

Comparative Analysis of the Reproductive Health Effects of Fukushima and Chernobyl

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Abstract: This Fukushima Dai-ichi nuclear disaster and Chernobyl nuclear disaster are two specific examples of an event that involved an issue with the nuclear power plant that led to a high amount of radioactive materials to get released into the surrounding environment. Radiation is known to be harmful to the human body as it has the potential to cause genetic damage. However, this paper specifically examines the effect of ionizing radiation on reproductive health on both males and females. It was discovered that at certain dose exposures, it is enough to cause biological changes that lead to infertility. With the very high levels of anxiety among the Japanese public on the radiation exposure, many fear that the radiation released from the Fukushima disaster is going to have a negative effect on their life. Consequently, it is key to analyze the potential health, more specifically reproductive health, issues that the radiation from the Fukushima disaster might have on an individual. The effect of radiation on reproductive health was observed in Chernobyl but not as much in Fukushima. This can be attributed to the fact that there was an overall lower amount of radioactive material that was released in the Fukushima disaster compared to the Chernobyl disaster. Any reproductive health issues that emerge surrounding the Fukushima area are likely to be caused by certain psychological effects such as anxiety or even exposure to endocrine disruptors.

Keywords: Radiation; reproductive health; nuclear disaster; public health; Fukushima; Chernobyl

1. Introduction

On March 11, 2011, a magnitude 9.0 earthquake hit the country of Japan followed by a 13-meter tsunami. These natural disasters ended up having an impact on the Fukushima Dai-ichi nuclear plant leading to multiple electrical system failures and meltdown of the reactor cores. The reactor meltdown released varying concentrations of radioactive materials such as strontium, cesium, plutonium, iodine isotopes, and radioactive noble gasses (Eddy, 2015). This release of radiation affected not just the surrounding land, but it also leaked into the ocean. In fact, the amount of radiation, around 1000 PBq, discharged at Fukushima is one of the reasons why the disaster was classified as a level 7 event on the International Nuclear and Radiological Event Scale (World Nuclear Association, 2024a). With such a significant amount of radioactive material being released into the environment, there is always a possibility of exposure to very high doses of radiation. These levels of radiation are associated with acute radiation sickness in addition to an increased risk for cancer depending on the dose received by the individual.

In an event similar to the Fukushima Dai-ichi nuclear power plant disaster in 2011, the Chernobyl nuclear power plant incident in 1986 also involved the destruction of the nuclear power plant that led to massive amounts of radiation being expelled to the public. The glaring similarities between both events have led the events to often be compared to each other, but that is not to say that there are differences among those two events. Chernobyl was a much more destructive disaster than Fukushima was. The Chernobyl disaster

led to two plant workers to die and 28 more followed in the upcoming days due to the high levels of radiation that they were exposed to. On the other hand, there are no known deaths from the Fukushima incident in both the initial explosion and the radiation exposure. Not only was the Chernobyl disaster more destructive than Fukushima was, it also expelled ten times the amount of radiation than the Fukushima disaster. (Nuclear Energy Institute, 2019). The Chernobyl disaster expelled a total of 14 EBq to the surrounding environment (World Nuclear Association, 2024b). Furthermore, the government response to the Fukushima disaster was much more appropriate compared to that of Chernobyl's. While the Japanese government responded quickly to protect individuals from the potential harms of radiation exposure by stopping the spread of radiation contaminated foods and also disseminated potassium iodide to individuals to prevent thyroid cancer, the Soviet authorities was late to make the same protective measures, leading to new cases of thyroid cancer among young children. The mechanism of the radiation release was also different among the two separate disasters. While the Chernobyl nuclear power plant had its cores explode, leading to radioactive material being launched into the atmosphere and the reactor materials to burn, Fukushima nuclear power plant went through an overheating of its reactors that led to the meltdown of the cores, which is one of the main reasons why there was significantly less expelling of radioactive materials into the atmosphere (Nuclear Energy Institute, 2019).

Despite the radiation exposure in Chernobyl being high enough to cause reproductive health issues such as infertility, the doses of radiation (20-75 mSv) from the Fukushima disaster are not enough to incur significant damage to the reproductive health of both male and female workers of the Fukushima nuclear power plant. Therefore, any potential reproductive health issues may be attributable to other factors besides ionizing radiation exposure such as endocrine disruptors and psychological effects such as increased anxiety after the event.

2. Data analysis and results

2.1. Molecular Effects of Ionizing Radiation and Reproductive Health

Ionizing radiation has the potential to cause DNA mutations through the creation of single and double stranded breaks leading to incorrect repair. It is known that females tend to get affected more from the same dose of the ionizing radiation compared to their male counterparts (Ruff, 2013). On the other hand, factors such as the amount of radiation received and type of radiation also plays a big part in determining the effects on an individual. There are countless ways that ionizing radiation can cause a biological change within a human, but this paper will specifically examine the reproductive health effects from the exposure to ionizing radiation. Due to the differences among reproductive systems/organs, it is crucial to examine the effects of ionizing radiation on both male and females separately.

In the case of males, radiation exposure can often lead to sperms showing lowered movement levels, increased morphological abnormalities, and an increase in the fragmentation of the genome. When male gonads are exposed to a relatively low dose (150 mSv) of ionizing radiation, it can possibly cause transitional infertility. However, at higher doses (3.5-6 Sv) to the male gonads, it can result in permanent infertility and an increase in the risk of congenital anomalies in offspring (Wdowiak et al. 2019).

In the case of females, it can get much more complicated due to their ability to carry the offspring and conceive them. The effects of ionizing radiation are also hugely dependent on the developmental stage of the oocytes as the oocytes in early developmental stages such as prophase I showed a high sensitivity to ionizing radiation. On the other hand, immature oocytes showed higher resistance to the effects from ionizing radiation compared to the mature oocytes, with the mature oocytes showing relatively high sensitivity (Skrzypek et al. 2019). Additionally, about 30% of young females will be permanently sterilized upon exposure to 25-50 Gy of radiation to their ovaries. The LD50 is less than 2 Gy for oocytes leading to translational infertility and menstruation issues. In addition to increasing infertility, ionizing radiation can

complicate pregnancies as it can cause conditions such as placental disorder, fetal malposition, preterm delivery, low birth weight, as well as a high risk of uterine rupture. Ionizing radiation is also known to potentially cause chromosomal damage in egg cells (Skrzypek et al. 2019).

2.2. Reproductive Health Effects in Chernobyl

After closer investigation of women from certain populations surrounding the Chernobyl nuclear power plant such as those from the Chechersky district in Belarus and the Polesky district in Ukraine, there were some discoveries about their reproductive health that likely can be attributed to the radiation exposure. Most individuals of the study were living in an environment that had a radiation level of around 20 kCi/km² as found in surrounding soil samples (Kulakov et al. 1993). Following the Chernobyl incident, it was discovered that the rate of extragenital pathology among pregnant women also increased during this time, risking the health of the women carrying the baby. In terms of specific organ related changes, pregnant women experienced a decrease in thyroid function as well as an increase in the thickness of their placentas. In addition, women who were exposed to the radiation from Chernobyl were also known to have higher instances of anemia after pregnancies (Kulakov et al. 1993).

In another study conducted, they looked at the effects of the radiation from the Chernobyl disaster on the male salvage workers. They revealed that the levels of motile spermatozoa was lower in the salvage workers who were exposed to radiation compared to the control group. It was also discovered that there were some morphological effects of radiation exposure as well. For example, the nucleus of the spermatozoa from the workers exposed to the radiation was less intact compared to that of the control group and amorphous head shapes of the spermatozoa were also more common among individuals who were exposed to the radiation (Fischbein et al. 1997).

Radiation exposure to both men and women in populations surrounding the Chernobyl power plant seem to show decreased fertility overall. For males, the radiation's effects on the spermatozoa such as decreased motility affects fertility by decreasing. On the other hand, the radiation exposure to women near Chernobyl has led to decreased fertility. This is mainly because radiation exposure can lead to premature menopause in women, making them infertile and unable to go through pregnancies (Cwikel et al. 2020).

2.3. Reproductive Health Effects in Fukushima

Fukushima, on the other hand, being a catastrophe of a lesser degree also is evident by the reproductive health effects shown by the individuals surrounding the Fukushima Dai-ichi nuclear plant. In comparison to the actual amounts of reproductive health effects in the surrounding area, there is a disproportionate amount of anxiety and fear on the issue. Two months after the disaster, the data showed that the Fukushima incident led to an exposure to an annual dose of 20 mSv within the 20km evacuation zone (World Nuclear Association, 2021). This is part of the reason why there isn't a significant issue concerning the reproductive health of individuals in Fukushima as the radiation exposure is significantly lower than what the individuals near Chernobyl had been exposed to. The dose of 20 mSv, which is the dose that most individuals have received over a year, isn't enough to cause a noticeable impact on the reproductive health of individuals. Additionally, the workers at the nuclear plant after the disaster occurred were exposed to an average dose of 35 mSv, with one outlier individual receiving a dose of 102 mSv (Ministry of Health, Labour and Health, 2024). Table 1 highlights the distributions of dose exposure further. Even the workers who are considered to have been involved with high dose work aren't exposed to a level of radiation where it would cause harm to an individual's reproductive health. While there is a decline in the birth rate in the surrounding area following the disaster, this is more likely due to the behaviors of individuals rather than it being due to the consequence of radiation exposure. With people refraining from planning pregnancies due to the uncertainty of how the radiation in the environment might affect them and individuals moving

away from the nuclear plant in fear of their pregnancies being affected, this most likely contributes to the declining birth rate (Kurita, 2019). Although birth rate is often associated with fertility among the individuals, there isn't enough evidence to suggest that this decline of the birth rate is attributable to an issue with fertility. This suggests that any reproductive health issues are likely not a direct cause of the radiation exposure, but rather other factors. Some factors are exposure to endocrine disruptors and psychological impacts following the disaster.

Table 1. The distribution of the total effective doses of workers involved in high-dose work (Ministry of Labor and Welfare, 2024).

Effective Dose (E) mSv	March 2011- September 2015
100<	1
75<E≤100	191
50<E≤75	233
20<E≤50	267
10<E≤20	186
5<E≤10	129
1<E≤5	145
≤1	51

2.4. Endocrine Disruptors in Fukushima

Endocrine disruptors such as polychlorinated biphenyls and perfluoroalkyl/polyfluoroalkyl substances, or PFAS, may play a bigger part in inducing reproductive health issues among individuals in Fukushima rather than the radiation exposure causing them. In a study conducted, they found out that polychlorinated biphenyls were found to be present in individuals, and the amount also increased with age. The levels of polychlorinated biphenyls are likely attributable to the diets of the Japanese, which consists of a lot of fishes. This chemical is not excreted well within a human's body, so it is known to bioaccumulate and it also be passed on from the mother to the fetus (Mori et al. 2014). The accumulation of this chemical within the human body has the capability to cause disruptions to an individual's reproductive health. Table 2 exemplifies this as it highlights the constant increase in the levels of the polychlorinated biphenyls as an individual ages, likely signifying that they are constantly being exposed to it. In addition, another endocrine disruptor that is known to be able to affect an individual's reproductive health are PFAS. Last year, PFAS were detected in a water purification plant in western Japan at a level that is 28 times higher than what is nationally accepted (Jiji, 2024). With there being detections of PFAS from across the country and the government only recently looking to take a stronger stance on this issue, there is a possibility that individuals who developed any reproductive health issues may have also come in contact with these PFAS.

Table 2. The median blood polychlorinated biphenyl concentrations of a sample of Japanese individuals (Mori et al. 2013).

Age	Median (nanogram per gram wet weight)	Study Participants
0-4	0.41	28
5-9	0.20	7
10-14	0.21	10
15-19	0.47	2
20-29	0.25	69
30-39	0.30	85
40-49	0.47	98
50-59	0.76	118
60-69	0.91	75
70-85	0.97	15
Total	0.49	507

2.5. Psychological Effects on Fukushima residents

Besides endocrine disruptors, reproductive health issues are also known to be able to stem from psychological conditions. For example, it was discovered that the people of Fukushima have an increased anxiety and stress about the potential harm of being exposed to the radiation released by the Fukushima disaster (Orita et al. 2015). It is also known that stress can lead to decreased fertility among males (Sharma et al. 2022). Among females, psychological effects can make pregnancies more difficult through making it harder to control ovulations and by causing/worsening certain period problems (Office on Women’s Health, 2021). With the increased anxiety and stress that was caused by the radiation release from the Fukushima nuclear disaster, it is possible that this could be the cause of some reproductive health issues among individuals in Fukushima.

3. Conclusion

With there being glaring similarities between the FDNPP disaster and the Chernobyl disaster, it is also important to note the difference among these events as well. The magnitude of these disasters are a big factor with the Fukushima disaster being much less disastrous.

Overall, the Fukushima disaster has expelled much less radioactive content into the environment compared to the Chernobyl disaster. Yet, the consensus belief among people in Japan is that the radiation in the environment from the Fukushima disaster is still enough to cause significant harm to an individual's health, which isn't true.

Looking back at the data, it showed that while individuals near the Chernobyl disaster showed noticeable effects on their reproductive health, individuals from Fukushima showed a much less significant effect on their reproductive health. Despite this fact, there still remains anxiety over the possible effects of the radiation from the Fukushima disaster. In reality, it is highly unlikely that the radiation itself was the sole cause of certain reproductive health issues among individuals in Fukushima, but rather that it was a result of other factors such as psychological conditions and exposure to endocrine disruptors.

This calls for the Japanese government to increase communication with the public about the risk assessment of the radiation exposure from the Fukushima disaster to lower the general anxiety that is present about the health effects from the radiation. Better communication from the Japanese government to the general public about the radiation risks will provide everyone with accurate data so that the public has a correct understanding of how certain radiological events can affect their health.

Consequently, as the general anxiety levels that are present start to fade with increased communication, certain trends that are harming Japanese society can also be mitigated. The decline in birth rate in Fukushima largely stems from individuals' fears of the harms of radiation exposure, adding to Japan's problem of an aging society. Increased communication from the government, however, will work to limit this as individuals will have a more accurate understanding of how radiation will affect them.

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