Comprehensive whole-body counter surveys of Miharu-town school children for three consecutive years after the Fukushima NPP accident

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Abstract: Comprehensive whole-body counter surveys covering over 93% of the school children between the ages of 6 and 15 in Miharu town, Fukushima Prefecture, have been conducted for three consecutive years, in 2011, 2012 and 2013. Although the results of a questionnaire indicate that approximately 60% of the children have been regularly eating local or home-grown rice, in 2012 and 2013 no child was found to exceed the $^{137}$Cs detection limit of 300 Bq/body.

Keywords: Fukushima Dai-ichi accident, radioactive cesium, whole-body counting, committed effective dose

In our previous paper1) based on the whole-body-counter (WBC) measurements (n = 32, 811), we reported that the internal exposure levels of residents of Fukushima and surrounding prefectures are much lower than initially estimated from the soil deposition density of radiocesium and the knowledge of post-Chernobyl accident studies. The $^{137}$Cs detection frequency was shown to be 1.0% (0.09% among children), and even for those who had detectable-level of radiocesium in their bodies, the estimated committed effective doses (CEDs) were less than 1 mSv/y. These results were referred to in the recently-published UNSCEAR report,2) as one of a few in vivo results published in peer-reviewed journals by the end of 2013.

Also presented therein were the results of comprehensive WBC screening measurements of school children in the town of Miharu, located 50 km west of Fukushima Dai-ichi nuclear power plant (NPP). The measurements were conducted at the request of the Miharu-town school board.

In the first survey, conducted in the fall-winter of 2011, 54 children out of 1,494 (coverage 94.3%) had detectable level of $^{137}$Cs,** while in the second survey, carried out in the fall of 2012, no child out of 1,383 (coverage 95.0%) exceeded the detection limit. The results of most internal contamination surveys of Fukushima residents indicate contamination levels which are lower than initially feared; our surveys showed that such results were plausible even when sampling bias has been eliminated.

In the present paper, the results of the third survey carried out in the fall of 2013 (coverage 93.4%) are reported, together with the results of a questionnaire filled out by all of the participating children or their parents before undergoing WBC measurement. The study was approved by the Ethics Committee of the University of Tokyo.

As before, a whole-body counter (FASTSCAN Model 2251, Canberra Inc.) installed at the Hirata Central Hospital in Fukushima Prefecture, located 45 km southwest of Fukushima Dai-ichi NPP was used. The detection limits were 300 Bq/body for both $^{134}$Cs and $^{137}$Cs following a 2-minute scan. For subjects shorter than 110 cm in height, a platform of 20 cm was used to adjust the height, and for those between 110 cm and 125 cm, a platform of 12 cm was

** As discussed in Ref. 1, some of these detections may have been caused by surface (clothes) contamination.

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used, as recommended by the manufacturer. In the 2012 and 2013 measurements, all subjects changed into a hospital gown in order to eliminate confounding from surface contamination of clothing, but this was not the case in 2011.

The WBC was calibrated on November 8, 2013, by a team of National Institute of Radiological Sciences using four sets of BOMAB (BOttle MAinnkin ABsorber) phantoms ($^{60}$Co, $^{137}$Cs, $^{133}$Ba and water, manufactured by Japan Radioisotope Association), and the overall efficiency was found to be accurate within 10%.

Figure 1 shows the age distribution of the subjects measured in the winter of 2011 (gray bars). Of these children, those who graduated or left the town are indicated by dashed bars, while the white bars indicate children who were newly enrolled in 2012. This graph shows that the mobility of Miharu children is rather low.

The results of the comprehensive study of the Miharu-town school children are summarized in Table 1. As shown, all the 1,338 children measured in 2013 (coverage 93.4%) were tested negative, i.e., the radiocesium level was below the detection limit.

Table 1. WBC measurement results breakdown for Miharu-town school children (age 6–15). The numbers of children enrolled in schools were published by the school board of Miharu town, which may not match the actual numbers of children attending schools when the WBC measurements were carried out.

| Year | Enrolled | Measured | Coverage | Radiocesium detected | Detection percentage |
|------|----------|----------|----------|----------------------|---------------------|
| 2011i) | 1,585a) | 1,494 | 94.3% | 54 | 3.6% |
| 2012ii) | 1,456b) | 1,383 | 95.0% | 0 | 0.0% |
| 2013iii) | 1,433c) | 1,338 | 93.4% | 0 | 0.0% |

i) Measured between Nov. 24, 2011 and Feb. 2, 2012. No change of clothes.
ii) Measured between Sep. 3, 2012 and Nov. 8, 2012.
iii) Measured between Sep. 2, 2013 and Nov. 29, 2013.

Mondal 3$^3$ is the standard software used in Japan for calculating committed effective doses (CEDs). It indicates that in order to exceed the detection limit of 300 Bq/body, the necessary levels of continuous $^{137}$Cs ingestion would be approximately 3 Bq/day for a 15 year old, 6 Bq/day for a 10 year old, and 10 Bq/day for a 6 year old. The corresponding CEDs of 0.01, 0.02 and 0.04 mSv respectively are much lower than the Japanese-average CEDs incurred by the intake of the naturally-occurring radioisotope $^{40}$K, which is about 0.18 mSv.

It would be reasonable to suspect that the low body burdens detected were the result of Miharu residents avoiding the consumption of locally-grown food, but the result of the questionnaire shows otherwise.

Table 2. Results of the questionnaire to children and/or parents:

| Food & year* | Supermarket | Local or homegrown | Both |
|--------------|-------------|--------------------|------|
| Rice 2012    | 41%         | 58%                | 1%   |
| Rice 2013    | 41%         | 58%                | 1%   |
| Vegetable 2012 | 65%      | 21%                | 14%  |
| Vegetable 2013 | 66%      | 23%                | 11%  |

*This questionnaire was not administered in 2011.

Table 2 shows that nearly 60% of the children have been regularly eating local or home-grown rice, and more than 20% have been eating local or home-grown vegetables. Figure 2 further shows that the “local” percentages are flat across all age bands, and are also consistent between 2012 and 2013. In general, parents with small children are more cautious about the food at home, so that we initially assumed that the “local” percentage would be significantly lower for households with smaller children. Figure 2 does not seem to show such a trend.
Local or home grown
Both

radiocesium. According to the published results,4) of and 2013. No child was found to exceed the 137Cs
conducted for three consecutive years, in 2011, 2012
surveys of Miharu-town school children have been
Fukushima Prefectural Government has been screen-
Fukushima rice is found to be low. Since 2012, the
This is because the radiocesium concentration of
low, despite their regular consumption of local rice.
A “Levels and effects of radiation exposure due to the nuclear accident after the 2011 great east-
Japan earthquake and tsunami”. United Nations.

The questionnaire also asked about fruit, meat,
fish, milk and mushrooms, but most of these were
found to be obtained from supermarkets, which
source a large proportion of their food from beyond
Fukushima Prefecture.

The internal exposure level of Miharu children is
low, despite their regular consumption of local rice.
This is because the radiocesium concentration of
Fukushima rice is found to be low. Since 2012, the
Fukushima Prefectural Government has been screen-
ing every bag of rice harvested in Fukushima for
radiocesium. According to the published results,5) of
the 10,345,689 bags examined in 2012 (each contain-
ing 30 kg), only 71 (0.0007%) exceeded the govern-
ment set limit of 100 Bq/kg. In 2013, 10,960,652 bags
were tested, and 28 (0.0003%) exceeded the limit.

The low level of contamination detected in this
primary staple is clearly an important contributing
factor to the low level of internal contamination
detected so far in Fukushima. The present results are
consistent with the results of other WBC measure-
ments,5)–8) or duplicate-portion studies.9)

In conclusion, comprehensive whole-body counter
surveys of Miharu-town school children have been
conducted for three consecutive years, in 2011, 2012
and 2013. No child was found to exceed the 137Cs
detection limit of 300 Bq/body in 2012 and 2013,
although the results of the questionnaire show that
about 60% of them are regularly eating local or home-
grown rice. The significance of the low contamination
level of food distributed in Fukushima, rice in
particular, for maintaining low Cs body burdens is
thereby highlighted.

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