | --- |
| Seismic intensity | Human perception and reaction | Indoor situation | Outdoor situation |
| 0 | Imperceptible to people but recorded by seismometers. | - | - |
| 1 | Felt slightly by some people keeping quiet in buildings. | - | - |
| 2 | Felt by many people keeping quiet in buildings. Some people may be awoken. | Hanging objects such as lamps swing slightly. | - |
| 3 | Felt by most people in buildings. Felt by some people walking. Many people are awoken. | Dishes in cupboards may rattle. | Electric wires swing slightly. |
| 4 | Most people are startled. Felt by most people walking. Most people are awoken. | Hanging objects such as lamps swing significantly, and dishes in cupboards rattle. Unstable ornaments may fall. | Electric wires swing significantly. Those driving vehicles may notice the tremor. |
| 5 Lower | Many people are frightened and feel the need to hold onto something stable. | Hanging objects such as lamps swing violently. Dishes in cupboards and items on bookshelves may fall. Many unstable ornaments fall. Unsecured furniture may move, and unstable furniture may topple over. | In some cases, windows may break and fall. People notice electricity poles moving. Roads may sustain damage. |
| 5 Upper | Many people find it hard to move; walking is difficult without holding onto something stable. | Dishes in cupboards and items on bookshelves are more likely to fall. TVs may fall from their stands, and unsecured furniture may topple over. | Windows may break and fall, unreinforced concrete-block walls may collapse, poorly installed vending machines may topple over, automobiles may stop due to the difficulty of continued movement. |
| 6 Lower | It is difficult to remain standing. | Many unsecured furniture moves and may topple over. Doors may become wedged shut. | Wall tiles and windows may sustain damage and fall. |
| 6 Upper | It is impossible to remain standing or move without crawling. People may be thrown through the air. | Most unsecured furniture moves and is more likely to topple over. | Wall tiles and windows are more likely to break and fall. Most unreinforced concrete-block walls collapse. |
| 7 | Most unsecured furniture moves and topples over or may even be thrown through the air. | Wall tiles and windows are even more likely to break and fall. Reinforced concrete-block walls may collapse. |

*Source*: The website of the Japan Meteorological Agency: http://www.jma.go.jp/jma/en/Activities/inttable.html (Accessed May 7, 2019).

Appendix 2. Health Indicators Taken from Aggregate Data

We examined the aggregate data from the *Comprehensive Survey of Living Conditions* by the Ministry of Health, Labour, and Welfare in Japan to compare the health indicators between the afflicted areas (Iwate, Miyagi, and Fukushima prefectures) with non-afflicted areas. We found that all the health indicators in the afflicted areas are worse than the other areas and the differences evidently expand after 2011.

Figure A1. Comparison of health indicators between the afflicted and non-afflicted areas

(i) Proportions reporting poor subjective health



(ii) Proportions having functional limitation



(iii) Proportions having psychological stress



Appendix 3. Examination of Attrition Bias

As mentioned in section 2, the JSTAR survey in 2011 was conducted approximately six months after the GEJE. The disaster may have led to sample attrition, which would influence our results. We check this potential bias by comparing the response rates[[1]](#footnote-1) using the following probit model for the respondents who participated in the 2009 survey.

*Cont* is a binary variable that equals one for the individual who participated in the 2011 survey and zero otherwise. If Sendai residents were more likely to drop out of the 2011 survey than other residents, then *δ1* will be significantly and negatively estimated.

Figure A2 summarizes the response rates in the follow-up JSTAR surveys by municipality. Those of Sendai residents are in line with the averages of each wave, which indicates sample attrition has little impact on the empirical results. The most common reason for non-response in 2009 and 2011 was “*Refusal*,” which accounted for 77.3 percent of non-response in 2009 and 67.1 percent in 2011. The most common reasons for non-response in 2009 in Sendai were “*Refusal* (85.0%),” “*Relocation* (10.9%),” “*Long-term absence* (2.0%),” and “*Absence at the time of the visit* (2.0%).” In 2011, “*Refusal* (52.1%)” was the most common reason for non-response, but those based on “*Relocation* (15.6%),” “*Unknown reasons* (12.5%),” “*Absence at the time of the visit* (7.3%),” “*Long-term absence* (6.3%),” and “*Address unknown* (6.3%)” all increased. We assume the changes in reasons for non-response were as a result of the GEJE disaster.

Our estimation results are presented in Table 2. Contrary to expectation, *δ1* is significant but positive. This indicates that, controlling for other characteristics, Sendai residents were more likely to continue participation in the 2011 survey than respondents of other municipalities. Nevertheless, to control for adverse attrition bias, we employ an inverse weighting model (Robins et al., 1995; Wooldridge, 2002; 2007).

Figure A2. Response Rates in the Follow-up Surveys in the JSTAR



Table A2. Results of Probit Estimation for Examining Potential Attrition Bias

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Prob of participating in the 2011 Survey | Coef | SE | Coef/ SE | SE |
| Treat (=1 if Sendai residents) | 0.190\*\* | 0.091 | 0.176\*\*\* | 0.056 |
| Female | -0.033 | 0.075 | 0.009 | 0.069 |
| Age | 0.006 | 0.006 | 0.006 | 0.005 |
| Years of education | 0.011 | 0.030 | 0.046\*\* | 0.018 |
| Married | -0.235\* | 0.126 | -0.278\*\* | 0.116 |
| Widowed | -0.158 | 0.173 | -0.161 | 0.155 |
| Household income | 0.067\*\*\* | 0.014 | 0.067\*\*\* | 0.013 |
| Householder & Landholder | 0.148 | 0.144 | 0.086 | 0.135 |
| Household financial asset | 0.004 | 0.009 | 0.003 | 0.008 |
| Dependents | -0.009 | 0.084 | 0.033 | 0.085 |
| Medical institution density |  |  | -1.062\*\*\* | 0.121 |
| Nursing care facility density |  |  | 0.347\*\*\* | 0.089 |
| Unemployment rate |  |  | -0.052 | 0.069 |
| Financial capability index |  |  | -0.167\*\*\* | 0.027 |
| Constant | 0.871 |  | 3.995\*\*\* | 0.559 |
| Log likelihood | -871.907 |  | -849.002 |  |
| Observations | 3797 |  | 3797 |  |
| Individual characteristics (**x**) | Yes |  | Yes |  |
| Community characteristics (**z**) | No |  | Yes |  |

*Note*: This table reports probit estimates to examine the sample attrition in our data. \*\*\*, \*\*, and \* represent statistical significance at the 1, 5, and 10 percent levels, respectively. Clustering robust standard errors allowing for correlated residuals within prefectures are in parentheses.

Appendix 4. Estimation Results without the Adachi Province

As shown in Table 1, the one municipality of Adachi-Ward in Tokyo was also affected by the earthquake. Although its human and property damages were very modest, it may influence the estimation results. We use the sample without including Adachi to estimate the equations here. The results are reported in Table A3, and we found that DD and DDD estimates are very similar to those for the sample including Adachi Ward, as shown in Tables 4, 5, and 6.

Table A3. Results without Adachi province

(i) Effects of the GEJE on Health by DD model

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Health outcome | Poor subjective health (N = 3731) | | | Chronic disease (N = 4447) | | | Functional limitation (N = 4439) | | | Depression (N = 2872) | |  | Poor memory (N = 2716) | | |
| Model | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) |
|  | 0.003 | 0.004 | 0.003 | 0.001 | 0.001 | 0.014\*\*\* | 0.070\*\*\* | 0.070\*\*\* | 0.075\*\*\* | 0.027\*\*\* | 0.028\*\*\* | 0.033\*\*\* | 0.131\*\* | 0.122\*\* | 0.138\*\*\* |
|  | (0.008) | (0.008) | (0.007) | (0.005) | (0.005) | (0.002) | (0.012) | (0.010) | (0.010) | (0.006) | (0.006) | (0.005) | (0.050) | (0.047) | (0.026) |
|  | 0.007 | 0.006 | -0.001 | 0.024\*\*\* | 0.023\*\*\* | 0.017\*\*\* | 0.031\*\* | 0.033\*\* | 0.021\*\* | 0.009 | 0.009 | 0.009 | 0.012 | 0.020 | -0.021 |
|  | (0.008) | (0.009) | (0.006) | (0.005) | (0.005) | (0.003) | (0.012) | (0.012) | (0.007) | (0.006) | (0.006) | (0.006) | (0.050) | (0.047) | (0.042) |
| R2 | 0.000 | 0.002 | 0.007 | 0.000 | 0.002 | 0.003 | 0.002 | 0.005 | 0.011 | 0.000 | 0.002 | 0.003 | 0.002 | 0.007 | 0.031 |
| Individual characteristics (**x**) |  | Yes | Yes |  | Yes | Yes |  | Yes | Yes |  | Yes | Yes |  | Yes | Yes |
| Community characteristics (**z**) |  |  | Yes |  |  | Yes |  |  | Yes |  |  | Yes |  |  | Yes |

*Note*: This table reports FD estimates of the effects of the GEJE and years on health outcomes. \*\*\*, \*\*, and \* represent statistical significance at the 1, 5, and 10 percent levels, respectively. Clustering robust standard errors allowing for correlated residuals within municipalities are in parentheses.

(ii) Effects of the GEJE on Care Utilization by DD model

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Service types | Outpatient (N = 2262) | |  | Inpatient (N = 3351) | |  | Dentistry (N = 4349) | |  | In-home formal care (N = 4447) | | |
| Model | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) |
| *Treat After Policy* | 0.132 | 0.139 | -0.104 | 0.029 | 0.032 | 0.023 | 0.040 | 0.034 | -0.038 | 0.004 | 0.003 | 0.005 |
|  | (0.082) | (0.085) | (0.111) | (0.030) | (0.032) | (0.027) | (0.032) | (0.031) | (0.051) | (0.005) | (0.005) | (0.005) |
| *TreatAfter* | -0.210\*\*\* | -0.206\*\*\* | -0.021 | 0.032\*\*\* | 0.033\*\*\* | 0.026\*\*\* | -0.118\*\*\* | -0.117\*\*\* | -0.051 | 0.004\*\*\* | 0.005\*\*\* | 0.006\*\*\* |
|  | (0.024) | (0.025) | (0.052) | (0.006) | (0.006) | (0.004) | (0.024) | (0.025) | (0.025) | (0.000) | (0.000) | (0.001) |
| *Treat Policy* | 0.029 | 0.026 | -0.036 | -0.034\*\*\* | -0.033\*\*\* | -0.030\*\*\* | 0.030\*\*\* | 0.030\*\*\* | -0.024 | -0.003 | -0.003 | -0.005\*\* |
|  | (0.015) | (0.015) | (0.065) | (0.001) | (0.003) | (0.006) | (0.003) | (0.003) | (0.031) | (0.002) | (0.002) | (0.002) |
| *After Policy* | -0.461\*\*\* | -0.460\*\*\* | -0.071 | 0.023 | 0.027 | 0.034 | -0.237\*\*\* | -0.239\*\*\* | -0.057 | 0.011\* | 0.011\* | 0.010\* |
|  | (0.073) | (0.072) | (0.084) | (0.030) | (0.031) | (0.025) | (0.031) | (0.032) | (0.037) | (0.005) | (0.005) | (0.005) |
| *Policy* | 0.120\*\*\* | 0.121\*\*\* | 0.034 | 0.037\*\*\* | 0.035\*\*\* | 0.032\*\*\* | 0.052\* | 0.056\* | 0.000 | 0.003 | 0.003 | 0.004\* |
|  | (0.024) | (0.024) | (0.039) | (0.006) | (0.007) | (0.007) | (0.024) | (0.023) | (0.014) | (0.002) | (0.002) | (0.002) |
| *After* | -0.012 | -0.015 | -0.104\* | -0.004 | -0.006 | -0.001 | -0.071\*\* | -0.072\*\* | -0.086\*\* | 0.000\*\* | 0.000 | 0.000 |
|  | (0.024) | (0.026) | (0.047) | (0.006) | (0.006) | (0.005) | (0.024) | (0.025) | (0.024) | (0.000) | (0.000) | (0.001) |
| R2 | 0.077 | 0.080 | 0.159 | 0.003 | 0.007 | 0.008 | 0.019 | 0.020 | 0.042 | 0.008 | 0.009 | 0.010 |
| Individual characteristics (**x**) |  | Yes | Yes |  | Yes | Yes |  | Yes | Yes |  | Yes | Yes |
| Community characteristics (**z**) |  |  | Yes |  |  | Yes |  |  | Yes |  |  | Yes |

*Note*: This table reports FD estimates of the effect of the GEJE, the health insurance system, and years on care utilization. \*\*\*, \*\*, and \* represent statistical significance at the 1, 5, and 10 percent levels, respectively. Clustering robust standard errors allowing for correlated residuals within municipalities are in parentheses.

(iii) Effects of the Reduction on Copayment on Health by the DDD model

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Health outcomes | Poor subjective health (N = 3731) | | | Chronic disease (N = 4447) | | | Functional limitation (N = 4439) | | | Depression (N = 2872) | |  | Poor memory (N = 2716) | | |
| Model | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) |
| *Treat After Policy* | -0.046 | -0.047 | -0.058\*\* | -0.043\* | -0.043\* | -0.058\*\* | -0.047 | -0.044 | -0.043\*\* | 0.018 | 0.015 | -0.006 | -0.486\* | -0.477\* | -0.529\*\*\* |
|  | (0.030) | (0.028) | (0.017) | (0.021) | (0.021) | (0.020) | (0.036) | (0.035) | (0.011) | (0.042) | (0.041) | (0.037) | (0.193) | (0.199) | (0.072) |
| *TreatAfter* | 0.016\* | 0.018\* | 0.019\* | 0.017\*\*\* | 0.016\*\* | 0.028\*\*\* | 0.072\*\*\* | 0.072\*\*\* | 0.081\*\*\* | 0.006 | 0.008 | 0.018 | 0.400\*\*\* | 0.388\*\*\* | 0.366\*\*\* |
|  | (0.007) | (0.008) | (0.009) | (0.004) | (0.004) | (0.005) | (0.011) | (0.010) | (0.008) | (0.010) | (0.009) | (0.012) | (0.080) | (0.079) | (0.029) |
| *Treat Policy* | -0.012 | -0.013 | 0.009 | 0.022 | 0.023 | 0.024 | 0.009 | 0.008 | 0.026\*\* | 0.055\*\*\* | 0.054\*\*\* | 0.053\*\*\* | 0.073 | 0.074 | 0.228\*\*\* |
|  | (0.016) | (0.016) | (0.011) | (0.022) | (0.021) | (0.020) | (0.020) | (0.020) | (0.007) | (0.007) | (0.008) | (0.006) | (0.071) | (0.074) | (0.047) |
| *After Policy* | 0.043 | 0.045 | 0.036\* | -0.045\* | -0.046\* | -0.022 | 0.078\*\* | 0.079\*\* | 0.056\*\*\* | 0.006 | 0.008 | 0.044 | 0.030 | 0.027 | -0.029 |
|  | (0.026) | (0.024) | (0.017) | (0.021) | (0.021) | (0.021) | (0.028) | (0.028) | (0.010) | (0.033) | (0.033) | (0.032) | (0.132) | (0.133) | (0.090) |
| *Policy* | 0.032\* | 0.033\* | 0.030\*\* | 0.031 | 0.030 | 0.021 | 0.024 | 0.024 | 0.028\*\* | -0.002 | 0.000 | -0.013 | 0.050 | 0.042 | -0.005 |
|  | (0.014) | (0.015) | (0.009) | (0.022) | (0.022) | (0.021) | (0.015) | (0.015) | (0.011) | (0.006) | (0.005) | (0.008) | (0.048) | (0.049) | (0.060) |
| *After* | -0.012 | -0.013 | -0.019\* | 0.019\*\*\* | 0.019\*\*\* | 0.013\*\* | 0.009 | 0.009 | -0.002 | 0.007 | 0.006 | 0.003 | -0.022 | -0.011 | -0.023 |
|  | (0.007) | (0.008) | (0.007) | (0.004) | (0.004) | (0.005) | (0.011) | (0.011) | (0.006) | (0.010) | (0.009) | (0.010) | (0.080) | (0.078) | (0.039) |
| R2 | 0.006 | 0.009 | 0.011 | 0.002 | 0.003 | 0.004 | 0.011 | 0.014 | 0.016 | 0.001 | 0.003 | 0.005 | 0.009 | 0.013 | 0.039 |
| Individual characteristics (**x**) |  | Yes | Yes |  | Yes | Yes |  | Yes | Yes |  | Yes | Yes |  | Yes | Yes |
| Community Characteristics (**z**) |  |  | Yes |  |  | Yes |  |  | Yes |  |  | Yes |  |  | Yes |

*Note*: This table reports FD estimates of the effect of the GEJE, the health insurance system, and years on health outcomes. \*\*\*, \*\*, and \* represent statistical significance at the 1, 5, and 10 percent levels, respectively. Clustering robust standard errors allowing for correlated residuals within municipalities are in parentheses.

Appendix 5. Placebo Experiment

There is a potential concern that *Policy* may substantively capture the age effect on health and utilization because this binary variable is an indicator of being 70 years and over. We conduct a placebo experiment by redefining the variable to aged 65 to 69. They are also insured, but not eligible for the reduction in copayment under the Japanese elderly health system. The results are reported in Table A4, and we found that the key coefficients of *Policy* and its interaction terms are insignificant. Further, we additionally estimate the whole effect of the policy,, also finding that the placebo policy effects are mostly insignificant on health outcomes. However, we acknowledge that it is difficult to strictly estimate the true effect of the policy based on age and discuss this limitation herein.

Table A4. Results of Placebo Experiment

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Health outcomes | Poor subjective health (N = 4503) | | | Chronic disease (N = 5346) | | | Functional limitation (N = 5338) | | | Depression (N = 3445) | |  | Poor memory (N = 3291) | | |
| Model | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) |
| *Treat After Policy* | 0.070\*\* | 0.068\*\* | 0.076\*\*\* | -0.041 | -0.040 | -0.050 | -0.029 | -0.029 | -0.009 | -0.060 | -0.061 | -0.069\*\* | 0.088 | 0.119 | 0.062 |
|  | (0.024) | (0.024) | (0.014) | (0.039) | (0.040) | (0.029) | (0.034) | (0.034) | (0.037) | (0.034) | (0.031) | (0.023) | (0.145) | (0.113) | (0.067) |
| *TreatAfter* | -0.005 | -0.002 | -0.004 | 0.016 | 0.016 | 0.035\* | 0.078\*\*\* | 0.079\*\*\* | 0.077\*\*\* | 0.037\*\*\* | 0.038\*\*\* | 0.056\*\*\* | 0.052 | 0.012 | 0.054 |
|  | (0.007) | (0.006) | (0.007) | (0.013) | (0.013) | (0.014) | (0.011) | (0.007) | (0.014) | (0.004) | (0.006) | (0.009) | (0.049) | (0.025) | (0.040) |
| *Treat Policy* | -0.039\*\* | -0.038\*\* | -0.026\* | 0.018\*\* | 0.019\* | 0.017\* | 0.005 | 0.003 | 0.009 | 0.008 | 0.008 | 0.010 | 0.105 | 0.110 | 0.192\*\*\* |
|  | (0.014) | (0.015) | (0.012) | (0.007) | (0.009) | (0.007) | (0.020) | (0.022) | (0.020) | (0.031) | (0.030) | (0.030) | (0.080) | (0.082) | (0.046) |
| *After Policy* | 0.020 | 0.021 | -0.012 | -0.005 | -0.007 | 0.013 | 0.017 | 0.016 | -0.030 | 0.011 | 0.012 | 0.022 | 0.229\* | 0.220\* | 0.175\*\* |
|  | (0.019) | (0.019) | (0.015) | (0.029) | (0.032) | (0.029) | (0.030) | (0.029) | (0.035) | (0.034) | (0.034) | (0.021) | (0.105) | (0.094) | (0.055) |
| *Policy* | -0.022 | -0.024 | -0.011 | 0.015 | 0.011 | 0.003 | -0.029\* | -0.026 | -0.007 | -0.005 | -0.012 | -0.017 | -0.089\* | -0.117\*\* | -0.117\*\* |
|  | (0.012) | (0.015) | (0.010) | (0.010) | (0.010) | (0.013) | (0.013) | (0.016) | (0.013) | (0.032) | (0.030) | (0.023) | (0.039) | (0.037) | (0.039) |
| *After* | 0.008 | -0.130 | -0.153 | 0.011 | -0.341 | -0.411 | 0.032\*\* | 0.212 | 0.159 | 0.008 | -0.574 | -0.639 | -0.007 | -2.212 | -2.621\* |
|  | (0.007) | (0.626) | (0.652) | (0.013) | (0.640) | (0.658) | (0.011) | (0.499) | (0.486) | (0.004) | (0.524) | (0.511) | (0.049) | (1.344) | (1.170) |
| ∂*Y*/ ∂*Policy* | 0.008 | 0.008 | -0.004 | -0.002 | -0.003 | 0.005 | 0.006 | 0.005 | -0.012 | 0.002 | 0.002 | 0.006 | 0.095\*\* | 0.095\*\* | 0.092\*\*\* |
|  | (0.008) | (0.009) | (0.005) | (0.011) | (0.012) | (0.011) | (0.013) | (0.013) | (0.015) | (0.018) | (0.017) | (0.011) | (0.038) | (0.037) | (0.017) |
| R2 | 0.001 | 0.005 | 0.010 | 0.000 | 0.004 | 0.005 | 0.003 | 0.008 | 0.012 | 0.000 | 0.002 | 0.003 | 0.010 | 0.020 | 0.046 |
| Individual characteristics (**x**) |  | Yes | Yes |  | Yes | Yes |  | Yes | Yes |  | Yes | Yes |  | Yes | Yes |
| Community characteristics (**z**) |  |  | Yes |  |  | Yes |  |  | Yes |  |  | Yes |  |  | Yes |

*Note*: This table reports FD estimates of the effect of the GEJE, the health insurance system, and years on health outcomes. \*\*\*, \*\*, and \* represent statistical significance at the 1, 5, and 10 percent levels, respectively. Clustering robust standard errors allowing for correlated residuals within municipalities are in parentheses.

1. See the JSTAR website: https://www.rieti.go.jp/en/projects/jstar/. [↑](#footnote-ref-1)