

## 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  $^{137}\text{Cs}$  detection limit of 300 Bq/body.

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

In our previous paper<sup>1)</sup> 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  $^{137}\text{Cs}$  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,<sup>2)</sup> 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  $^{137}\text{Cs}$ ,\*\* 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  $^{134}\text{Cs}$  and  $^{137}\text{Cs}$  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

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

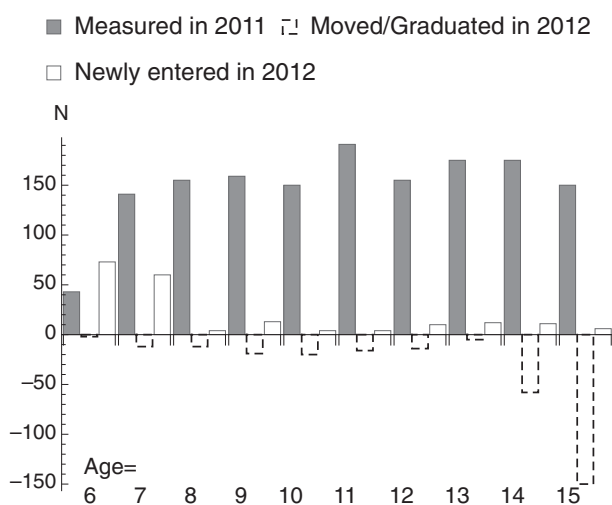


Fig. 1. The age distribution of subjects measured in the winter of 2011 (gray bars). Of these children, those who graduated or left the town are indicated by dashed bars, while the white bars indicate children who were newly enrolled in 2012. This graph shows that the mobility of Miharu children is rather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

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 MANNikin ABsorber) phantoms ( $^{60}\text{Co}$ ,  $^{137}\text{Cs}$ ,  $^{133}\text{Ba}$  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), and how the number of children changed in each age band in 2012. This figure shows that the mobility of the Miharu-town children is rather low, so that nearly the same set of children are measured until their graduation at age 15.

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.

Mondal 3<sup>3</sup>) 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  $^{137}\text{Cs}$  ingestion would be approximately 3 Bq/day for a 15 year old, 6 Bq/day for a 10 year old,

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

	Enrolled	Measured	Coverage	Radiocesium detected	Detection percentage
2011 <sup>i)</sup>	1,585 <sup>a)</sup>	1,494	94.3%	54	3.6%
2012 <sup>ii)</sup>	1,456 <sup>b)</sup>	1,383	95.0%	0	0.0%
2013 <sup>iii)</sup>	1,433 <sup>c)</sup>	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.

a) Based on the Miharu school board statistics as of August 25, 2011.

b) Based on the Miharu school board statistics as of April 1, 2012.

c) Based on the Miharu school board statistics as of April 1, 2013.

Table 2. Results of the questionnaire to children and/or parents: “Where does your household usually obtain rice and vegetables?”

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.

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  $^{40}\text{K}$ , 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 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.

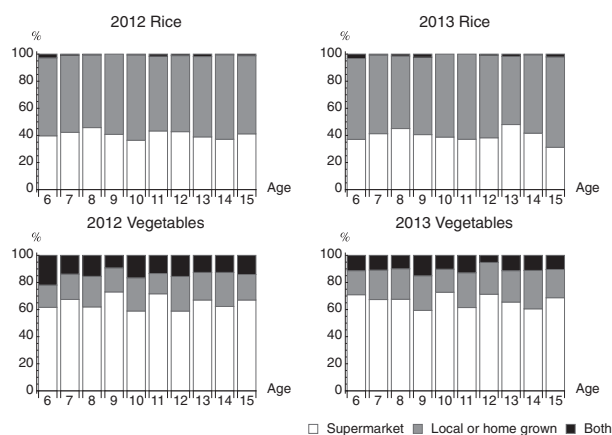


Fig. 2. Food sources by age group: 2012 (left), 2013 (right). The percentages of children who have been regularly eating local or home grown rice or vegetables are shown in gray; The percentages obtained from supermarkets is shown in white. The percentages are stable across the all age groups between 2012 and 2013.

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 screening *every* bag of rice harvested in Fukushima for radiocesium. According to the published results,<sup>4)</sup> of the 10,345,689 bags examined in 2012 (each containing 30 kg), only 71 (0.0007%) exceeded the government 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 measurements,<sup>5)-8)</sup> or duplicate-portion studies.<sup>9)</sup>

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 <sup>137</sup>Cs 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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