1 Supplemental Material

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3 Title

4 Was there an improvement in the years of life lost (YLLs) for noncommunicable diseases in

5 the Soma and Minamisoma Cities of Fukushima after the 2011 disaster?: A longitudinal study

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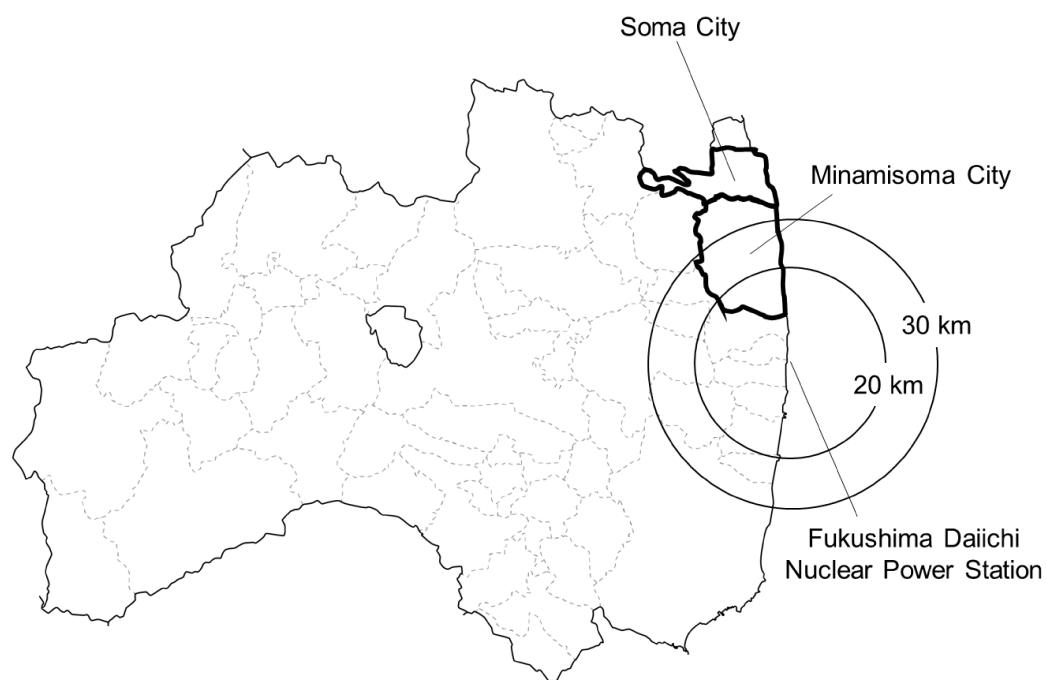
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33   Figure S1. Location of Soma City and Minamisoma City.

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MATERIALS AND METHODS

Rationale of calculation for life expectancy (LE) and years of life lost (YLL)

Life expectancy (LE) is an index of the health status of a cohort, which is calculated from the age-specific mortality of a specific cohort over a given period using the life table method. This measure emphasizes the impact of deaths occurring in younger age groups compared to the relative risk or hazard of mortality.[1] YLL is the difference in LE between a cohort with a specific cause of death and for the cohort in which the cause of death was eliminated. YLL is a population outcome of social health. For example, the Global Burden of Disease studies [2] adopted the YLL as an index of regional health.

LE can be calculated from the age-specific mortality rates (life table analysis). Using the death data and population data, we conducted a life-table analysis for the subject area and the national average of Japan, respectively. The life table consists of the mortality rate, number of surviving population l, number of deaths d, age-specific mortality q, which is obtained by dividing number of deaths by the number of the surviving population, and total survival time of population T.

A conceptual diagram of the YLL is shown in Figure 1. A detailed explanation of the calculation of LE and YLL has been provided elsewhere.[3] Generally, an LE at age x is the value of how long a person survives on average in the population after age x. Survival at age x is described by the mortality rate at age x. LE can be obtained by dividing the total survival time of the population.

$$T_x = \int_x^\infty l_t dt$$

(eq. 1)

Here, T_x [unit: person-years] is the total survival time of the population after age x by the population l_x at age x. LE at age x; e_x [unit: years] is obtained as

$$e_x = \frac{T_x}{l_x}$$

(eq. 2)

YLL_x was defined as the difference of e_x between a risk event (e_x') and without a risk event (e_x) at age x:

$$YLL_x = e_x - e_x' \quad \text{(eq. 3)}$$

YLL can be estimated for any risk event that causes additional mortality. YLL can be estimated for any population if the survival probabilities are available for the population.

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69 **Mortality rate**

70   We obtained the mortality rate of patients aged 1–94 years using the following concept. Based

71   on the basics of human demographics that normalized the mortality rate of age, which is the

72   ratio of the number of deaths at the age of x in an arbitrary year to the number of population

73   (survivals) at the age of x in the middle of the year. In the formula,

74    $q_x = \frac{d_x}{l_x + \frac{d_x}{2}}$ (eq. 4)

75   where q_x is the mortality rate at age x. If death occurs at a constant rate, the number of population

76   at age x at the beginning of the observation period should be $l_x + d_x/2$. For the right side of (eq.4),

77   divide both the numerator and denominator by l_x and replace d_x/l_x as m_x.

78    $\frac{d_x}{l_x + \frac{d_x}{2}} = \frac{\frac{d_x}{N_x}}{\frac{l_x}{l_x} + \frac{d_x}{2 \times l_x}}$ (eq. 5)

79    $q_x = \frac{m_x}{1 + \frac{m_x}{2}}$ (eq. 6)

80   where q_x is the mortality rate at age x, *and* m_x is the crude mortality rate at age x. Thus, we

81   calculated q_x using (eq. 6) for further analyses. We calculated mortality rates at age x with risk

82   events (q_x') in the same way using cause-specific death data.

83

84   The mortality rates at age 0 were adopted as national values for 2010 and 2015, respectively.

85   Both were reported by the MHLW.[4,5] The birth data of the subject area did not include details

86   on the month of birth or death for babies at age 0. Generally, the baby cohort has a large change

87   in mortality over a short period of time. Thus, monthly life table data should be used for these

88   analyses, but we could not do so due to limited data availability at age 0. Therefore, we adopted

89   national data to calculate q_0 for the subject area. Although this assumption for the age 0 might

90   cause a discrepancy in YLL because YLL weighs heavily on younger age, we assumed the

91   discrepancy was negligible by using the national data instead of data of the subject area. At

92   ages over 95 years, we used the force of mortality instead of q_x. This assumption is commonly

93   used for national averages and subject areas. The force of mortality was based on Gompertz–

94   Makeham coefficients obtained from the MHLW [6,7] because of the large annual variability

95   of q in this age range because the number of deaths for the population is small. This assumption

96   on mortality rates for the elderly, such as for an age over 95 years, has little effect on the

97   calculated results of LE.

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99 **Methodological details of sensitivity analysis on YLL in the subject area**
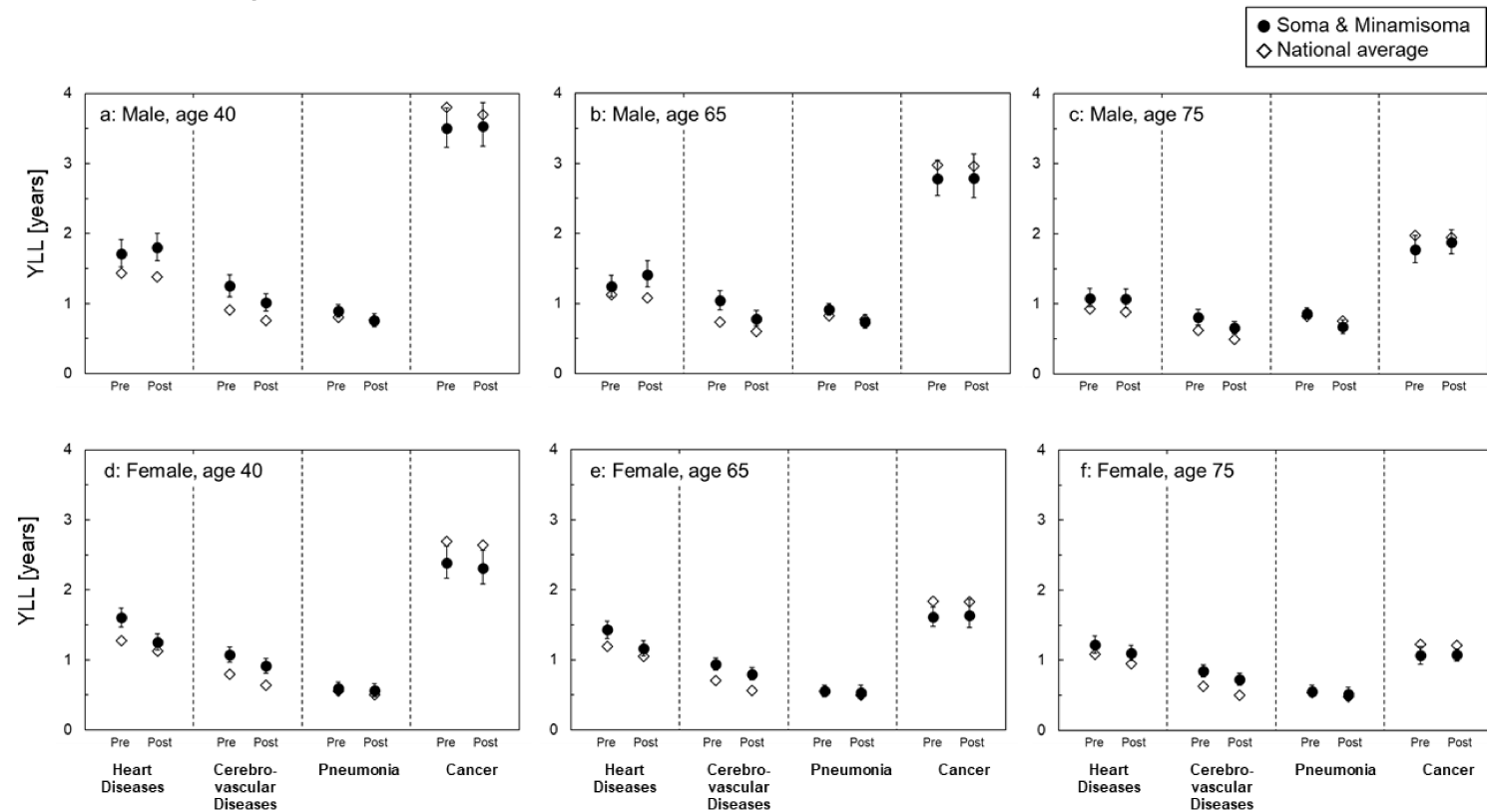
100   We performed a sensitivity analysis for the subject area. The Monte Carlo simulation was

101   conducted using a random number generation based on the 5-year-average and standard

102   deviation for both the populations and crude mortality rates at age 0–94 years before the

4

103 calculation of the mortality rates. The uncertainty interval (UI) was estimated according to the
104 following procedure:
105
106 Oracle Crystal Ball ver.11.1 was used for the Monte Carlo simulation. We used two-sided
107 truncated normal distributions for crude mortality rates to avoid a random selection of crude
108 mortality rates of less than 0. Thus, the distributions were set as symmetrical, around the
109 average, with the lower limit being 0 and the upper limit being two times the average. The Excel
110 add-in "NTTRUNCNORMINV" function in NtRand Ver 3.3.0 [8] was combined with the
111 Monte Carlo simulation. Sampling was performed according to the Latin hypercube method,
112 and the number of trials was set to 10000 times. Random numbers were generated for all the
113 causes of death and for each specific cause of death, separately, and the calculation of YLL was
114 conducted at each trial. At age 0 and at ages over 95 years, we assumed no distribution for the
115 force of mortalities.
116
117 We performed an additional Monte Carlo simulation with the condition that the mortality rate
118 q was less than 0 (no truncated option) for validation. We confirmed that the change in the
119 median was approximately 3% for the absolute value of YLL and the truncated assumption
120 rendered the median change into both higher and lower values. Although the range of the UIs
121 was broadened, it was confirmed that the conditions with and without the truncated option did
122 not affect the results significantly.
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124 **YLL and its difference at ages 40, 65 and 75**

125
126 Figure S2a-f. YLLs due to heart diseases, cerebrovascular diseases, pneumonia, and cancer before and after the disaster of ages 40, 65 and 75 (a–
127 c: Males, d-f: Females). For the subject area (Soma and Minamisoma cities), the error bar indicates the 95% uncertainty interval (95% UI) of the
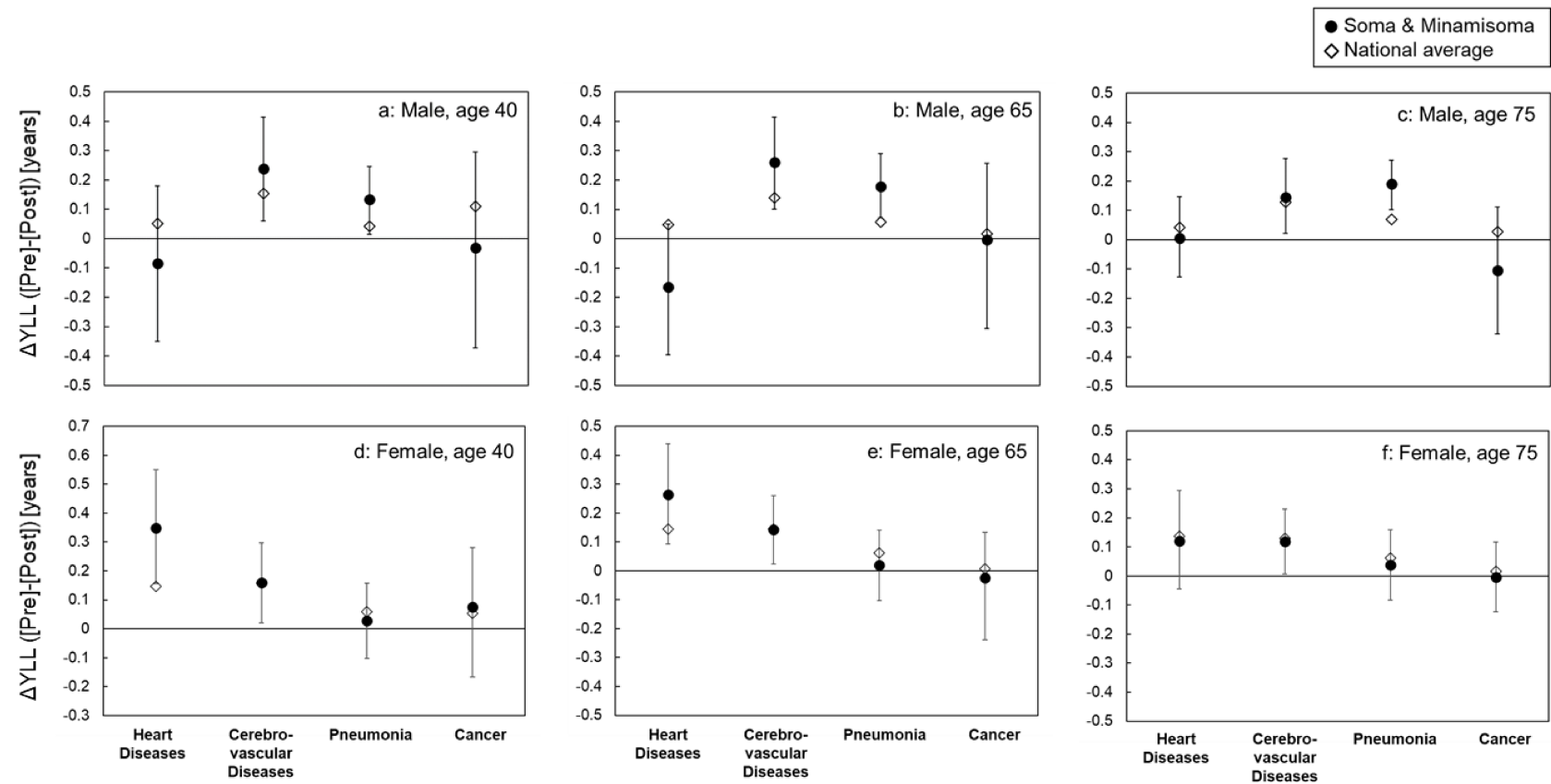128 estimate.

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130 Figure S3a-f. Differences between YLL pre-disaster and YLL post-disaster due to heart diseases, cerebrovascular diseases, pneumonia, and
131 cancer at ages 40, 65 and 75 (a –c: Males, d–f: Females). For the subject area (Soma and Minamisoma cities), the error bar indicates the 95% UI
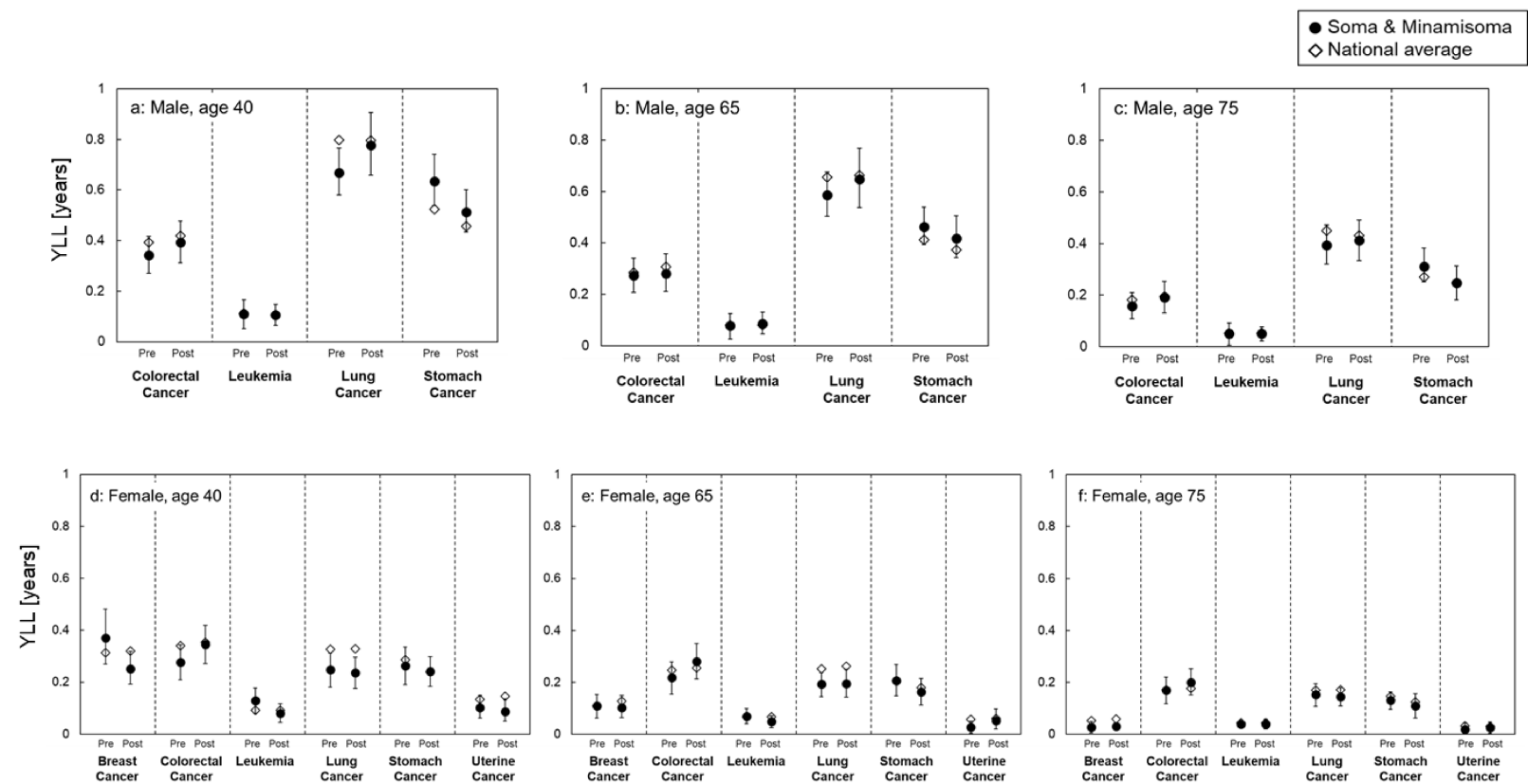132 of the estimate.

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134 Figure S4a-f. YLLs due to specific cancers before and after the disaster at ages 40, 65 and 75 (a–c: Males; colorectal cancer, leukemia, lung
135 cancer, and stomach cancer. d-f: Females, breast cancer, colorectal cancer, leukemia, lung cancer, stomach cancer and uterine cancer.). For the
136 subject area (Soma and Minamisoma cities), the error bar indicates the 95% uncertainty interval (95% UI) of the estimate.
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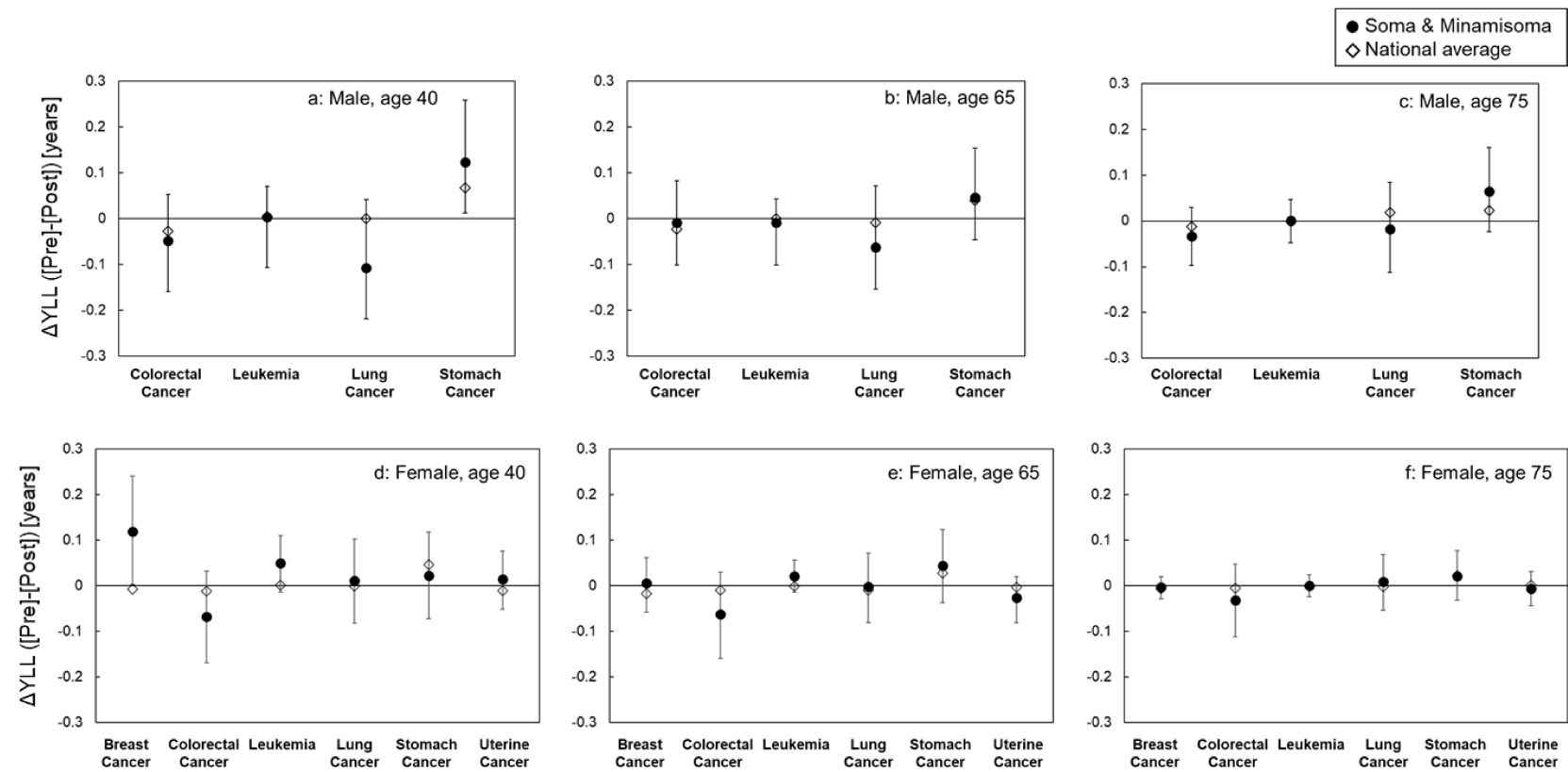
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139   Figure S5a-f. Differences between YLL pre-disaster and YLL post-disaster due to specific cancers at ages 40, 65 and 75 (a –c: Males, d–f:
140   Females). For the subject area (Soma and Minamisoma cities), the error bar indicates the 95% UI of the estimate.

9

141 **YLL at the year of the disaster (2011) and after the year of the disaster (2012–2015)**

142

143 We calculated the YLL post-disaster separately for two periods, i.e. 2011 and 2012–2015

144 (Tables S1a and S1b). For YLL in 2011, we used population data and death records for a single

145 year (2011) and calculated the values. Similar to that for YLL in 2012–2015, we used population

146 data and death records for the four years and calculated the values. The UI of the estimation

147 was not calculated. The mortality rate at age 0 followed the national values in 2015, both

148 reported by the MHLW.[5] For ages over 95 years, we used the force of mortality instead of q_x.

149 The force of mortality was based on the Gompertz–Makeham coefficients obtained from the

150 MHLW.[7]

151

152

153 Table S1a. YLL at the year of the disaster (2011) and after the year of the disaster (2012–

154 2015) [years]: Males

	Age 0 years		Age 40 years		Age 65 years		Age 75 years	
	2011	2012–2015	2011	2012–2015	2011	2012–2015	2011	2012–2015
Heart diseases	1.53	1.86	1.57	1.86	1.37	1.41	1.00	1.10
Cerebrovascular diseases	1.08	0.98	1.05	1.00	0.84	0.76	0.77	0.64
Pneumonia	1.05	0.69	1.08	0.69	1.02	0.67	0.90	0.61
Cancer	3.24	3.62	3.19	3.60	2.26	2.90	1.65	1.95

155

156 Table S1b. YLL at the year of the disaster (2011) and after the year of the disaster (2012–

157 2015) [years]: Females

	Age 0 years		Age 40 years		Age 65 years		Age 75 years	
	2011	2012–2015	2011	2012–2015	2011	2012–2015	2011	2012–2015
Heart diseases	1.33	1.24	1.33	1.22	1.28	1.12	1.22	1.06
Cerebrovascular diseases	0.87	0.91	0.88	0.92	0.68	0.82	0.70	0.73
Pneumonia	0.61	0.68	0.62	0.54	0.60	0.51	0.62	0.48
Cancer	2.26	2.44	2.11	2.34	1.43	1.67	0.86	1.13

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