

MONITORING REGIONAL CANCER INCIDENCE AND MORTALITY PRECEDING AND FOLLOWING FUKUSHIMA DAIICHI NUCLEAR PLANT ACCIDENT



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BACKGROUND

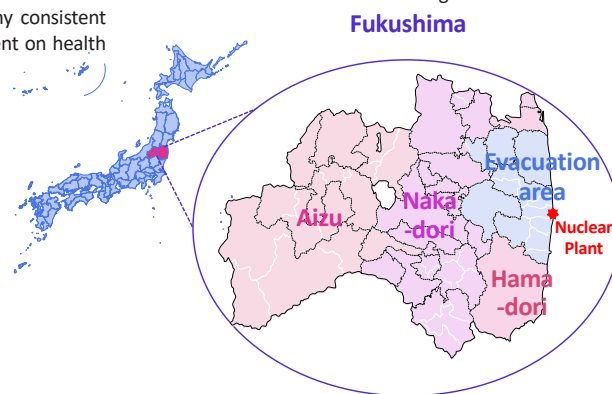
- The health impacts of the Fukushima Daiichi Nuclear Plant accident, which occurred as a result of the Great East Japan Earthquake in 2011, have garnered significant attention from the general public.
- Our research group has been conducted as part of the “Research on the Health Effects of Radiation,” organized by the Ministry of the Environment, Japan, focusing on investigating the health impacts associated with the nuclear accident since 2015.
- Up to this point, our investigations on the results at the prefectural level have not revealed any consistent trends or long-term effects related to cancer. This suggests that the impacts of the nuclear accident on health have been relatively limited.

METHODS

- **Target areas:**
 - The entire Fukushima Prefecture
 - Division into four regions: **Evacuation area (EA)**^a, Hama-dori, Naka-dori, Aizu
- **Data sources:**
 - Incidence: population-based Cancer Registry in Fukushima Prefecture for the years 2008 to 2015 and the National Cancer Registry for the years 2016 to 2019.
 - Mortality: death certificates from the Vital Statistics of Japan from 2008 to 2019.
 - Population: population data based on Basic Resident Registration.
- **Statistic methods:**
 - Calculation of age-standardized incidence (ASIR) and mortality rates (ASMR) utilizing the 1985 model population of Japan.
 - The Joinpoint regression analysis was applied to assess statistically significant consistent trends from 2008 to 2019, identify any changes in these trends at joinpoints, and the subsequent evaluation of trends’ significance before and after such joinpoints, if detected.

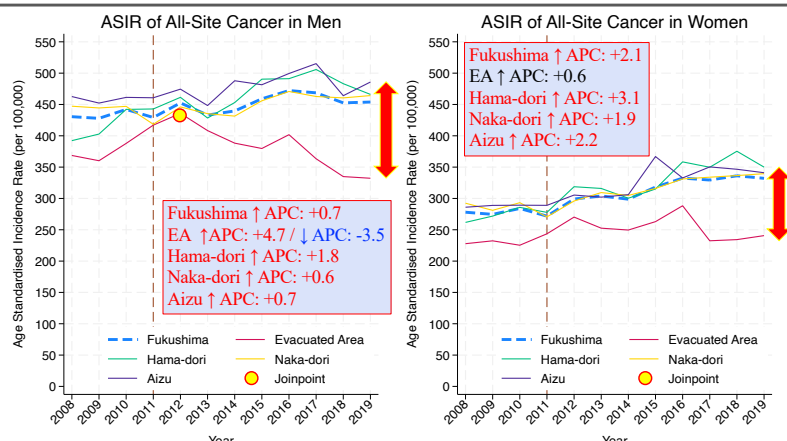
OBJECTIVE

- To elucidate the health impacts of the nuclear accident at the regional level within Fukushima, this study focused on the analysis of trends in cancer incidence and mortality rates across Fukushima Prefecture and its regions.



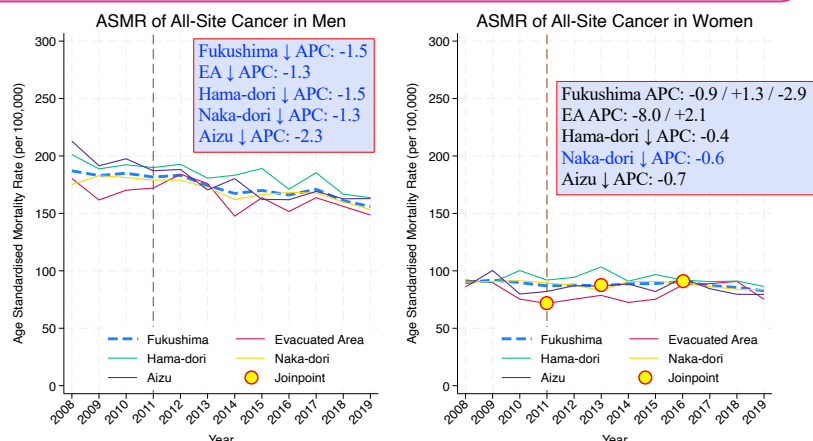
^a The Evacuation area for this study is defined within a 30-kilometer radius of the Fukushima Daiichi Nuclear Plant, targeting regions anticipated to accumulate 20 millisieverts of radiation within one year post-accident. This area includes 12 municipalities, representing approximately 2.7% (371km²) of Fukushima Prefecture’s total.

RESULTS



INCIDENCE

- In Hama-dori, Naka-dori, and Aizu, a significant increase in the all-site cancer incidence is observed for both men and women.
- In EA, a joinpoint in 2012 for men’s ASIR indicates a shift from an annual increase of 4.7% to a decrease of 3.5%, while women’s ASIR remained stable. **Both genders showed a different pattern from other regions.**



MORTALITY

- Significant declining trend observed in all-site cancer mortality rates for men across all regions.
- For women, a significant decline confirmed in Naka-dori.
- **No significant divergence in trends between regions detected.**

Figure Legends

APC	Annual Percentage Change
Red	Statistically significant increase (positive value)
Blue	Statistically significant decrease (negative value)
Black	Not statistically significant

DISCUSSION

- The divergence in trend between regions was observed in incidence rates, but not in mortality rates. This may be attributed to a lack of correspondence between the numerator and the denominator for incidence rates, whereas this discrepancy does not exist for mortality rates.

Numerator and Denominator Information Used in This Study

Indicator	Numerator	Address	Denominator	Address
ASIR	Population-based Cancer Registry	Officially registered address	Basic Resident Registration	Officially registered address
		OR Current living address		
ASMR	Vital Statistics	Officially registered address	Basic Resident Registration	Officially registered address

- Following the accident, residents of the EA came to have two addresses due to evacuation: **officially registered address (within the EA)** and **current living address (outside the EA)**.
- The **phenomenon of dual residency could result in an underestimation of cancer incidence within the EA**. This issue arises as cancer cases, registered at the current living address outside the EA, are counted in other regions and subsequently omitted from the EA statistics, despite their officially registered addresses are within the EA.

To address the issue, we are currently considering a method to obtain an unbiased incidence rate.

✖ The authors have no conflicts of interest to declare.
✖ This work was supported by Research on the Health Effects of Radiation organized by Ministry of the Environment, Japan
✖ The data from 2016 onwards presented in the figures and tables are created based on the provision by the Japan National Cancer Registry in accordance with the law.

Appendix: Age-Standardized Incidence Rate (ASIR) and Age-Standardized Mortality Rate (ASMR) of All-Site Cancer (per 100,000) by Regions in Fukushima Prefecture, 2008-2019

Sex	Region	Year	ASIR1985 ^{a,b}	ASIR2015 ^{a,c}	ASMR1985 ^b	ASMR2015 ^c
Male	Fukushima	2008	430.5	928.9	187.1	475.5
Male	Fukushima	2009	427.9	942.6	182.9	470.4
Male	Fukushima	2010	442.1	966.4	184.9	475.0
Male	Fukushima	2011	429.3	936.8	181.6	468.9
Male	Fukushima	2012	452.5	979.7	183.3	462.7
Male	Fukushima	2013	433.2	943.2	174.3	450.6
Male	Fukushima	2014	439.7	962.0	167.3	440.2
Male	Fukushima	2015	459.1	1005.5	170.0	446.7
Male	Fukushima	2016	472.2	1056.8	166.0	435.8
Male	Fukushima	2017	468.6	1039.5	171.0	451.5
Male	Fukushima	2018	452.6	1005.4	161.0	420.1
Male	Fukushima	2019	453.9	1009.7	156.0	413.2
Male	Evacuated Area	2008	368.6	828.4	180.4	479.5
Male	Evacuated Area	2009	360.2	768.5	161.7	407.9
Male	Evacuated Area	2010	387.8	835.2	170.2	441.7
Male	Evacuated Area	2011	417.0	912.3	172.1	455.5
Male	Evacuated Area	2012	435.8	954.0	184.1	471.2
Male	Evacuated Area	2013	408.3	886.2	176.1	438.6
Male	Evacuated Area	2014	388.3	853.3	147.6	402.1
Male	Evacuated Area	2015	379.8	836.9	163.7	429.2
Male	Evacuated Area	2016	401.8	901.7	151.6	398.7
Male	Evacuated Area	2017	363.3	803.0	163.7	419.9
Male	Evacuated Area	2018	334.9	752.1	156.1	400.4
Male	Evacuated Area	2019	332.2	732.9	148.6	390.3
Male	Hama-dori	2008	392.3	849.7	201.2	504.5
Male	Hama-dori	2009	402.8	904.5	188.8	475.9
Male	Hama-dori	2010	442.1	979.8	192.3	500.6
Male	Hama-dori	2011	442.9	972.9	189.9	463.5
Male	Hama-dori	2012	461.4	982.8	192.8	480.4
Male	Hama-dori	2013	428.4	925.7	180.7	470.0
Male	Hama-dori	2014	453.1	1004.9	183.2	476.1
Male	Hama-dori	2015	490.4	1057.4	189.1	492.4
Male	Hama-dori	2016	491.2	1076.8	171.1	438.1
Male	Hama-dori	2017	505.8	1109.8	185.4	487.8
Male	Hama-dori	2018	483.2	1073.1	166.8	435.7
Male	Hama-dori	2019	466.1	1045.2	163.7	438.5
Male	Naka-dori	2008	447.2	960.5	175.1	445.3
Male	Naka-dori	2009	444.4	974.1	182.8	474.6
Male	Naka-dori	2010	447.0	970.4	181.3	463.5
Male	Naka-dori	2011	418.5	911.7	179.0	466.6
Male	Naka-dori	2012	446.0	965.7	179.0	456.3
Male	Naka-dori	2013	435.4	947.2	172.6	446.9
Male	Naka-dori	2014	431.4	940.3	162.1	428.0
Male	Naka-dori	2015	455.9	999.9	166.3	436.1
Male	Naka-dori	2016	470.7	1055.6	168.2	444.6
Male	Naka-dori	2017	462.7	1026.0	167.8	442.1
Male	Naka-dori	2018	460.5	1021.5	160.0	420.5
Male	Naka-dori	2019	464.2	1029.8	153.4	407.3
Male	Aizu	2008	462.6	987.9	212.9	531.2
Male	Aizu	2009	452.2	1004.0	191.5	494.5
Male	Aizu	2010	461.3	1026.4	197.6	504.3
Male	Aizu	2011	460.7	996.6	187.1	489.4
Male	Aizu	2012	474.5	1035.1	188.3	461.6
Male	Aizu	2013	448.3	988.6	170.4	447.8
Male	Aizu	2014	487.8	1060.4	180.3	464.2
Male	Aizu	2015	481.5	1072.3	162.2	439.6
Male	Aizu	2016	499.4	1136.4	161.9	428.5
Male	Aizu	2017	515.2	1157.7	169.1	459.8
Male	Aizu	2018	464.0	1036.0	162.7	414.8
Male	Aizu	2019	485.9	1088.3	162.9	424.2
Female	Fukushima	2008	278.0	498.3	89.7	210.6
Female	Fukushima	2009	274.6	487.4	91.9	214.0
Female	Fukushima	2010	284.0	499.1	89.8	209.1
Female	Fukushima	2011	271.8	478.6	86.9	204.7
Female	Fukushima	2012	299.1	519.8	87.6	206.6
Female	Fukushima	2013	304.1	513.7	87.0	198.8
Female	Fukushima	2014	298.8	519.6	88.7	203.8
Female	Fukushima	2015	318.2	545.0	89.0	205.5
Female	Fukushima	2016	332.5	585.9	90.6	214.1
Female	Fukushima	2017	329.4	573.5	87.2	202.4
Female	Fukushima	2018	336.2	586.7	85.5	200.7
Female	Fukushima	2019	332.1	580.8	82.7	196.3
Female	Evacuated Area	2008	227.8	403.6	92.0	212.0
Female	Evacuated Area	2009	232.4	411.0	89.7	208.1
Female	Evacuated Area	2010	225.3	412.2	75.4	181.4
Female	Evacuated Area	2011	243.6	420.6	71.6	175.8
Female	Evacuated Area	2012	270.2	468.1	75.3	182.7
Female	Evacuated Area	2013	252.6	438.2	78.6	186.7
Female	Evacuated Area	2014	249.6	441.5	72.5	173.9
Female	Evacuated Area	2015	263.0	447.4	75.3	168.8
Female	Evacuated Area	2016	288.4	495.5	87.7	213.3
Female	Evacuated Area	2017	232.5	413.0	88.8	205.3
Female	Evacuated Area	2018	234.3	439.5	90.8	216.3
Female	Evacuated Area	2019	240.7	423.0	75.3	185.8
Female	Hama-dori	2008	261.8	471.7	91.2	217.5
Female	Hama-dori	2009	271.8	481.6	90.1	216.0
Female	Hama-dori	2010	285.8	506.1	100.2	230.5
Female	Hama-dori	2011	277.8	504.4	92.0	215.4
Female	Hama-dori	2012	318.7	538.0	94.3	226.9
Female	Hama-dori	2013	316.0	529.4	103.4	224.4
Female	Hama-dori	2014	300.4	521.0	91.0	212.4
Female	Hama-dori	2015	315.1	546.0	96.8	215.2
Female	Hama-dori	2016	358.4	620.6	92.0	227.0
Female	Hama-dori	2017	349.8	608.0	90.6	214.2
Female	Hama-dori	2018	375.4	625.7	91.1	213.1
Female	Hama-dori	2019	350.0	604.1	86.4	199.8
Female	Naka-dori	2008	292.4	528.0	90.1	214.7
Female	Naka-dori	2009	281.1	503.8	90.7	211.9
Female	Naka-dori	2010	293.2	515.0	91.4	209.4
Female	Naka-dori	2011	270.6	474.1	89.4	209.1
Female	Naka-dori	2012	295.9	518.5	87.5	205.2
Female	Naka-dori	2013	309.4	523.3	83.0	193.9
Female	Naka-dori	2014	304.8	528.1	90.7	205.8
Female	Naka-dori	2015	316.0	541.4	90.8	213.7
Female	Naka-dori	2016	331.1	586.0	89.4	205.4
Female	Naka-dori	2017	334.0	584.3	86.3	200.1
Female	Naka-dori	2018	336.5	593.2	83.9	196.2
Female	Naka-dori	2019	339.5	598.5	83.6	198.2
Female	Aizu	2008	286.0	501.4	86.0	193.1
Female	Aizu	2009	288.9	496.4	100.3	224.7
Female	Aizu	2010	289.2	498.0	79.8	198.7
Female	Aizu	2011	289.0	499.7	82.0	197.1
Female	Aizu	2012	305.4	535.0	87.0	202.2
Female	Aizu	2013	302.1	511.5	86.8	192.5
Female	Aizu	2014	306.0	536.5	88.6	205.3
Female	Aizu	2015	366.9	617.6	82.0	191.5
Female	Aizu	2016	332.7	597.3	93.7	225.3
Female	Aizu	2017	350.4	598.7	84.5	194.5
Female	Aizu	2018	346.6	604.7	79.6	189.0
Female	Aizu	2019	341.1	590.7	79.5	190.6

^a The data published from 2016 onward is independently compiled and processed based on information provided from the National Cancer Registry in accordance with the law.

^b Age-standardized incidence and mortality rates were calculated based on the 1985 Japanese standard population.

^c Age-standardized incidence and mortality rates were calculated based on the 2015 Japanese standard population.