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Health Consequences of Fukushima

Speech in Berlin, February 27th, 2016

Thank you Chairman,

1. Title Slide
2. Epidemic Curve

We can learn many things from the 1986 Chernobyl accident. This is an epidemic curve on thyroid cancer incidence for ages 14 and younger in Belarus. In the sense of duration since the nuclear accident, Fukushima is here now. Although a remarkable increase was observed beginning 4 years after the accident in Chernobyl, we can see a relatively small but significant excess even within the first 4 years. It is an important point whether or not to notice the excess of thyroid cancer between 1987 and 1989. The small excesses were observed without any screening programs not only in Belarus but also in Ukraine and Russia. It was, however, completely neglected in Japan, even today. We are now at about five years after the Fukushima accident. so we examined whether the excess can also be seen in Fukushima using the most recent data released just 2 weeks ago on February 15, 2016.

3. Exposure after March 11, 2011.

This graph shows an air dose rate change around the plant every four hours after March 11th. Y axis shows air dose rates in μ Sv per hour in logarithmic scale. As you can see here, air dose rate remarkably increased beginning late night on March 14th. Although it is not shown in this graph, there was another massive release from March 21st to 22nd.

4. Plume after March 11, 2011.

Let's look at the main movements of radioactive plume as it changed directions over time, by the time series maps by Professor Hayakawa of Gunma University. The leftmost panel indicates a small northward flow on March 12th. The next panel shows the widespread flow in the early morning of March 15th, which contaminated the south areas. This plume was reported be loaded with gaseous iodine. since the boiling temperature of iodine is relatively low. Here is Tokyo. The third panel shows the plume heading northwest towards Iitate Village. in the afternoon of March 15th. This contributed the most to the present air dose rate. The fourth panel shows the northward flow on March 20th. The fifth shows the southward flow on March 21st, approaching Tokyo.

5. Different distributions of ^{131}I and ^{137}Cs

   These are computer simulated maps showing cumulative deposition rates of iodine 131 and cesium 137 from March 11th to March 29th, 2011. The deposition pattern was quite different with iodine mainly flowing to the south.

6. Screening on Thyroid Cancer in Fukushima.

   Fukushima Prefecture planned thyroid cancer screening program for all children and teens up to age 18. The screening consists of two stages. First, all subjects are screened by ultrasound in the primary examination. Those who have nodules with diameter larger than 5.0 mm or cysts larger than 20.0 mm screen positive. In the secondary examination, the positive examinees of the primary examination undergo more detailed ultrasound, blood and urine tests, and cytological examination by fine-needle aspiration, if necessary. When cancer cells are detected by fine-needle aspiration cytology. they are diagnosed with suspicion of cancer. Final confirmation of cancer comes only after the operation and histological confirmation of the excised tissues.

7. Current schedule of screening on thyroid cancer

   The 1st round of the screening program took three years to cover all residents who were 18 years old or younger at the time of the accident. The first year of the 1st round screening from October 2011 to March 31st 2012 covered residents in the nearest areas to the nuclear power plant. The second year of the 1st round from April 2012 to March 2013 screened residents in the middle area. The third year of the 1st round was from April 2013 to March 2014, and residents in the least contaminated area were screened. The 2nd round is scheduled to take two years to cover all residents who were 18 years old or younger at the time of the accident, plus children who were fetuses (or unconceived) at the time of the accident. The first year of the 2nd round began in April 2014 covering the nearest and the middle areas. In the second year of the 2nd round, which is the Japanese fiscal year 2015, screening was conducted in the least contaminated areas. The 3rd round screening will begin in April 2016.

8. The Map of Fukushima

   The screening schedule was determined according to the order of air dose rates in the prefecture. Higher air dose rates meant earlier screening. This means the order of schedule is based on the order of cesium exposure, not radioactive iodine. This map of Fukushima Prefecture shows the order of screening for each year in the 1st round. Also note the population density of Fukushima Prefecture is three times higher than Chernobyl.

9. Methods: Comparison Group

For comparison, we employed age- and sex-specific national incidence estimates of thyroid cancer between 1975 and 2008. This can be obtained from the web page of the National Cancer Center in Japan. Fukushima prefectural government releases their thyroid screening results every 3 months. The present data were released on February 15th 2016. The English version of the data is found on the website of Radiation Medical Science Center for Fukushima Health Management Survey by Fukushima Medical University.

10. Divided into 9 Districts (Map of ①～⑨)

Strictly speaking, because cases detected by screening should be considered as prevalent cases, we derived incidence through division by average duration. In this case, the "duration" means duration from the time when thyroid cancer grew larger than 5 mm in diameter and became detectable by screening and cytology to the time when it can be diagnosed in usual clinical settings without screening. Then, sensitivity analysis was conducted using several different durations. Poisson distribution was used to estimate the 95% confidence interval.

11. Methods: External Comparison

From age- and sex-specific incidence estimates of thyroid cancer from the National Cancer Center, Japan, we employed 3 per 1,000,000 as the national annual incidence for comparison with the 1st round data. For comparison with the 2nd round data, we used 5 per 1,000,000 considering the aging of the subjects.

12. Methods: Internal Comparison

The southeastern least contaminated district was chosen as "reference district." We estimated prevalence odds ratio and its 95% confidence interval on the remaining 8 districts based on prevalence of the reference district. We employed MLE Odds Ratio (Mid-P) of "StatCalc" in EpiInfo 7.

13. Table 1 (1st Round: data as of June 30, 2015)

This table shows information of subjects of 1st round for each screening year: Population aged 18 years old or younger at the time of the accident; the number of primary examination participants; the number who screened positive in primary examination; the number of participants in secondary examination; the number of thyroid cancer cases diagnosed by Fine Needle Aspiration Cytology, and the number of operated cases. Color of each row corresponds to the colored area for each screening year in the map. As of now, 113 thyroid cancer cases plus 3 additional cases have been identified, including one benign case.

14. Table 2 (4 districts in Middle Area)
    This table shows information on subjects for 4 districts in the Middle Area.

15. Table 3 (4 districts in the Least Contaminated Area)
    This table shows information on subjects for 4 districts in the Least Contaminated Area.

16. Table 4: External Comparison (1st Round)
    This shows the results of External Comparison for the 1st round. About a 50-fold increase was observed in the highest district compared with the Japanese annual thyroid cancer incidence. In the lowest district, no cancer case was observed, and this is the district we employed as a reference. Even in the second lowest district, a 20-fold increase was observed.

17. Table 4-2: Internal Comparison and POR (1st round)
    This table shows the results of Internal Comparison for the 1st round. About a 2.6-fold difference was observed between the highest district and the second lowest district used as reference.. In the highest district of the central middle district, one thyroid cancer case was detected among about 1,650 examinees.

18. Back Door Path between Areas/Districts and Prevalence of Cancer
    The order of screening was such that the highest exposed area was screened first, followed by the second highest exposed area and finally the lowest exposed area. So, the order of screening itself was a confounding factor of the estimates. This means there is a back-door path between radiation doses of the districts and thyroid cancer detection. This confounding bias leads to severe underestimation of the prevalence odds ratio for the nearest area and the middle area.

19. Table 5 Latency Adjusted External (IRR) and Internal Comparison (POR)
    Therefore, we adjusted the estimates of both external and internal comparison by latency. After the adjustment, clear dose-response relationship was observed between the districts and excess incidence of thyroid cancer cases. This means that more excess cancers were detected in districts closer to the nuclear power plant. Furthermore, more excess cancers tended to be observed in the southern area of the prefecture.

20. The order of screening in the 2nd round
    This map shows the order of screening in the 2nd round. The nearest and the middle areas were combined to be screened in the first year (Fiscal Year 2014) in the 2nd round.

21. Table 7: Current results of the 2nd round screening

This is the result of the 2nd round screening as of December 31, 2015. 51 thyroid cancer cases were detected by fine-needle aspiration cytology. Among 51, 16 cases were operated. All 16 cancer cases were histologically identified as papillary carcinoma.

22. Table 8 Result of 2014 Fiscal Year in 2nd Round

This table shows information for subjects of the Nearest area and the 4 districts in the Middle area. Although both primary and secondary examinations are still ongoing and not all results have been confirmed, 45 thyroid cancer cases have already been observed in the 2nd round as of December 31, 2015.

23. Table 9 Result of 2015 Fiscal Year in 2nd Round: 4 districts in the Least Contaminated Area

This table shows information for subjects of the 4 districts in the Least Contaminated Area. Although the progress of both primary and secondary was less advanced in these districts, 6 thyroid cancer cases have been detected in the 2nd round as of December 31, 2015.

24. Table 10 External Comparison in the 2nd Round

This table shows the results of external comparison in the 2nd round with 2 years of latency. As an exception, the latency of the nearest area was set as 2.5 years. This is because in the Nearest area, the 1st round screening began in October, 2011 and the 2nd round screening began in April, 2014 As in the 1st round, similar excesses were observed in the 2nd round. The highest was a 38-fold excess in the Nearest area. where prevalence of thyroid cancer exceeds that in the 1st round.

25. Tentative Conclusion 1

In Chernobyl, the outbreak of thyroid cancer began to rise one year after the accident, rather than four or five years after the accident when the marked increase was seen..

As of 57 months after the accident in Fukushima, the first round screening conducted from October 2011 to March 2014 revealed a 20- to 50- fold increase in thyroid cancer incidence in ages 18 years or younger. A higher rate of thyroid cancer was seen closer to the power plant and in the south area.

26. Tentative Conclusion 2

Post-operative findings of the 1st round thyroid cancer patients indicate that 92% of the operated cases had lymph node metastasis, distal metastasis and/or extrathyroidal extension. In the 2nd round screening, a 20- to 38-fold increase is already seen although primary and secondary examinations are still ongoing. Screening effect discussed in the 1st round does not apply to the 2nd round. About 80% of thyroid cancer cases detected in the 2nd round had no nodules, including nodules under 5.0 mm, in the 1st round. This means these cancers seemed to grow over 5.0 mm diameter in only 2 years. We have to prepare to take measures to deal with not only thyroid cancer but also other cancers and non-cancer diseases. Further investigation is necessary, especially in prefectures adjacent to Fukushima and in residents older than age 18, so that we can grasp the number of such cancer cases in those populations.

27. What is next?

Information on thyroid cancer is reported by Fukushima Prefecture every three months. The next release will be in May.