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Engaging with local stakeholders: some lessons from Fukushima for recovery

R.S. Hayano

Department of Physics, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan; e-mail: hayano@phys.s.u-tokyo.ac.jp

Abstract–The Fukushima Daiichi nuclear power plant accident contaminated the soil of densely populated regions in Fukushima prefecture with radioactive caesium, which poses significant risks of internal and external exposure to the residents. Applying the knowledge of post-Chernobyl accident studies, internal exposures in excess of a few mSv per year would be expected to be common in Fukushima. However, extensive whole-body-counter surveys have shown that the internal exposure levels of residents are much lower than estimated; in 2012–2013, the Cs-137 detection percentages (the detection limit being $\sim$300 Bq body^{-1}) were approximately 1% for adults and practically 0% for children. These results are consistent with those of many other measurements/studies conducted to date in Fukushima. As a consequence, risks from external exposure assume greater importance for the majority of residents in Fukushima due to the lower contribution from internal exposure. In both cases, average doses remain low, although some residents are exposed to higher-than-average risks; it is these members of the population who need to be identified and followed-up. Consequently, it is essential to re-establish communication at all levels in society.

Keywords: Fukushima Daiichi nuclear power plant accident; Internal exposures; External exposures; ICRP *Publication 111*

1. INTRODUCTION

The author works at CERN in Geneva on 'antimatter', and began generating graphs soon after the Fukushima Daiichi accident (Tanaka, 2012) in order to better understand the situation. These graphs and other information were shared using Twitter (@hayano), and these activities caught the attention of many people;

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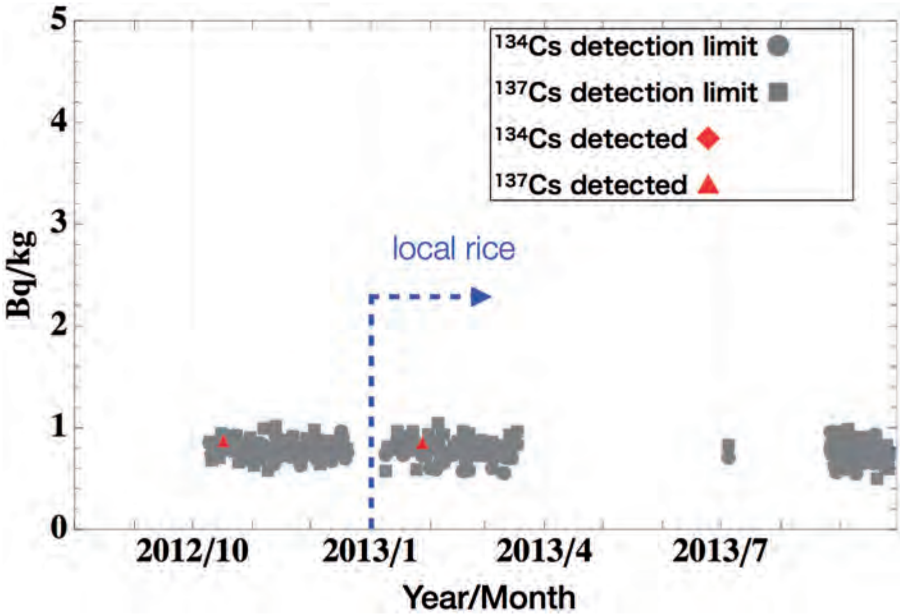

Fig. 1. Results of radioactivity measurements in school lunches in Fukushima city.

as such the number of 'followers' increased from some 3000 to more than 150,000 within a few days. A recent study conducted by Tohoku University showed that the author had the seventh most influential Japanese Twitter account following the Great East Japan Earthquake and the Fukushima Daiichi nuclear power plant accident. Being bidirectional, Twitter is quite different from conventional media such as television and newspapers. Before Summer 2011, there was an increasing trend of tweets on food safety, especially by worried mothers.

At that time, no data were available regarding the level of internal contamination. As such, the author proposed to the Japanese Government that school lunches should be measured systematically for radioactive caesium contamination. This proposal was adopted by the Government, and was included in the 2012 and 2013 Japan Fiscal Year 2012 budget.

Fig. 1 shows the results of the school lunch tests conducted in Fukushima city. The detection limit was approximately $1\,\mathrm{Bq\,kg^{-1}}$. Positive results were reported in two cases, but they were at the level of the detection limit and were not considered to be significant. This is despite the fact that Fukushima city started to use local rice in January 2013. Similar tests conducted in all other cities, towns, and villages in Fukushima prefecture have shown that school lunches are practically free of radiocaesium.

These activities related to the measurement of radioactive caesium contamination in school lunches attracted the attention of medical doctors in Fukushima, who were struggling to establish reliable whole-body-counter (WBC) measurements in 2011.

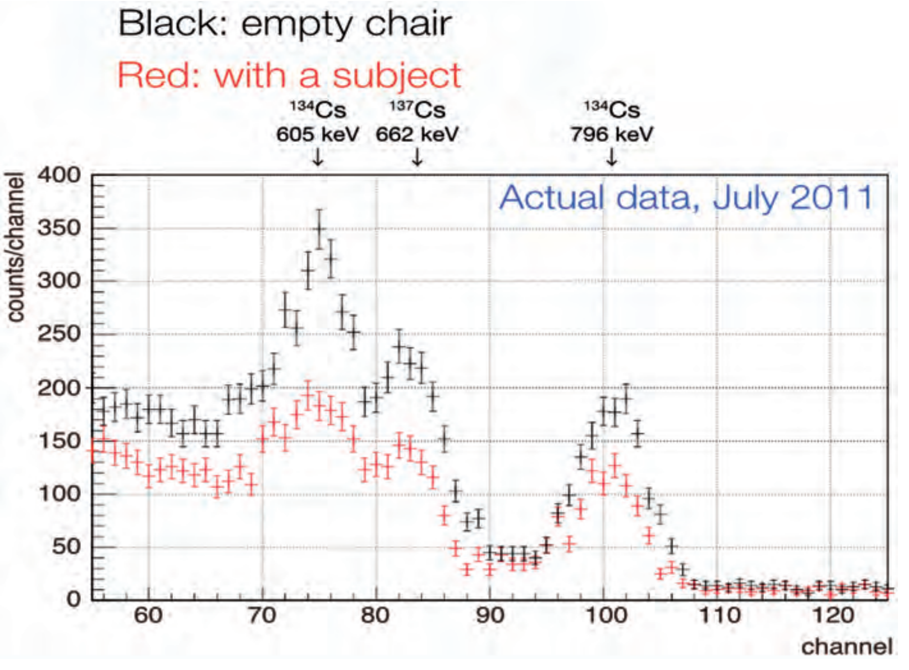

Fig. 2. Spectra measured with a chair-type whole-body counter at Minamisoma General Hospital in July 2011.

Fig. 2 shows an example of the difficulties that doctors were facing. The two spectra were taken with a chair-type WBC (with insufficient shielding), installed in July 2011 at Minamisoma General Hospital, located 23 km north of Fukushima Daiichi nuclear power plant. The spectrum shown in black is a background measurement in July 2011, which clearly shows peaks for Cs-134 and Cs-137. Superimposed in red is the spectrum taken with a subject. As shown, the caesium peak heights are lower with the subject sitting on the chair; the shielding effect by the body was more visible than that of the internal contamination. It was very difficult to interpret such spectra correctly, and this started the author's involvement in WBC measurements in Fukushima.

2. INTERNAL EXPOSURES

The Cs-137 deposition map presented in Fig. 3 for the contaminated area indicates that a typical level of Cs-137 in densely populated cities such as Fukushima (population ~ 290,000) and Koriyama (~340,000) is approximately 100,000 Bq m^{-2}. According to the coefficient (2 μSv 100 Bq^{-1} m^{-2}) published by UNSCEAR (1988), the average committed effective dose of a person living in the Fukushima–Koriyama region would amount to approximately 2 mSv year^{-1} for Cs-137 from ingestion alone, and up to 5 mSv year^{-1} when the contribution from Cs-134 is also considered (important in Fukushima for the first 1–2 years after the accident).

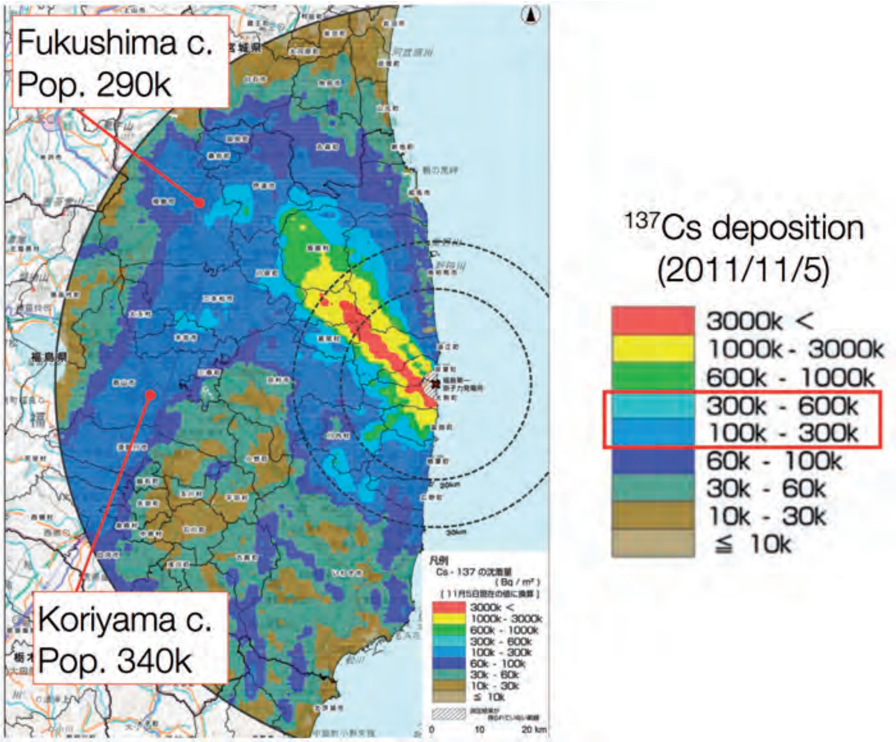

Fig. 3. Results of the airborne monitoring survey by MEXT, Japan (MEXT, 2011).

However, as shown in a recent paper (Hayano et al., 2013), approximately 99% of Fukushima residents do not have detectable levels of radiocaesium in their bodies (detection limit was 300 Bq body^{-1}). For the remaining 1% of residents, the median caesium concentration was approximately 10 Bq kg^{-1} (Fig. 4); a level similar to that received by Japanese adults in the 1960s as a result of global fallout (Uchiyama et al., 1996).

This surprisingly low level of internal exposure is not likely to be due to sampling bias. In Autumn 2012, all school children (1456 enrolled, 1383 measured, coverage 95%) in the town of Miharu, in the suburbs of Koriyama, were measured, and none of them exceeded the detection limit. Questionnaires sent to their parents revealed that 60% of these children were eating local or home-grown rice, and 20% were eating local or home-grown vegetables. These results are consistent with those of many other measurements/studies conducted to date in Fukushima [e.g. rice inspection, foodstuff screening, and duplicate-portion studies (e.g. Harada et al., 2013; Sato et al., 2013)].

Particularly important is the low caesium concentration in rice grown in Fukushima (Nakanishi and Tanoi, 2013). In 2012, Fukushima Prefectural Government tested every bag of brown rice harvested in Fukushima prefecture (more than 10 million 30-kg bags). Only 71 bags exceeded the limit of 100 Bq kg^{-1} set by the Government (Fig. 5).

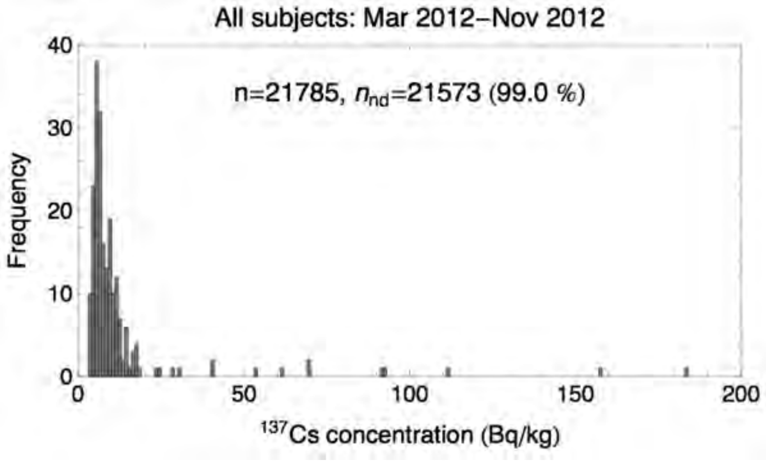

Fig. 4. Cs-137 concentration for 21,785 subjects measured at Hirata Central Hospital in Fukushima prefecture between March 2012 and November 2012 (source: Hayano et al., 2013). Non-exposed (non-detected) subjects have been excluded from the plot.

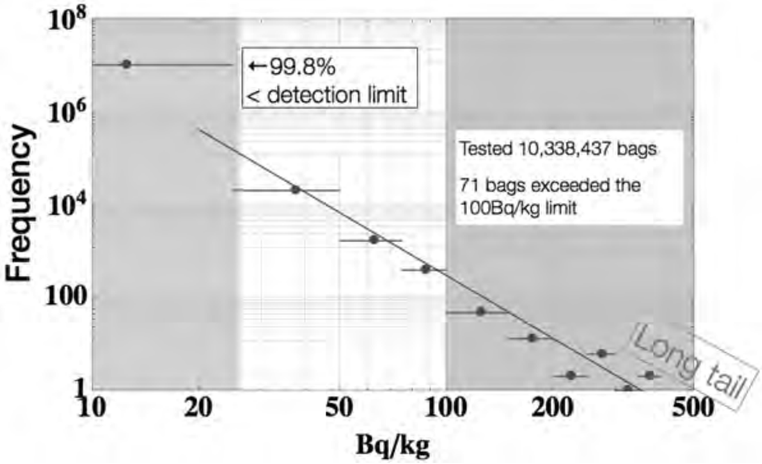

Fig. 5. Results of the brown rice inspection conducted by Fukushima Prefectural Government in 2012 (note: log-log scale).

The contamination level of marketed food is kept low, and therefore ordinary Fukushima residents are not exposed to high risk of internal contamination. Fig. 6 shows the WBC results for Hirata Hospital. They have been re-plotted using a log-log scale, which reveals a characteristic long tail indicative of a small number of residents at higher risk of internal contamination.

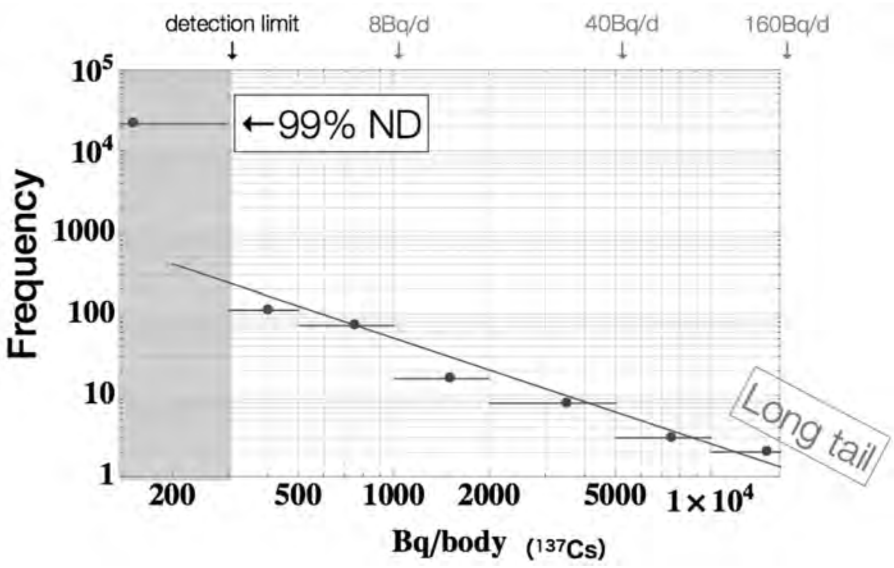

Fig. 6. Whole-body-counter results for Hirata Hospital (including non-exposed subjects) presented using a log-log scale.

On identification of an individual with higher-than-average levels of caesium in their body, the aim is to identify the source of the contaminated food, either by interview or by measurement of the suspected food using a germanium detector. In most cases, it has been possible to identify the source of contaminated food (e.g. wild or home-grown mushrooms, wild boar, etc.). These foodstuffs are known to accumulate high levels of radiocaesium, but as they are not placed on the market, they are not tested for radiocaesium. People who consumed these foods regularly were advised to stop eating them and to come back to the hospital after a few months for whole-body measurements. In individuals who received this advice, body burdens have decreased at a rate consistent with the known biological half-life.

3. EXTERNAL EXPOSURES

In Winter 2011, many municipalities in Fukushima started to distribute ‘glass badge’ personal dosimeters, the results of which are shown in the top panel of Fig. 7 (results of wearing badges for 2–3 months were converted to annual doses). As shown, most people were subject to external exposures below 2 mSv year^{-1}.

Comparison of ‘glass badge’ measurements in Fukushima city between Winter 2011 and Winter 2012 (Fig. 8) shows that most external doses were below 1 mSv year^{-1} in Winter 2012. Nevertheless, there is a long tail in the distribution of doses, extending to approximately 5 mSv year^{-1}, where more attention is required. To date, this has not been performed systematically in Fukushima.

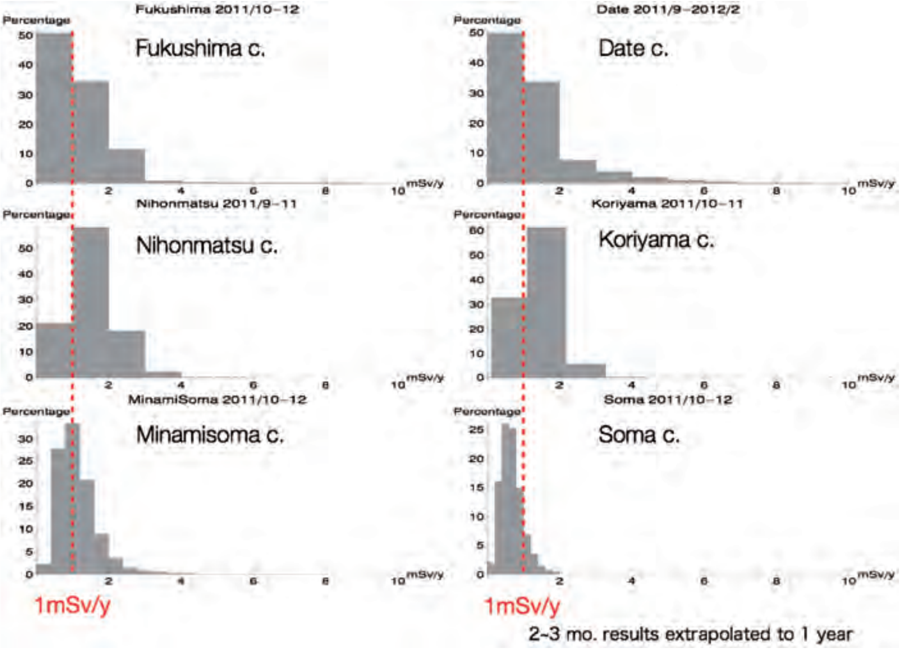

Fig. 7. Results of the 'glass badge' measurements carried out by Fukushima municipalities in Winter 2011.

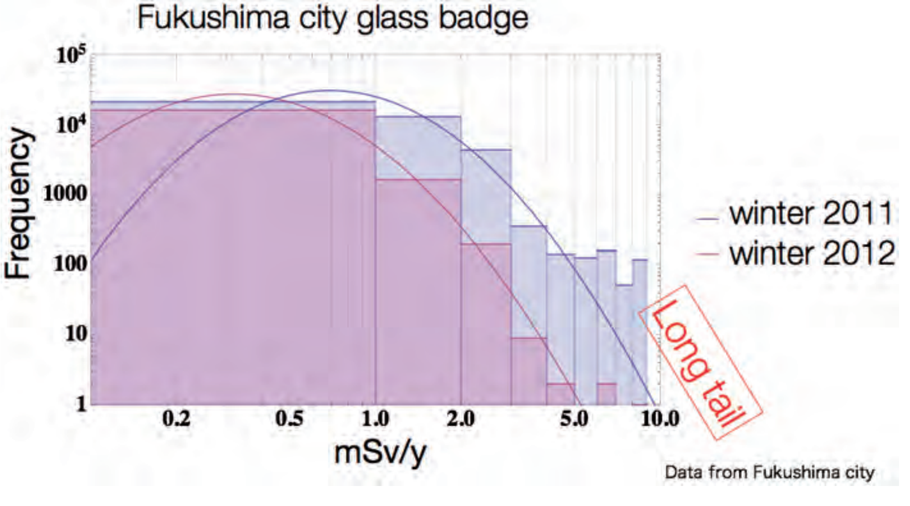

Fig. 8. Comparison of the Fukushima city 'glass badge' results for Winter 2011 (blue) and Winter 2012 (red), presented using a log-log scale.

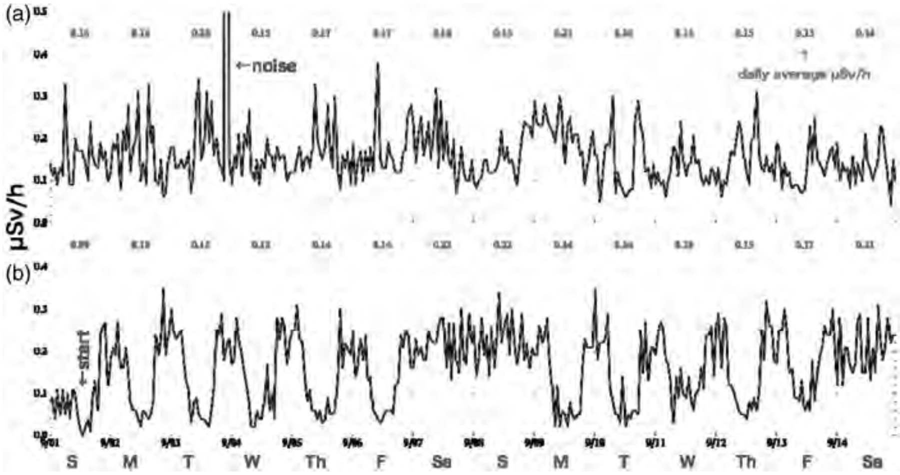

Fig. 9. One-hour integrated dose recorded by personal dosimeters. (A) A farmer who returned recently to the former 20-km-exclusion zone in Tamura city. (B) A school teacher in Fukushima city.

The ‘glass badge’ dosimeters are useful for identifying people at higher risk, but as they are typically worn for 2–3 months, it is difficult to relate the behaviour of each person to the integrated dose. This is why the use of a solid-state personal dosimeter is currently being promoted, which is capable of recording 1-h integrated dose for up to 1 year (AIST, 2012). Initially, the plan was to use this device together with a GPS; however, it was found to be sufficient to use a graph (Fig. 9), and discuss the result with the resident. If an interview is performed within 2–3 weeks of wearing the dosimeter, residents generally remember their whereabouts, and can correlate their behaviour with the dosimeter readings.

4. CONCLUSIONS

Internal and external doses were considered in Fukushima prefecture following the accident at Fukushima Daiichi nuclear power plant. Internal contamination was much lower than predicted initially, with radiocaesium being undetectable in 99% of residents sampled. Risks from external exposures were higher than risks from internal exposures, although most were less than 1 mSv year^{-1}. Whilst average doses remain low in both cases, it is apparent that some residents are being exposed to higher-than-average risks, and it is these members of the population who need to be identified and followed-up. Establishing lines of communication between residents and local medical staff, between central government and municipalities, and with experts will help to develop awareness among residents about exposures and how to reduce them in the future.

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