

**Determinants for the Return to Hometowns after the Accident at Fukushima  
Dai-ichi Nuclear Power Plant: A Case Study for the Village of Kawauchi.**

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## **Abstract**

The Great East Japan Earthquake in March 2011 destroyed the Fukushima Dai-ichi Nuclear Power Plant (FNPP) and almost all residents in a 20 km radius from the plant eventually evacuated. FNPP reactors had stabilized in December 2011 and some evacuees decided to return to their hometowns, the other evacuees remain. We tried to identify the determinants that affect the decision to return home in order to promote recovery of the surrounding area of FNPP. We selected 71 residents who had not returned to home town and 56 residents who had returned. Logistic regression analysis adjusted for confounding factors showed that being female (OR: 2.43,  $p=0.03$ ), living in areas with relatively higher ambient doses (OR: 3.60,  $p=0.01$ ) and expressing anxiety over radiation exposure (OR: 8.91,  $p<0.01$ ) were independently associated with decisions not to return. Our current results suggest the importance of active participation by scientists and local authorities in communicating the risk to the general population involved in returning home.

## **Introduction**

On March 11, 2011, Japan suffered a magnitude 9 earthquake, known as The Great East Japan Earthquake, the largest ever recorded in Japan. The power supply for cooling in the Fukushima Dai-ichi Nuclear Power Plant (FNPP) stopped under the influence of the tsunami generated by the earthquake. Hydrogen explosions occurred at units of FNPP and fission-reactor-related radionuclides were released from the reactor buildings into the environment. <sup>(1)</sup>

The director general of the nuclear emergency response headquarters issued several instructions to evacuate or remain in homes. On the afternoon of March 12, 2011, areas located within a radius of 20 km from the FNPP were designated as “evacuation zones”. On March 15, 2011, those living within 20 km to 30 km were instructed to seek shelter inside houses. On March 17, 2011, the government initiated food control to minimize internal radiation exposure, and all contaminated cow milk was discarded. After the major atmospheric releases had passed, the Japanese authorities took several measures to protect the population from exposure to radioactivity from material deposited on the ground. On April 22, 2011, the government designated “deliberate evacuation areas” where the annual cumulative radiation dose could reach 20 mSv. Residents in this area

were told to evacuate their homes. This area extended to a radius of 20 km from FNPP. In addition, the government designated a radius of 20 km to 30 km from the plant as “emergency evacuation preparation areas.”<sup>(2)</sup> In these areas, residents were redirected to evacuate from their residences. Due to these decisions, many people evacuated.

Kawauchi village is located southwest of FNPP and lies in both the evacuation zone and emergency evacuation preparation area (Figure 1). Due to the accident, almost all residents evacuated, with about 75% relocating to Koriyama city where the Kawauchi government office has relocated its functions. In December 2011, Japanese Prime Minister Yoshihiko Noda declared that FNPP reactors had stabilized and achieved a state of ‘cold shutdown.’<sup>(3)</sup> On January 31, 2012, the head of Kawauchi Village declared that residents could safely return to their homes because radiation doses were found to be at comparatively low levels<sup>(4)</sup>. Nine towns and villages in close proximity to FNPP had evacuated, and since the ambient dose rate of Kawauchi village was relatively lower than the other towns, those evacuees were the first to return. Thorough decontamination work is continuing in the village, the evacuation orders for the village were lifted on April 1, 2012. The government office of the village resumed normal services for schools and other public facilities at the start of fiscal 2012 (April 1) to facilitate the residents’ return to their homes. Worldwide experience following accidents has shown that

individuals are often not particularly willing to leave affected areas. In addition, in the long term people wish to live life that is as normal as possible, <sup>(5)</sup> but as of May 31, only 500 of 2,900 residents had returned to Kawauchi village. Furthermore, most of the residents remain in Koriyama city even though it has a higher ambient dose rate than Kawauchi village. We tried to identify the determinants which affected the residents' decision to return to their homes in the village.

## Methods

For this study, a Kawauchi municipal government officer randomly selected 71 residents who had not returned to the village and 56 residents who had returned to the village, and we conducted an anonymous investigation. Subjects of this study are not only heads-of-household, but also individuals from a family unit. This study is intended for adults, not include children. Informed consent was obtained from all subjects by explaining both orally and in writing the following; study objectives, study methods, that consent for participation could be withdrawn at any time, and if a participant were to withdraw consent, the participant would not be disadvantaged, and that privacy would be protected. Before the study, the study protocol was approved by Kawauchi Municipal Government, Fukushima, Japan. We asked the residents about their anxiety concerning radiation exposure and the consumption of contaminated food. We also noted socio-demographic characteristics including age, sex, employment status and measured dose rate at their home (areas with relatively higher or lower ambient doses), and difficulties of being away from familiar stores, medical facilities and schools. We analyzed several independent variables with a logistic regression analysis  $\chi^2$  test to determine if the differences between the two groups were significant.

## Results and Discussion

Table 1 lists the results from the logistic regression analysis. Residents who had not returned to the village were more often women than men (83.1% female residents who had not returned to the village, 60.1% female residents who had returned,  $p=0.01$ )- showed higher levels of anxiety over radiation exposure (64.8% residents who had not returned to the village vs. 19.6% residents who had returned,  $p<0.01$ ), higher levels of anxiety over consumption of contaminated foods (45.1% vs. 35.7%,  $p=0.03$ ), had lower rates of employment (39.4% vs. 61.7%,  $p=0.02$ ), and relatively higher ambient doses in areas lived in the village (72.9% vs. 41.1%,  $p=0.01$ ).

On the other hand, we found no difference in age ( $p=0.99$ ), difficulty of being away from familiar medical facilities ( $p=0.46$ ), shores ( $p=0.09$ ) and schools ( $p=0.53$ ) between residents who had returned to the village and residents who had not returned.

Results from our logistic regression analysis showed that being female, living in areas with relatively higher ambient doses and expressing anxiety over radiation exposure were independently associated with decisions not to return to their homes in the village after the evacuations caused by the accident at FNPP.

On the other hand, employment status, anxiety to radiation exposure by eating and

difficulty of being away from familiar stores were not independently associated with decisions not to return to the village.

Past experience of existing exposure situations resulting from such as a nuclear accident has revealed that all dimensions of the daily life of residents within the contaminated areas are affected. The International Commission on Radiological Protection (ICRP) recommends that these are complex situations which cannot be managed with radiation protection considerations alone, and must address all relevant dimensions such as health, environmental, economic, social, psychological, cultural, ethical, and political. <sup>(5)</sup> The case of Kawauchi village is the first model for the return of residents to their hometown after the FNPP accident.

Since the accident, measurements of external and internal individual exposure doses of residents surrounding the FNPP reported by various research institutes, and the reports have shown that those individual exposure doses less than the guideline exposure. <sup>(4, 6, 7)</sup> Nevertheless, we found that anxiety over radiation exposure is still a major problem for residents in Fukushima Prefecture.

After the accident, radiation health risk communication is definitely needed in every generation, in order to avoid misunderstanding about radiation exposure and health effects. Based on experiences from a comparable incident in Chernobyl, Lochar



suggests that an effective way to improve reconstruction <sup>(8)</sup> is by the direct involvement of residents and local professionals in management of the situation. Based on our finding that residents not returning to their homes were more likely to have anxiety about radiation, our current results suggest the importance of active participation by scientists and local authorities in communicating the risk to the general population involved in returning home.

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**Figure Legend:**

**Figure 1:** Location of Kawauchi village, Fukushima Prefecture

**Table 1** Odds ratio (OR) and 95% confidence interval (CI) of study variables for not returning home, as assessed by logistic regression analysis.

Variable	Unit	OR	95%CI	p-Value
Sex	Women/ Men	2.43	1.13-10.45	0.03
Measured dose rate at their home	Higher dose/ Lower dose	3.60	1.42-9.17	0.01
Employment	Yes/ No	0.44	0.18-1.08	0.07
Anxiety to radiation exposure	Yes/ No	8.91	3.23-24.58	<0.01
Anxiety to radiation exposure by eating	Yes/ No	0.69	0.27-1.77	0.43
Difficulty of being away from familiar stores	Yes/ No	0.46	0.16-1.33	0.15

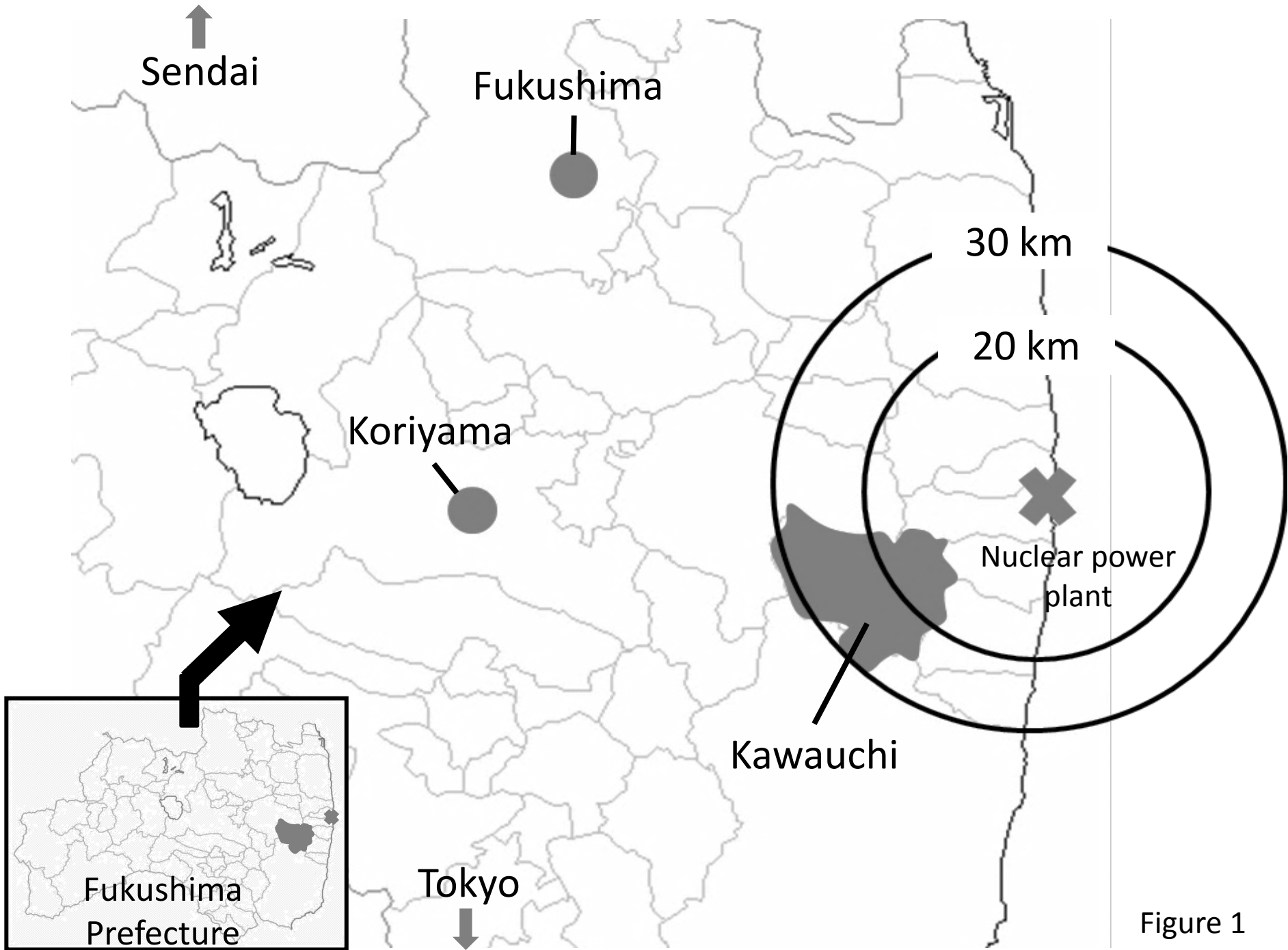


Figure 1