A Review for the Epidemiological Study as A Health Monitoring of Potential Risk of Radiation Exposure near the Nuclear Power Plants in Japan

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Abstract—An apparent increase of leukemia risk raises occasionally public concern of radiation exposure in the developed countries where nuclear power plants (NPPs) are located although the facilities operate normally. On the contrary a reactor plant accident certainly poses a threat to increase thyroid cancer risk in children by radiiodine uptake mainly resulted from contaminated fresh milk due to the fallout. As the end of 1998, there were 52 NPPs operating in Japan. One of our important issues of radiation epidemiology is how to elucidate scientific, social, and political controversy about the potential public health risk of radiation exposure near NPPs if nuclear energy is necessary in Japanese society from now on. A review was conducted for the epidemiological study as a public health monitoring of potential risk of radiation exposure near the NPPs in Japan with respect to two points; routine releases of radioactive effluents from NPPs and consequence of a NPP accident.

Introduction
In Japan the peaceful uses of atomic energy began under the Atomic Energy Commission (AEC) as an advisory organization for the government after the promulgation of the Atomic Energy Basic Law in 1956. The first commercial operation of NPP started in 1966 by Japan Atomic Power Co.. As the end of 1998, there were 52 NPPs operating in Japan. After radiation leakage incident of nuclear-powered ship “Mutsu” in 1974, the restructure of the nuclear administration system was considered. The Nuclear Safety Commission (NSC) was established as an additional advisory organization for the nuclear safety control in 1978. In the same year the Radiation Dose Registration Center started its operation to keep the dose records of all nuclear workers. Many years had passed since the AEC recommended such a system in 1965. The System for Prediction of Environmental Emergency Dose Information (SPEEDI) has been developed after the accident in 1979 at Three Mile Island, USA. In 1986 the Chernobyl NPP accident occurred following a leukemia cluster argument near the Sellafield nuclear facility reported by an England TV program in 1983. These events remind most Japanese people of the experiences of the atomic bomb survivors in 1945 and the Japanese fishermen on board exposed to the fallout from hydrogen bomb detonated on Bikini atoll in 1954. In 1995 Iwasaki et al reported an English paper of leukemia and lymphoma mortality in the vicinity of nuclear power stations in Japan. For clarifying the health effects of low dose and low dose rate of radiation the first analysis of mortality of nuclear industry workers in Japan entrusted by the Science and Technology Agency of the government was published in 1997.

A review was conducted for the epidemiological study as a public health monitoring of potential risk of radiation exposure near the NPPs in Japan with respect to two points; routine releases of radioactive effluents from NPPs and consequence of a NPP accident. For a more closely understanding public health impact in the contaminated areas from fallout after Chernobyl accident we also have conducted cooperative studies with the former USSR researchers using various Japanese scientist exchange programs since 1996.

Mortality data in Japan and the Chernobyl accident data of our cooperative studies
Our ongoing epidemiological study as a public health monitoring of the potential risk near the NPPs is on the basis of the mortality data permitted by the governmental Statistic Bureau. The number of age- and sex-specific deaths for cancers, tumors of central nervous system, and congenital anomalies between 1972 and 1997 were obtained for about 3,370 municipalities (ward/city/town) from the annual vital statistics. The population census data enumerated every 5 years between 1975 and 1995 were also obtained to calculate the mortality. The additional data were obtained from the published document by necessity.

The Chernobyl accident data were obtained for a more closely understanding public health impact of the contaminated areas in the former USSR through the cooperative epidemiological study with the Research Center for Radiation Medicine (RCRM) of Academy of Medical Sciences of Ukraine at Kiev and the Medical Radiological Research Center (MRRC) of Russian Academy of Medical Sciences at Obninsk. The RCRM provided the mortality (1979-1995) data set of Ukrainian people involved five oblasts (Zhytomir, Rovno, Kiev, Chernigov, and Poltava). The MRRC provided the data set of thyroid cancer incidence (1991-1996) of the public aged of less than 19 years old at the accident in Bryansk oblast in Russia.

The case of routine releases of radioactive effluents from NPPs
The Japanese NPPs have been designed to limit the quantity of gaseous and liquid radioactive effluents so that the effective dose of the public due to the routine releases is 50 μSv or less per year. The operating organizations have conducted the effluents monitoring by stack monitors and liquid waste sampling before being discharged as well as the radiation monitoring of on-site environment. The local governments also
have carried out the radiation monitoring of off-site environment. As a result the annual effective doses of the public satisfy the mandatory dose constraint of 1 mSv and the doses of the most exposed individuals are thought to be less than 20 μSv.

There are about 740,000 residents of 20 or more cities/ villages within 10 km of NPPs in Japan. Because of the closely monitored regulation as the above, the individual radiation doses resulting the routine releases are usually very low so that we can ignore the potential risk at the time of normal operation. However, an apparent increase of leukemia risk raises occasionally public concern of radiation exposure in the developed countries where nuclear power plants (NPPs) are located although the facilities operate normally. Hoffmann et al. concerned that the data published by Iwasaki et al. are compatible with the hypothesis of a leukemogenic impact of NPPs in Japan. The relative risk was about 1.2 and barely statistically significant at the 5% level on the basis of the systematic difference between 18 municipalities with NPPs and 72 control areas. But no clear evidence of increase was observed in childhood in contrast to a leukemia cluster argument near the Sellafield. It should be cautious for the interpretation of the findings derived from, so called, ecological study especially because individual radiation doses are reasonably small. An important issue of radiation epidemiology is how to elucidate scientific, social, and political controversy about the public concern of potential risk of radiation exposure near the NPPs. It is not hanging on to very small potential risks or seizing one positive aspect to prove no risk.

The proportion of chronic lymphocytic leukemia (CLL) of all leukemia types deaths (1972-1997) in Japan is very small; 1~3%, especially it increases since 1990 but still small. No evidence of radiation-induced risk is generally seen for the CLL. A decrease in Japanese childhood leukemia mortality has been observed similarly as in the developed countries. Leukemia mortality rate has dramatically increased among the elderly persons between the 1960s and the mid-1980s. A geographic clustering of adult T-cell leukemia (ATL) is well known to have a relationship with HTLV-I infection in endemic areas of southern Japan. The ATL is not classified as a disease entity before International Classification Diseases-10th revision. For example the population size in 1960 of Tokai village, 120 km northeast of Tokyo, was about 14,000. The first commercial operation of NPP started here in 1966. The population has increased to be about 33,000 in 1995. Total expected number in consecutive 5 years of leukemia deaths in the village have increased from three to seven. The other 19 municipalities with NPPs locate in four main islands. Their population in 1995 varies from 67,000 to 2,100.

Of course incidence data provide better estimates of risk than mortality. But Japan does not have a comprehensive national cancer registry program although continuous efforts by the research group for population based cancer registration have been made since 1975. In 1995 regional cancer registries were operating (two cities and 33 prefectures out of 49 prefectures). There are still difficulties to overcome in order to analyze histological type-specific incidence rate, especially about time trend around NPPs located in different areas throughout of Japan because of different reporting rate and quality of data among the regional registries. Our work will depend largely on the mortality data for the time being.

Most of cancers are considered to be life-style related diseases. An apparent increase of leukemia risk near the NPPs is considered to have been found by chance or common residence-related factors other than routine radiation exposures from NPPs. But one possible challenge is to provide ‘evidence-based epidemiological translations’ for the Japanese public to recognize what a potential risk from our society with NPPs is likely to be. In no distant future it is expected to use national health statistics and realistic estimate of routine radiation concentration from NPPs with geographic information system. As a result, we would like to demonstrate that “From a public health perspective, the perception of a cluster in a community may be as important as, or more important than, an actual cluster.”

The case of consequences of a NPP accident

At the 1957 Windscale (now Sellafield) reactor accident there were the views that short-lived 131I was the most important radionuclide concerned, especially with respect to its ingestion in milk by infants, and that control of milk distribution would significantly reduce its effects. As a result, based on the off-site impact, it is classified as level 5 of International Nuclear Event Scale (INES, designed in 1989 by the International Atomic Energy Agency and the Nuclear Energy Agency). A cancer incidence study was conducted for about 10 years period (1975-1985) before and after the 1979 NPP accident at Three Mile Island (TMI) in United States and it concluded that observed findings did not reflect an accident effect. The TMI accident is classified as INES level 5 based on the on-site impact although the off-site release of radioactivity was very limited. The Chernobyl NPP accident in the former USSR in 1986 is classified as INES level 7 because it raised widespread environmental and public health effects. A significant release of radiiodine to the environment due to the severely damaged reactor building and the difficulty of supply control of contaminated fresh milk after the accident have increased thyroid cancer risk among the former USSR individuals who were children at the time of the accident (ATA).

Through our cooperative study with the MRRC we also confirmed that thyroid cancer risk has increased in Bryansk oblast as the thyroid organ dose increased among the age ATA group of less than 19 years old. It was thought that the risk still remains. The oblast includes the one of the three main contaminated areas, so called, the Central, Gomel-Mogilev-Bryansk and Kaluga-Tula-Orel areas. The Bryansk contaminated areas
assessment of environment but also epidemiological assessment of long-term public health consequences. A justification for the adopted implementation for decontamination is sometimes to be determined through not only radiological threat from the radionuclides-contamination once a serious NPP accident occurred. In the analysis the thyroid organ mean doses were used for all 27 rays in the oblast of about 35,000 km² areas. They were based on the estimated ¹³¹I soil contamination density by about 3000 settlement units and assumptions made through direct individual thyroid measurements. It is said that a cartographic system developed by Information-Computer Center of Science and Production Association ‘Typhoon’ such as SPEEDI in Japan was used to reconstruct space-time characteristics of depositions, primarily for ¹³⁷Cs and ¹³¹I. The information collection of the individual exposure circumstances for the cases is relatively easy. But it should be emphasized that such ecological study is indispensable in radiation epidemiology for the comprehensive risk assessment with very low background incidence rate and very huge areas, corresponding to about 350 general cities or towns (11,600,000 individuals) in Japan.

Except the increase in thyroid cancer risk we have no evidence of a major public health impact from the fallout after the Chernobyl accident yet. Through our cooperative study with the RCRM the data of Ukrainian vital statistics (1972-1995) were examined including selected five oblasts; Zhitomir, Rovno, Kiev, Chernigov, and Poltava. These include most contaminated areas in Ukraine (consists of 25 oblasts and 2 special cities) except Poltava where it is called ‘clean’ areas. Generally a similar time trend of mortality appeared in both national- and oblast- levels for the causes; neoplasm, leukemia, diseases except neoplasm, external causes, and congenital anomalies (age<1 year). It was noteworthy that 1) the relatively high proportion of CLL cases in leukemia patients was seen, and 2) the public health impact from the former USSR economical/political destruction could be considered large. Mortality data by rayon-level were also collecting but the procedures were time-consuming and delayed because of the lack of Ukrainian research resources. Further continuous efforts should be done to confirm that no major public health impact from the fallout after the Chernobyl accident is to be observed except the increase in thyroid cancer risk.

Although it is not a direct epidemiological issue, it should be kept in mind that the prospect is still unknown for the residents to rehabit with remedial measures against the residual long-lived radionuclides (¹³⁷Cs, ⁹⁰Sr, ²³⁹Pu) remaining in the 30 km zone from the Chernobyl reactor. The area corresponds to about 28 general cities or towns (940,000 individuals) in Japan. It is a little relief that the Japanese NPPs locate in front of the sea. The population size within 30 km from a Japanese NPP is about the range from 900,000 to 90,000.

Various efforts should be conducted to deal with all the day-to-day aspects that have been affected or threatened by the radionuclides-contamination once a serious NPP accident occurred. A justification for the adopted implementation for decontamination is sometimes to be determined through not only radiological assessment of environment but also epidemiological assessment of long-term public health consequences.

The accident at JCO Tokai uranium processing plant

On 30 September 1999, at the JCO Tokai uranium processing plant, the worst Japanese nuclear accident occurred to raise the evacuation of the people near the facility (350 m radius) and the advice for the people within about 10 km to stay indoors. As a result it was ‘irradiation’ accident but not ‘contamination’ one because of no apparent damage of the JCO conversion building. Three JCO workers had an acute radiation syndrome and one of them died 83 days after the accident. The Japanese government has assigned a preliminary INES level 4 to the accident because of no significant off-site risk. It is expected for the Japanese NSC to conduct appropriate attempts to the social concern for ‘undetectable’ radiological effects on the health of local residents and regain public trust in radiation risk information.

Conclusion

An important issue of radiation epidemiology is how to elucidate scientific, social, and political controversy about the public concern of potential risk of radiation exposure near the NPPs. It is not hanging on to very small potential risks or seizing one positive aspect to prove no risk. One possible challenge is to provide ‘evidence-based epidemiological translations’ for the Japanese public to recognize what a potential risk from our society with NPPs is likely to be. In no distant future it is expected to use national health statistics and realistic estimate of routine radiation concentration from NPPs with geographic information system.

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