

< Review >

Secondary health issues associated with the Fukushima Daiichi nuclear accident, based on the experiences of Soma and Minamisoma Cities

Masaharu Tsubokura

Soma Central Hospital

Abstract

Nuclear accidents and their associated radiation hazards can cause radioactive contamination in the surrounding areas and health effects associated with radiation exposure for local residents. However, the effects of radiation disasters on local residents are not limited to those caused by radiation exposure. This paper outlines the secondary health issues, unrelated to radiation exposure, experienced by residents of Soma and Minamisoma Cities after the Great East Japan Earthquake and Fukushima nuclear power plant accident. The most serious problem, during the early stages of the accident, involved the health effects of evacuation, especially among elderly people. While evacuation is the most effective way to reduce radiation dose, it can have the greatest mid- and long-term health impact, in particular, by exacerbating of chronic diseases, lifestyle diseases, and motor functions. In fact, the worsening of diabetes can have much more significant health effects than radiation exposure. There are also problems related to medical treatment, consultation behaviors, and nursing care, resulting from the lack of social support, rather than the judgment or decision-making of individuals. It is therefore necessary to give serious, balanced consideration to a wide range of health risks and to put in place long-term countermeasures after a nuclear accident.

keywords: Evacuation, diabetes, lifestyle disease, social determinants of health, emergency transport, decontamination worker

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I. Introduction

Nuclear accidents and associated radiation hazards can cause radioactive contamination in the surrounding areas; local residents may have health effects associated with radiation exposure [1]. It is therefore necessary to measure radiation doses from the early phase of an accident. Environmental monitoring and countermeasures to reduce radiation dose, such as evacuation and decontamination, are essential. However, the effects of a radiation disaster on local residents are not all caused by radiation exposure.

Studies of Three Mile Island and the Chernobyl nuclear power plant accidents have revealed that evacuation and migration can themselves cause danger in the short term, compounded by a shortage of human and material resources

[2-4]. In the medium term, while evacuation can reduce the dose of radiation local people are supposed to receive, it has also been reported to cause lifestyle changes and stress leading to lifestyle disease, posttraumatic stress disorder (PTSD), and depression [5-7]. After the Chernobyl nuclear accident, local people exposed to radiation faced prejudice and stigmatization, leading to an increase in the number of abortions, cases of alcohol addiction, and psychosomatic disorders [8,9]. In the long term, radiation hazards have an impact on social and cultural transformation and national energy policy.

It is known that radiation hazards damage communities, not just through radiation exposure, but also through multifaceted health, economic, and social impacts. This paper outlines secondary health issues, unrelated to

Corresponding author: Masaharu Tsubokura
3-5-18 Okinouchi, Soma city, Fukushima, 976-0016, Japan.
E-mail: tsubokura-ky@umin.ac.jp

radiation exposure, that emerged as a result of the Great East Japan Earthquake and subsequent Fukushima Daiichi Nuclear accident (Fukushima disaster). The data come from the cities of Soma and Minamisoma in Fukushima, located in the range of 10–50 km north of the Fukushima Daiichi Nuclear Power Plant in Hamadori District.

II. What can be learned by analyzing the long-term mortality rate after the Fukushima disaster?

Following the Great East Japan Earthquake and Fukushima Daiichi nuclear accident, the health of local residents was seriously affected by various factors, including the evacuation immediately after the nuclear accident, the deterioration of lifestyle habits, and social changes. This study asks when the impact on residents' health was most severe, in the years following the disaster. One possible answer to that question has been provided by Morita et al. (2016), who have compared the age-adjusted death rate of residents in Soma and Minamisoma Cities before and after the disaster [10].

In this 2016 study, Morita et al. used the death-date and cause-of-death data (ICD-10 code) for all residents of Soma and Minamisoma Cities between January 2006 and December 2015, and compared the monthly mortality risks between January 2011 and December 2015 with the average mortality risk before the disaster. The aim of this study was to evaluate the “secondary” mortality risks associated

with the nuclear accident. Deaths directly caused by the earthquake and tsunami immediately after the disaster were excluded from the analysis.

This study showed that the risk of death rose in both gender and every age group, during the first month after the disaster, in comparison to the period before the disaster. Especially for women aged 85 and older, the risk of death increased during the first three months after the disaster (up to May 2011) (Figure 1).

Three important lessons can be derived from this study:

1. In the five years after the Fukushima disaster, the risk of death for residents was at its highest one month after the disaster. In other words, even with deaths directly caused by the disasters excluded, the risk of “secondary” mortality was at its highest immediately after the disaster. This was the period of time when the most human lives were lost, during the five-year span. The rise in the risk of death reflects the worsening of diseases during evacuation, and the inability of damaged local communities and medical infrastructures to maintain the health of local residents.
2. While the rise in the risk of death among women aged 85 and older was sustained for 3 months after the disaster, the indirect health risks of the disaster for elderly people were more serious and lasted for a long time. Most high-risk elderly people were those living in nursing homes, and their cause of death was “pneumonia.” This means that they died as a result of weakness, a decrease in care, and the general deterioration of their physical condition,

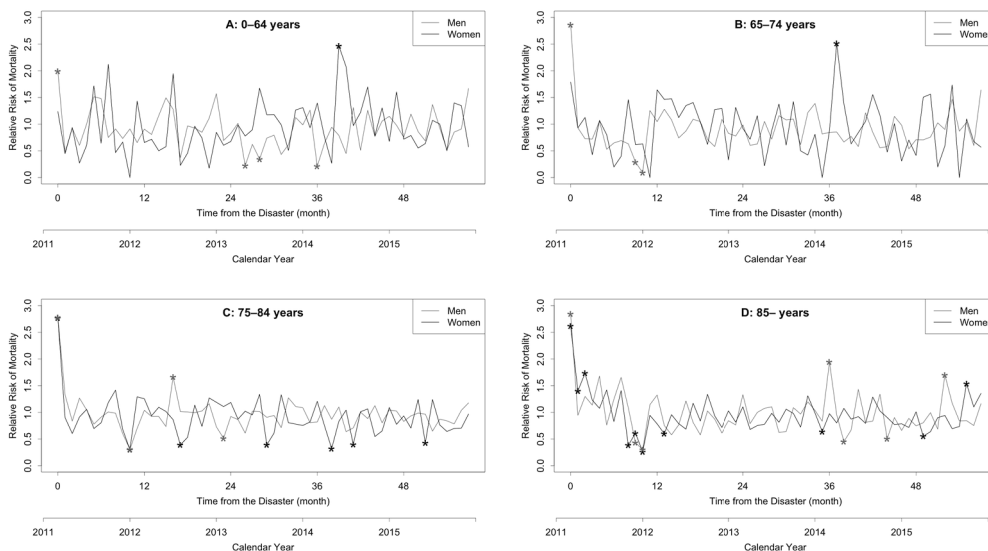


Figure 1 Age-specific monthly trends showing the relative risks of indirect mortality pre- and post-disaster [10]

(A) 0–64 years. (B) 65–74 years. (C) 75–84 years. (D) 85+ years. The baseline risk was defined as the monthly mortality rate per year from 2006 to 2010. The relative risks were adjusted by city; the asterisk (*) indicates statistical significance at the 0.05 level.

and not from the onset of any particular disease.

3. The risk of death during the five years after the disaster was at its highest during the first month following the disaster; there was no clear rise in the mortality rate after that. Deaths due to indirect impacts, including disaster-related deaths, spiked immediately after the disaster, but then decreased to levels that cannot be statistically detected. No statistically obvious or excessive death rate, associated with disaster-related deaths, can be seen for the years immediately following the disaster.

Reducing radiation risks among residents is an important issue that should be given the highest priority after nuclear accidents. For this reason, evacuation is an unavoidable necessity and the first procedure to consider. However, a simple analysis of the numbers suggests that the most important category of health damage that occurred after the Fukushima disaster involved the impact of evacuation on elderly people. Given the life risk to elderly people in nursing homes caused by evacuation (described in the next chapter), it is necessary to balance the risks associated with radiation and evacuation. Although this is a great lesson learned from the Fukushima disaster, it is a difficult problem to solve, with no easy solutions.

III. Health effects associated with evacuation in the acute phase

Emergency evacuation without adequate preparation forces evacuees to bear the physical burdens of moving, and the long-term burdens associated with environmental changes, and with mental and psychological strain. Evacuation will destabilize vulnerable people in various social, physical, and economic contexts, creating situations that will damage weaker people more than others. During the process of evacuation after a nuclear accident, residents of facilities such as nursing homes are typical examples of the types of vulnerable people who need adequate care and countermeasures [11].

Nomura et al. conducted a survey comparing the death rate before and after the disaster among a total of 715 nursing home residents in five of the eight nursing homes forced to evacuate from Minamisoma City [12]. The relative risk of death among nursing home residents after the disaster was about 2.7 times higher than before the disaster. It is worth noting that the risk of death varied from facility to facility. At two facilities, there was no change (a statistically significant difference was not observed between before and after the disaster). In facilities with a high risk of death after the disaster, the mortality rate was about 3.8 times higher than before the disaster. In the facility with the highest mortality rate, approximately 25% of the residents

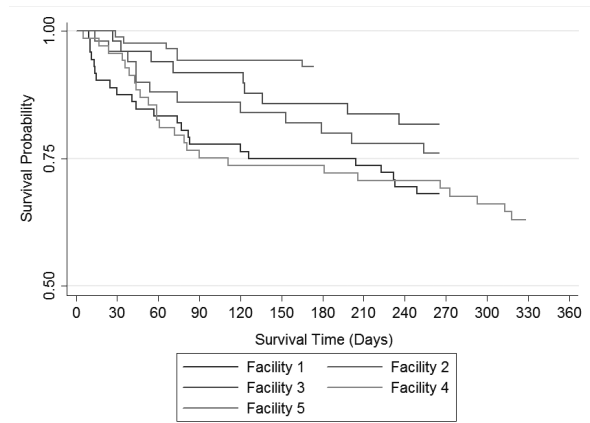


Figure 2 Estimated post-earthquake survival rate by facility among nursing home residents in Minamisoma City [12]

died within 90 days of the disaster (Figure 2). Differences in the actual evacuation distance did not affect the mortality rate, but the mortality rate during primary evacuations was 1.98 times higher than during subsequent evacuations (many residents were forced to evacuate several times after the earthquake.)

Nomura et al. have compared the death rates of evacuated and unevacuated nursing home residents after the disaster [13]. Evacuated nursing home residents in Minamisoma City had a higher mortality risk of 1.82 times (95% confidence interval: 1.22–2.70) than those in Soma City who did not evacuate (Figure 3).

Interviewing to the staff of each facility, the researchers noted that the following four factors had a significant health effect on elderly patients: (1) the presence or absence of dietary care after evacuation, (2) the quality of care received at the evacuation destination facility, (3) whether nutrition management before evacuation was sufficient, (4) evacuation measures.

Murakami et al. have used the loss-of-life-expectancy measure to compare the risks of evacuation with the risks of radiation exposure (caused by staying, without being evacuated) among nursing home residents and the staff members who cared for them in Minamisoma City [14].

They have shown that the risk of rapid evacuation without sufficient preparation (for the action actually selected during the disaster) was about 400 times higher than the risk of radiation exposure associated with staying in the nursing home for 3 months after the disaster. The risk of rapid evacuation was higher than the risk associated with 100 mSv of radiation exposure, which is the reference index of evacuation (Table 1).

Many factors affect logistics during a nuclear accident. The size of the accident and the degree of contamination are not uniform. The extent to which vulnerable people,

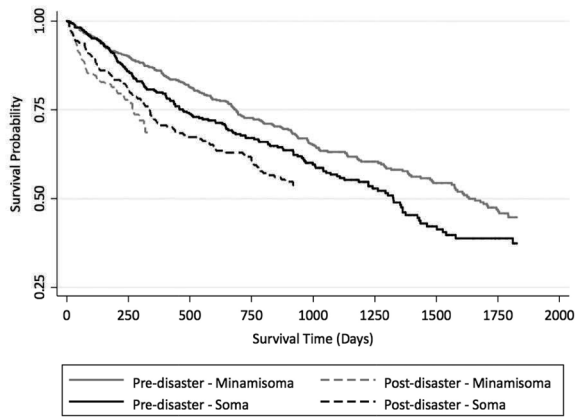


Figure 3 Estimated pre- and post-disaster survival rates among nursing home residents in Minamisoma and Soma Cities [13]

such as nursing home residents, evacuate early—or at all—is determined on a case-by-case basis. Although Murakami et al. [14] emphasize the risk of evacuation, not evacuating is not a zero-risk option. Staying in the contaminated area creates a mental burden; people also worry about logistical crises, a lack of goods, and a lack of human assistance [15,16].

It has been reported that, immediately after the nuclear accident in Minamisoma City [17], the number of medical staff members actually working in hospitals decreased to about one third of those working before the disaster. It is difficult to choose not to evacuate during such an emergency. The author of the present paper would not wish these findings to be used to argue that particular groups of people should or should not have evacuated after the nuclear accident. However, there is much scope to reduce evacuation risks, and it is important to prepare and plan for future possible nuclear power plant accidents. These

studies present us with a lesson learned: that evacuation without sufficient preparation is accompanied by a large health risk, involving the delay of care at the evacuation destination, and the physical burdens caused by long-term movement.

The author believes that the main cause of the increased mortality rate associated with the evacuation was the collapse of medical care and the eventual lost continuity of care due to a failure of local logistics. For example, children and living family members tend to recognize slight changes in the physical condition of their own elderly parents and relatives better than anyone else. For this reason, maintaining pre-disaster human relationships after evacuation is very important to maintaining the health of frail people. It may reduce the health risk faced by elderly patients if care-home staff members evacuate at the same time and continue to provide care. In the future, comprehensive measures that take into consideration both radiation and evacuation risks must be implemented to protect the weak. Further research is needed in this area.

IV. Medium- and long-term health effects: the deterioration of lifestyle diseases, especially diabetes

In discussing the secondary health problems that accompany nuclear accidents, we have mentioned the keyword “evacuation,” during the early phase of the accident. Evacuation-related changes to residents’ living and social environments have a major impact on their health in the medium and long term. Of these changes, one of the most serious involves the increased severity of chronic diseases, especially diabetes.

After the disaster, the number of diabetic patients

Table 1 Comparison of LLEs of residents and staff in nursing homes among rapid and 90-day delayed evacuation scenarios and 20-mSv- and 100-mSv exposure scenarios (persons-d).

Scenario 1, rapid evacuation; Scenario 2, 90-day delayed evacuation. Total LLEs of evacuation-related risk in Scenario 1 were much higher than those of avoidable risks due to radiation exposure in the other scenarios. Values in parentheses are 95% confidential intervals [14].

	Rapid evacuation	90-day delayed evacuation	20-mSv exposure	100-mSv exposure
Evacuation-related				
Nursing home residents	11000 (10000–13000) [880 (730–1200)] ^a	Unknown	-	-
Nursing home staff	Not observed	Unknown	-	-
Radiation-related				
Nursing home residents	0.01	1.7	100	530
Nursing home staff	0.1	26	1000	5300
Total	11000+ (10000+–13000+)	27+	1100	5800

^a LLEs due to non-evacuation-related effects (e.g. disaster-shock), as estimated from the data from Nursing home group B.

increased in Soma and Minamisoma Cities over the following years; in some age groups, the prevalence of the disease increased by about 5% after the disaster. Nomura et al. have retrospectively investigated data drawn from the health examinations of subjects between 40 and 74 years old in Soma and Minamisoma Cities (6,406 persons in total). They have reported that, for several years after the disaster, the risk of developing diabetes was higher than before [18]. In the evacuated area, the risk of developing diabetes after 2013 significantly increased (by 1.55–1.60 times) from the 2008–2010 baseline. Even outside the evacuation area, an increase (1.27–1.33 times) was observed after 2013 (Table 2). This pattern has also been revealed in the Fukushima Health Management Survey carried out by the prefectural government in evacuation areas south of Minamisoma City [19]. It is worth noting that a worsening of diabetes was observed, not only in residents of the evacuation area, but also in residents outside the evacuation area.

It is well known that diabetes carries a risk of vascular events, such as cerebral and myocardial infarction. In fact, the number of stroke-related visits to Minamisoma Municipal General Hospital increased after the disaster [20]. In addition, diabetes itself has a carcinogenic risk. Given the widespread deterioration of diabetes after the disaster, the “secondary” risk of diabetes was much greater than the risk of carcinogenesis associated with radiation exposure. Although future measures may change the prevalence of diabetes, Murakami et al. have shown that the loss of life expectancy among residents in their 40s and 70s in Soma and Minamisoma Cities, due to increased diabetes associated with the disaster, was about 30 times larger than that of radiation exposure, even if the risks associated with

diabetes were underestimated and the carcinogenic risk of radiation exposure was overestimated [21].

The main secondary health impact, following a nuclear accident, is a largescale change of people’s way of life, including work, exercise habits, dietary habits, and community. In this chapter, we have discussed the worsening of diabetes and its associated risks; this health effect was the direct consequence of lifestyle changes caused by the disaster. Although the most clear-cut cause of lifestyle change was “evacuation,” the health of diabetic residents outside the evacuation area also deteriorated, indicating that evacuation was not the only cause of worsening diabetes. These findings underline the importance of having a balanced set of responses to nuclear accidents, taking into consideration a wide range of risks, from lifestyle diseases to radiation exposure. Rather than focusing on a single type of risk, it is indispensable to recognize and understand various types of risk, in order to protect people’s health.

V. Which group of people faces the highest risk of the development of diabetes?

The worsening of diabetes is one of the most important mid-to-long-term health effects after a nuclear accident. Evacuation is one of the most important factors aggravating diabetes, as discussed above. However, diabetic patients outside the evacuation area also experienced worsening diabetes. The identification of high-risk groups is an important issue in public health. Although few studies have explored this issue, the following papers make important contributions to the discussion and implementation of

Table 2 Age-adjusted pre- and post-incident relative risk of the diseases (versus baseline (2008-2010)) [18]

	Evacuees	Non-/temporary-evacuees	P-value of the difference in row
Diabetes			
2011	1.12 (0.70–1.79)	0.94 (0.81–1.10)	p=0.5
2012	1.21 (0.88–1.67)	1.11 (0.97–1.27)	p=0.6
2013	1.55 (1.15–2.09)**	1.33 (1.17–1.52)***	p=0.3
2014	1.60 (1.18–2.16)**	1.27 (1.11–1.45)***	p=0.1
Hyperlipidemia			
2011	1.10 (0.94–1.27)	1.00 (0.95–1.05)	p=0.3
2012	1.16 (1.05–1.29)**	1.03 (0.98–1.08)	p<0.05
2013	1.30 (1.18–1.43)***	1.12 (1.07–1.17)***	p<0.01
2014	1.20 (1.08–1.32)**	1.14 (1.09–1.20)**	p=0.6
Hypertension			
2011	1.05 (0.91–1.21)	1.05 (1.01–1.10)	p=1.0
2012	1.04 (0.94–1.14)	1.03 (0.99–1.07)	p=1.0
2013	1.10 (1.00–1.21)*	1.01 (0.97–1.05)	p=0.1
2014	0.94 (0.85–1.05)	0.95 (0.91–0.99)*	p=0.8

* p<0.05, ** p<0.01, *** p<0.001 for given year versus baseline (2008-2010), adjusted for age.

future health measures.

The first study has examined the relationship between worsening diabetes and the social determinants of health in Minamisoma residents. Using data on 404 people over the age of 20 who were diagnosed as diabetes before the disaster and attended consultations at Minamisoma Municipal General Hospital, Leppold et al. investigated whether the condition of diabetes worsened after the disaster, and in which districts the health of diabetic patients was most likely to deteriorate [22]. They evaluated HbA1c levels at three points before and two points after the disaster (December 2011 and March 2012), and divided Minamisoma City into three areas: suburbs, city center, and middle area, based on residential land prices.

Their study has shown that worsening diabetes was observed after the disaster among young people and patients living in the center of the city. In patients who lived in the center of the city, diabetic symptoms were approximately three times worse than those of patients living in the suburbs. These findings are comparable to the results of Ishii et al., which found no apparent worsening of life-style diseases in 2012, one year after the disaster, in Tamano District, Soma City, a mountain area with one of the highest levels of radioactive contamination outside the evacuation zone [23].

The lifestyle habits of young people may have led to a worsening of “secondary” diabetes after the nuclear accident, in comparison to elderly people. In addition, the more urban lifestyle in the city center may have affected diabetes control more than the suburban lifestyle.

The second paper to evaluate the relationship between regular hospital consultations after the disaster and the worsening of chronic diseases is Toda et al., which has analyzed the data of 563 people who visited a specific health check-up every year for four years (2009–2012) before and after the Fukushima disaster in Minamisoma City. This study has examined changes in the cardiovascular disease risk score (Framingham score) to discover whether the risk of cardiovascular disease increased and the risk factor changed after the disaster [24]. No significant change was found in the post-disaster cardiovascular disease risk of any male and female participant; nor was there any change in the risk factors (Table 3).

Residents who remained in Minamisoma City after the disaster and regularly received specific health examinations over four years are an example of a group that did not evacuate or change their lifestyle habits significantly. In this population, there was no increase in the risk of cardiovascular disease. This finding is comparable to the study by Nishikawa et al. (2015), which showed that the HbA1c control of 58 diabetic patients who regularly attended consultations at Soma Central Hospital after the disaster did not deteriorate [25]. It has been suggested that chronic diseases such as diabetes do not worsen (at least, not easily) in groups that continue to receive hospital treatment or regular medical examinations.

The treatment of diabetes includes individual behavioral changes, such as diet and exercise therapy. To predict whether treatment will be successful, we often focus on individual problems, such as understanding and a positive attitude towards treatment. However, the health effects caused by the nuclear accident should not be attributed to individual commitment or ability; instead, they reflect a larger change in society—affecting people’s ability to continue the same lives they had before the disaster. It will be important to identify social risk factors and adopt countermeasures to combat worsening diabetes, rather than focusing on individual risk factors.

VI. Secondary health effects on newborns and children

Newborns and children are two groups that need particular attention to radiation. The results of radiation dose assessments after the Fukushima nuclear power plant accident indicate that radiation exposure itself cannot be expected to have a health impact on newborns and infants. However, changes in living environment can affect the health of neonates and children, as well as adults. Studies of past disasters have revealed that stress to the mother and environmental changes affected the health of newborn babies. In fact, problems caused by stress and lifestyle changes, especially obesity, were reported in children after the Fukushima disaster by various researchers. In this chapter, we will present two papers that discuss this issue.

To clarify the impact of the disaster on mothers and

Table 3 Comparison of age-adjusted cardiovascular risk score (Framingham score) before and after the disaster in male and female [24]

Cardiovascular risk score	baseline (2009–2010)	2011	2012
Male (Ave, SD)	1.36 (3.06)	1.50 (3.26)	1.46 (2.96)
Female (Ave, SD)	0.19 (3.19)	0.37 (3.30)	0.69 (3.31)

The Framingham score is calculated from the blood pressure value, cholesterol level, presence or absence of smoking, and presence or absence of diabetes. A higher point indicates that the risk of cardiovascular disease is higher.

neonates in the disaster-stricken area, Leppold et al. assessed the health status at birth of all newborn babies born between 2008 and 2014 at Minamisoma Municipal General Hospital (1,101 people) [26] to see whether rates of low-birth-weight infants and premature birth changed after the disaster. They found no statistically significant change in the rates of low-birth-weight infants or premature births after the disaster (Table 4). On the other hand, the proportion of elderly births (Mothers over 35 years of age at the time of delivery) increased after the disaster; the percentage of first-time mothers also increased.

Nomura et al. used school health examination data from Soma City in 2010 (before the disaster), 2012, and 2015 to analyze weight changes among junior high school students [27]. In 2012, one year after the accident, the obesity rate for boys increased, while the BMI and obesity rate for girls decreased. Both boys and girls seemed to experience weight changes, due to the change in their living environment. As no change to the weight of boys or girls was observed in relation to the restriction of outdoor school activities, these changes may have been caused by, for example, a decrease in extra-curricular exercise, stress, or changes in diet. Interestingly, in 2015, there was no difference in the weight index for either males or females; by that time, the weight index had returned to the same level as before the disaster.

However, in 2015, BMI variance increased for boys. Although the average body weight of children in this cohort returned to what it was before the disaster, this does not necessarily reflect the health of individual children, whose weight may have been increasingly variable after the disaster.

These studies show that the disaster had little impact (or a temporary effect) on the weight of newborn babies and children overall. However, the expansion of variance and diversification in the student weight index provides important data on the secondary health impacts of nuclear accidents on children. Although the study data do not directly show it, the authors believe that the weight of individual children who needed social support, whether obese or thin, worsened as a result of diminished social

support after the disaster. Although the average value has returned to the same level, social support continues to be inadequate. We recognize that the impact of the disaster on weak individuals has been masked, in some cases, by the normalized average value. Weaker children, as well as weaker adults, are likely to be disproportionately affected by a nuclear disaster.

VII. Impacts on bone health/motor function

So far, this paper has mainly discussed the impact of the disaster on chronic diseases and obesity. The deterioration of lifestyle habits also has a significant impact on motor function and bone health. This serious secondary health effect of the nuclear accident should also be considered.

Ishii et al. have used the health-check data of 1,890 residents of temporary housing in Soma City, aged 65 or above, to evaluate declining rates of motor function. Deteriorating performances in the TUG (up and go) test and the standing-on-one-foot test were observed in both male and female residents, indicating that their motor function may have declined in 1.5 years since the disaster. The percentage of residents who achieved a TUG test of 11 seconds or less, or a standing-on-one-foot test of 15 seconds or less, in temporary and other types of housing, rose (for the TUG) to 6.7% from 2.8% for men and to 9.2% from 2.8% for women. For the standing-on-one-foot test, it rose to 64% from 31% for men, and to 66% from 30% for women [28]. However, no deterioration of bone density, and osteogenesis or absorption markers was evident in patients visiting Soma Central Hospital [29].

Vitamin D is an important nutrient for bone health, and mushrooms and marine products are an important source of vitamin D among Japanese people. These foods were highly contaminated after the nuclear accident, and the problem was complicated by waste furnace water pollution. Many residents therefore refrained from ingesting them [30]. Since people's post-evacuation conditions have been prolonged, with some residents continuing to live in temporary housing for more than six years, it is possible that motor function and bone health are deteriorating in

Table 4 Post-versus pre-disaster risk ratios of low birthweight and preterm birth, adjusted for maternal age and neonatal sex [26]

Birth Outcome	Risk Ratio	95% CI	p-Value
Low Birthweight			
2012	0.71	0.29–1.75	0.46
2013	0.80	0.42–1.55	0.52
2014	1.28	0.76–2.17	0.35
Preterm Birth			
2012	0.40	0.10–1.64	0.20
2013	1.01	0.49–2.05	0.99
2014	0.52	0.21–1.30	0.16

these residents. There has not been an adequate long-term assessment of rates of fractures or of residents who are bedridden. This area needs long-term follow-up in the future.

VIII. Changes in the clinical behavior of cancer patients

Previous chapters have introduced secondary health effects that are mainly related to lifestyle habits. While the deterioration of lifestyle habits generally includes a poor diet and a lack of exercise, these characteristics should not be seen as individual self-management problems. Rather, these problems reflect social and environmental changes, including changed family relationships, a loss or change of occupation, and the connections between people known as social capital.

There are many examples of people whose health, previously maintained through human-human relationships, failed because of changes in the surrounding environment after the disaster. The change in the medical care of cancer patients is a good example. Ozaki et al. have targeted 219 breast cancer patients (122 patients before and 97 patients after the disaster) who visited one of two hospitals delivering breast cancer treatment in Minamisoma City, to see whether there was any delay in patients' initial visits (the time period between noticing the first symptoms and having a consultation). They also analyzed the relationship between the loss of family support and delayed first visits after the disaster [31].

This study has shown that the number of patients who delayed their consultations for more than 3 months increased from 18.0% before the disaster to 29.9% after the disaster (an age-adjusted risk ratio of 1.66), and that the number of patients who delayed their consultations for 12 months or more increased from 4.1% before the disaster to 18.6% after the disaster (an age-adjusted risk ratio of 4.49). This trend is continuing, even five years after the disaster. Of the patients who experienced a delay, only a low proportion lived with children. This suggests that, if you live with your children, when you notice something unusual in your physical condition, you have an increased chance of getting to the hospital. Previous reports have suggested that it is more important for breast cancer patients to have the support of their children than their partners, when it comes to improving the prognosis. The evacuation after the disaster greatly reduced the number of young people, and changed the family environment, leading to changes in the behavior of local residents in need of cancer treatment, and negatively affecting their health. Although the followings are case reports, similar changes in consultation behavior

have also been noted in relation to other types of cancer, including colorectal cancer [32,33].

Examples of such changes in the family environment affecting residents' health are often experienced in daily practice. In large-scale disasters such as nuclear accidents, family environment and environmental changes occur frequently here and there. Although we have currently focused on the consultation behavior of breast cancer patients, it is highly likely that similar things will happen, not only among patients with other types of cancer, but with many other medical conditions that need long-term follow up.

IX. The impact of changes in clinical service areas, due to the closure of hospitals

In the previous chapter, we introduced changes in the medical treatment behavior of breast cancer patients. Changes in the family environment can have a serious health impact on patients, both directly and indirectly. When an evacuation area was designated, after the disaster, many hospitals were closed and movement was restricted. It seems likely that that residents' consultation behaviors were affected by hospital closures and changes in clinical service areas. To assess the health effects of hospital closures and clinical service area changes on local residents, Morita et al. have analyzed changes in emergency transportation times, using post-disaster emergency transportation data in Soma area (Soma City, Minamisoma City, Shinchi Town, and Iitate Village) [34].

The number of emergency transportation cases was at the same level or lower than before the disaster after a peak of 162 cases in the week (Week 0) of the Great East Japan Earthquake. From Week 1 to Week 11, emergency transportation times were significantly longer than before the disaster; they then returned to the same level (Figure 4). Delays in emergency transportation occurred not only evacuation areas but across the entire Soma area. One possible reason for this is that hospital closures in the evacuation area and the emergency evacuation preparation area extended the travel distance from the emergency site to hospitals. In the first days after the disaster, there were many injuries caused by the disaster itself, and emergency medical treatment were needed. After several weeks, there were calls to transport elderly people left behind, dog bites among returning residents [35], and work-related injuries among construction workers involved in the reconstruction [36].

In the Soma area, hospitals outside the evacuation zone managed to sustain medical care, even after the disaster; However, hospitals in the emergency evacuation preparation

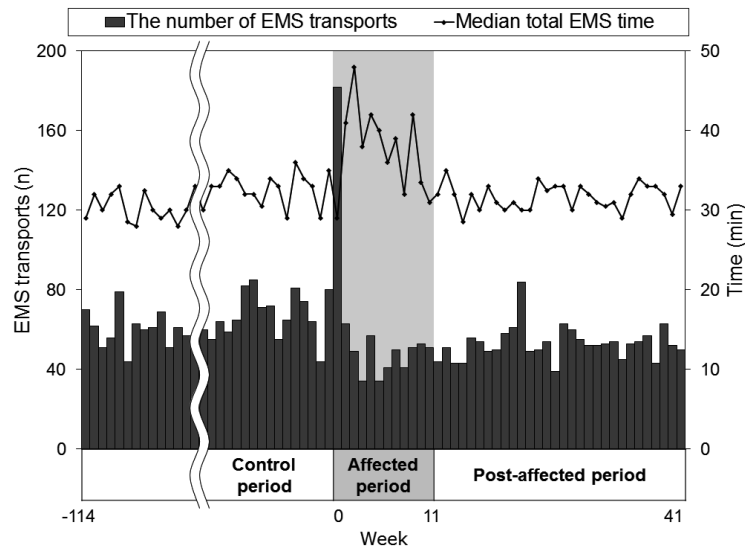


Figure 4 Trends in the number of emergency medical service (EMS) transports and median total EMS time. The week of the earthquake (11-17 March 2011) is defined as week 0 [34].

zone were not allowed to admit patients for months after the disaster. The extension of emergency transportation time, which is important for seriously ill patients, was affected for 3 months after the disaster. Although it was essential for patients to know whether medical treatment could continue or be completed within the area, there continues to be little available information and resources on the treatment of chronic conditions, or diseases requiring long-term continuous care, such as cancer. Local medical staff must work in cooperation with patient families to provide such care [37]. Further measures and research are needed to resolve this point.

Studies discussed above do not cover necessary medical treatment in the evacuation zone, especially in the Futaba area. Nishikawa et al. have described the type of outpatient clinical practice needed in Kawauchi Village after returning to the village [38]. As residents return to the former evacuation zone, future research and measures will be necessary to determine what kind of medical treatment is needed in such areas.

X. Changes in nursing care supply and demand

As a secondary health impact, we have discussed the worsening of diseases, the lack of access to medical treatment, and changes in medical treatment behavior. Another very important secondary impact concerns the shortage of nursing care. Most nursing care is targeted at the elderly; it is a system that depends on the connections between family and society.

Morita et al. have reported that the cost of nursing care rose 1.3 times per capita in Minamisoma City after the disaster [39]. Although a detailed investigation to determine the cause will be needed in future, this may reflect an increase in the number of residents who were forced to rely on systems such as nursing-care insurance because their families were split and local social support had disappeared. The number of nursing care insurance cases also rose among residents needing milder forms of care after the disaster. Changes in nursing-care supply and demand are barometers, revealing the social power that protects an area's health. Continual monitoring and countermeasures will be necessary in the future.

XI. Health issues among decontamination workers

Many decontamination workers were hired to reduce radiation levels in the contaminated area, following the nuclear accident. As reconstruction accelerated, workers from inside and outside the prefecture worked in radioactively contaminated areas; many of these workers lived in Hamadori District. While the radiation dose received by workers was relatively low (in 2015, averaging 0.6 mSv/year with the max of 7.8 mSv/year), they were reported to have various health problems, including lifestyle diseases, infectious diseases, and trauma-related conditions [40].

Sawano et al. have analyzed the health condition of decontamination workers by assessing the prevalence

and treatment of lifestyle diseases in 113 decontamination workers, who were hospitalized at the Minamisoma Municipal General Hospital between June 1, 2012 (the day Minamisoma City began decontamination work) and August 31, 2015 [41]. Approximately 80% of the hospitalized patients were admitted to the internal medicine department. There were high proportions of alcohol consumers and smokers, and a high rate of lifestyle diseases. This study has also suggested that decontamination workers were at risk of trauma. Risks posed by bee stings were reported during decontamination, in areas that people did not enter, due to radioactive contamination [42].

Decontamination workers have various health risks, apart from radiation exposure. For workers, health measures are often designed to cope with occupational accidents. In this case, decontamination workers were exposed to more health risks in their daily lives (including lifestyle diseases) than at work, due to their low socioeconomic situation. Although decontamination workers are required to have a health check every six months, we believe residents who engaged in reconstruction work need comprehensive and sustainable health support.

XII. Conclusion

This article outlines the secondary health effects of the nuclear accident based on the experiences of Soma and Minamisoma Cities. In the acute phase of the disaster, evacuation had a significant impact, especially on elderly people. Many problems, including the worsening of chronic diseases such as - diabetes, impaired motor function, inadequate medical treatment behavior, and a shortage of nursing care, emerged as middle- and long-term issues. Most of these issues should be seen as social and regional problems, rather than individual ones. While several important issues, including mental health problems and the effect of living in temporary housing, are not covered in this paper, it is clear that additional measures to address a range of different health risks in a well-balanced manner will be needed for the long term, following a nuclear accident.

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Conflict of Interest

The author declares that there is no conflict of interests regarding the publication of this article.

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原発事故に伴う二次的な健康課題

—相馬・南相馬地区での経験から—

坪倉正治

相馬中央病院

抄録

原発事故およびそれに伴う放射線災害は周辺地域の放射能汚染を引き起こし、周辺地域住民へ放射線被ばくに伴う健康影響を及ぼしうる。しかしながら、放射線災害の地域住民への影響は放射線被ばくによるものだけに留まらない。本稿では東日本大震災および福島原発事故後、放射線被ばく以外の事故後の二次的な健康課題について、福島県浜通り地区でも福島原発の北10km～50kmの範囲に存在する相馬市・南相馬市でのデータを元に概説する。

事故初期に最も問題となるのは避難に伴う特に高齢者への健康影響である。避難は放射線被ばくを低減するための最も有効な手段である一方で、震災数年間を通して最も大きな健康影響を持ちうる。中・長期的には糖尿病に代表される慢性疾患・生活習慣病、運動機能の悪化は最重要課題の一つである。特に糖尿病の悪化による影響は、放射線被ばくの数十倍の健康影響を及ぼしうる。診療行動、受診行動、介護にも多くの問題が存在する。これらの多くの問題は、個人の自己判断や意思決定の問題として考えるより、社会や地域の問題、地域が変容することで社会的なサポートが欠如してしまった結果として起こったものとして考え対策を行うべきものである。これらの様々な健康リスクをバランス良く考え、対策を長期的に行うことが原発事故後には必要となる。

キーワード：避難，糖尿病，生活習慣病，社会的健康決定資本，救急搬送，除染作業員