PEER REVIEW HISTORY

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ARTICLE DETAILS

TITLE (PROVISIONAL)	Compliance with the proper use of an individual radiation dosimeter among children and the effects of improper use on the measured dose: a retrospective study 18 to 20 months following Japan's 2011 Fukushima nuclear incident
AUTHORS	Nomura, Shuhei; Tsubokura, Masaharu; Hayano, Ryugo; Yoneoka, Daisuke; Ozaki, Akihiko; Shimada, Yuki; Furutani, Tomoyuki; Kanazawa, Yukio; Oikawa, Tomoyoshi

VERSION 1 - REVIEW

REVIEWER	Noboru Takamura Nagasaki University, Japan
REVIEW RETURNED	13-Aug-2015

GENERAL COMMENTS	The aim of the study of authors was to clarify the profiles of children who do not properly use the individual dosimeters in Fukushima. They included schoolchildren who screening program on the evaluation of external radiation exposure in Minamisoma city and identified the factors which is associated with the improper use of the dosimeters and found high frequencies of improper use of dosimeters and several sociodemographic factors such as school level and membership in outdoor sports club were associated with it. On the other hand, they also found that even if the dosimeters are not properly used, evaluation of the external radiation doses may be possible with some accuracy. The manuscript is well written and obtained results are important for appropriate evaluation of external radiation exposure doses in Fukushima and future unexpected radiation disasters. 1. In discussion, authors listed study findings with their interpretations in each paragraph. On the other hand, authors cited only a few manuscripts in the discussion. Authors should carefully revise the discussion through the comparison of their findings with previous studies in discussion for the interpretation of their current results. If authors can not find out similar studies, they should clearly describe as a novelty of this manuscript. 2. Authors described about the CART method for the regression prediction only in "discussion section". Authors should explain about its concept in "data analysis" part of "methods" section. 3. Before re-submitting, authors should ask native speaker to correct English.

REVIEWER	Madan M Rehani Harvard Medical School &

	Massachusetts General Hospital, Boston, USA
REVIEW RETURNED	19-Aug-2015

GENERAL COMMENTS	The topic of radiation dose to population in exposed areas is relevant and is of interest to medical community and public. This paper deals with technical issue of non-use or improper use of dosimeter rather than a medical issue. The title talks about profile of children who improperly use dosimeter and the objectives also state “To identify profiles of children who do not properly use the individual radiation dosimeters…”, but the results presented pertain to extent of usage or compliance and factors associated with improper use or non-use. Thus there is mismatch between title and the contents of the paper. It is not clear if and how this paper adds additional and significant information over the existing knowledge, for example, in paper cited as reference number 12. The conclusions also focus on technical aspects of use of dosimeter as “Well-targeted rigorous instructions on the use of the dosimeter are required, with particular focus on ……..solid evaluation of the radiation exposure may be possible with some accuracy”. The disparities between measured and estimated dose is well known and cited by the authors. It is questionable if this study helps in reducing the disparity or explaining the reasons. The units for the dose in Table 3 are not provided. Page 5 of 32, Line 9: Have the health threats risen or perception thereof? Reference may be provided that validates the use of glass badge dosimeter for such situations and reported accuracies. There is a mention on page 8 or 32 in line 21, but no reference is provided. The Supplementary Table 1 seems out of place as the whole paper is directed at a topic different from that in this Table. The paper may be suitable for a radiation dosimetry or radiation protection journal

REVIEWER	Marcy Beth Grace Division of CBRN Countermeasures Project BioShield U.S. Department of Health & Human Services Assistant Secretary for Preparedness & Response Biomedical Advanced Research & Development Authority USA
REVIEW RETURNED	21-Sep-2015

GENERAL COMMENTS	The reviewer completed the checklist but made no further comments.

REVIEWER	Alexander Romanyukha

	Naval Dosimetry Center, U.S.A.
REVIEW RETURNED	05-Oct-2015

GENERAL COMMENTS	I didn't find any discussion on research ethics (e.g. participant consent, ethics approval). It seems to be important for children. General comment This paper describes design, results and interpretation of the interesting project devoted to measurement of radiation doses of children residing nearby Minamisoma City (located 20–30 km from the Fukushima nuclear plant) with individual dosimeters. The prime aims of the paper are to estimate number of children who were worn dosimeters properly, identify most common mistakes and evaluate effect of non-proper dosimeter wearing. The paper is well written, presented data are original and carried out data analysis seems to be appropriate. From my point of view this paper is worth to publish. Specific comments 1. There is no data on the lost dosimeters. It seems to be surprised that there were no lost dosimeters in this study. 2. Posted dosimeters. It would be interesting to see data from posted dosimeters in schools and open air, if any. 3. Personal dosimeters are typically calibrated using a reference source on a slab phantom which represents a torso of adult man. Did you consider to correct measured doses based on children body size? 4. The reported doses seem to be low. What are a LLD and dose uncertainty of the used dosimeter for three months issue period? 5. Did you measure only photon deep dose equivalent (no neutrons)? 6. How was mean air dose rate measured?

VERSION 1 – AUTHOR RESPONSE

Response to Reviewer #1
General comments
1. The aim of the study of authors was to clarify the profiles of children who do not properly use the individual dosimeters in Fukushima. They included schoolchildren who screening program on the evaluation of external radiation exposure in Minamisoma city and identified the factors which is associated with the improper use of the dosimeters and found high frequencies of improper use of dosimeters and several sociodemographic factors such as school level and membership in outdoor sports club were associated with it. On the other hand, they also found that even if the dosimeters are not properly used, evaluation of the external radiation doses may be possible with some accuracy. The manuscript is well written and obtained results are important for appropriate evaluation of external radiation exposure doses in Fukushima and future unexpected radiation disasters.

Thank you very much for your valuable review and your insightful comments on our paper. We have carefully edited the text accordingly.

Major comments
1. In discussion, authors listed study findings with their interpretations in each paragraph. On the other hand, authors cited only a few manuscripts in the discussion. Authors should carefully revise the discussion through the comparison of their findings with previous studies in discussion for the

interpretation of their current results. If authors can not find out similar studies, they should clearly describe as a novelty of this manuscript.

We appreciate your suggestions. Unfortunately, to the best of our knowledge, there are no similar studies primarily addressing the improper use of individual radiation dosimeters. Therefore, to clearly illustrate the novelty of this study, we added the following sentence in the first paragraph of the discussion section:

"This is the first study evaluating compliance with the proper use of an individual radiation dosimeter in children and the effects of improper use on the measured dose after a major radiation-release incident." (line 12, page 14)

2. Authors described about the CART method for the regression prediction only in “discussion section”. Authors should explain about its concept in “data analysis” part of “methods” section.

According to your suggestions, we described the assessment methods of the regression prediction accuracy in the methods section and showed the results of the assessment in the results section as follows:

"To assess the prediction accuracy of the Tobit model that we constructed for estimating the ‘expected’ dose in children who improperly used the Glass Badges, we built another prediction model using the classification and regression tree (CART) method. The CART method is a non-parametric method that does not require any assumptions regarding the distributions of the input data.[24] Then, we compared the pseudo R-squared values from the CART model pruned by ten-fold cross-validation with the deviance criterion rule to those from a Tobit model in order to examine which model provide a better dose prediction." (line 6, page 11)

"The pseudo R-squared values from the Tobit model were compared with those from a CART model pruned by ten-fold cross-validation with the deviance criterion rule to assess the prediction accuracy of the Tobit model. As a result, we obtained values of 0.86 for the Tobit model and 0.70 for the CART model, indicating that the Tobit model was slightly more predictive." (line 21, page 13)

3. Before re-submitting, authors should ask native speaker to correct English.

Thank you very much for your suggestion. This paper has now been proofread thoroughly for English language.

Response to Reviewer #2
General comments
1. The topic of radiation dose to population in exposed areas is relevant and is of interest to medical community and public. This paper deals with technical issue of non-use or improper use of dosimeter rather than a medical issue.

We appreciate your careful review of our article. We have edited the text according to your helpful comments.

Major comments
1. The title talks about profile of children who improperly use dosimeter and the objectives also state “To identify profiles of children who do not properly use the individual radiation dosimeters…”, but the results presented pertain to extent of usage or compliance and factors associated with improper use or non-use. Thus there is mismatch between title and the contents of the paper.

We greatly appreciate your concerns about the paper title. We agree with your point and edited the paper title as follows:

"Compliance with the proper use of an individual radiation dosimeter among children and the effects of improper use on the measured dose: a retrospective study 18 to 20 months following Japan's 2011 Fukushima nuclear incident" (line 2, page 1)

2. It is not clear if and how this paper adds additional and significant information over the existing knowledge, for example, in paper cited as reference number 12. The conclusions also focus on technical aspects of use of dosimeter as "Well-targeted rigorous instructions on the use of the dosimeter are required, with particular focus on ……..solid evaluation of the radiation exposure may be possible with some accuracy". The disparities between measured and estimated dose is well known and cited by the authors. It is questionable if this study helps in reducing the disparity or explaining the reasons.

Nomura et al. (2015), cited as reference number 12, primarily addressed inaccuracy and uncertainties in the Japanese government's dose reconstruction model. On the other hand, in this study, we focused on compliance with proper use of the individual radiation dosimeter used for direct dose measurement as well as the effects of improper use on the measured dose. We found high frequencies of improper dosimeter use and identified the factors associated with the improper use. In addition, we demonstrated that even if the dosimeters are not properly used, evaluation of the external radiation dose could be possible with some accuracy. Therefore, reducing the disparity between the measured and estimated/reconstructed dose was outside the scope of our study. All of our findings are new and important for appropriate evaluation of doses measured by individual radiation dosimeters in Fukushima and for future unexpected radiation disasters.

To clearly illustrate the novelty of this study, we added the following sentence in the first paragraph of the discussion section:

"This is the first study evaluating compliance with the proper use of an individual radiation dosimeter in children and the effects of improper use on the measured dose after a major radiation-release incident." (line 12, page 14)

3. The units for the dose in Table 3 are not provided.

Thank you very much for identifying this error. We have corrected Table 3 as follows:

Table 3 Comparison of the measured dose and regression estimates of dose [mSv] (n = 1,518)

	Measured dose (SD)	Estimated dose (SD)	Ratios (SD)
Overall	0.33 (0.11)	0.33 (0.09)	0.99 (0.35)
Time period			
To school	0.37 (0.14)	0.32 (0.07)	1.13 (0.43)**
At school	0.32 (0.10)	0.33 (0.09)	0.98 (0.31)
At home	0.33 (0.11)	0.33 (0.09)	0.99 (0.34)
Outdoors	0.32 (0.10)	0.33 (0.09)	0.97 (0.33)*
At bedtime	0.33 (0.11)	0.33 (0.09)	0.99 (0.35)

*p < 0.05, **p < 0.01: paired t-test

4. Page 5 of 32, Line 9: Have the health threats risen or perception thereof?

At present, no acute radiation-related health damages have been reported. To avoid confusing

readers, we should have used 'concerned' rather than 'threats' in this context. We corrected the text as follows:

"After a major nuclear incident, radiation exposure is a public health issue.[1-2] Following Japan's Fukushima Daiichi Nuclear Power Plant incident, triggered by the Great East Japan Earthquake and subsequent tsunami on 11 March 2011, health concerns have arisen in the radiation-contaminated areas" (line 2, page 5)

5. Reference may be provided that validates the use of glass badge dosimeter for such situations and reported accuracies. There is a mention on page 8 or 32 in line 21, but no reference is provided.

Thank you very much for your suggestions. We provided a reference to the performance specifications of the Glass Badge, including accuracy.1

6. The Supplementary Table 1 seems out of place as the whole paper is directed at a topic different from that in this Table.

Thank you very much for your suggestions. I deleted Supplementary Table 1 and described the variables included in the estimation model in the text accordingly.

"The estimated model included the following variables: air dose rate at home and on school grounds, gender, dwelling area, school-level, floor of room where most daytime hours were spent at home, floor of sleeping place, seat position in the classroom, and hours spent outdoors after school and on holiday." (line 8, page 13)

Response to Reviewer #3
General comments
1. Very interesting article. I found it to be informative and well written.

Thank you very much for your valuable review.

Response to Reviewer #4
General comments
1. This paper describes design, results and interpretation of the interesting project devoted to measurement of radiation doses of children residing nearby Minamisoma City (located 20–30 km from the Fukushima nuclear plant) with individual dosimeters. The prime aims of the paper are to estimate number of children who were worn dosimeters properly, identify most common mistakes and evaluate effect of non-proper dosimeter wearing. The paper is well written, presented data are original and carried out data analysis seems to be appropriate. From my point of view this paper is worth to publish.

We appreciate your review of our article. We have carefully edited the text according to your helpful comments.

Major comments
1. I didn't find any discussion on research ethics (e.g. participant consent, ethics approval). It seems to be important for children.

Thank you very much for your concerns about the research ethics. The information of ethics approval was included in the footnotes section. The ethics committee of the Minamisoma Municipal General

Hospital agreed that written informed consent was not necessary for participants in this study.

2. There is no data on the lost dosimeters. It seems to be surprised that there were no lost dosimeters in this study

We asked the city office about lost dosimeters and were notified that less than 1% of those who received dosimeters from the city office lost them. However, these individuals were not counted as screening participants in our study and therefore had no influence on the study findings and conclusion.

To clarify this, we added the following sentence to the methods section.

"Note that a few dosimeters were lost during the program, and we did not include those individuals who lost their dosimeters in this study." (line 15, page 7)

3. Posted dosimeters. It would be interesting to see data from posted dosimeters in schools and open air, if any.

Unfortunately, there is no such dosimeter posted in the schools under consideration.

4. Personal dosimeters are typically calibrated using a reference source on a slab phantom which represents a torso of adult man. Did you consider to correct measured doses based on children body size?

In this study, we did not adjust the measured dose for the body size of an individual and directly used the measured dose as his/her effective dose. The Glass Badge measures dose in terms of a dose equivalent at a tissue depth of 1 cm [Hp(10)], and the Hp(10) value measured under the geometrical conditions in Fukushima is known to be comparable with the effective dose obtained using isotropic or rotational irradiation geometries. It is also known that there is a possibility that the body size of an individual affects the accuracy of an individual radiation dosimeter by, at maximum, about 10%, depending on the product type as well as the irradiation geometry in an environment.2 However, given the small percentages, this potential body-size-dependent inaccuracy does not influence our conclusions that the error (i.e., the difference between the measured dose and regression estimates of the ‘expected’ dose) generated by improper use of the Glass Badge was very small and that, even if the dosimeters are not properly used, solid evaluation of the radiation exposure may be possible with some accuracy.

As we agree this is one limitation of this study, we added the following sentences in the discussion section:

"In addition, in this study, we did not adjust the measured dose for the body size of an individual and directly used the measured dose as his/her effective dose. It is known that there is a possibility that the body size of an individual affects the accuracy of an individual radiation dosimeter by, at maximum, about 10%, depending on the product type as well as the irradiation geometry in the environment.[25] However, given the small percentages, this potential body-size-dependent inaccuracy does not influence our conclusions." (line 18, page 17)

5. The reported doses seem to be low. What are a LLD and dose uncertainty of the used dosimeter for three months issue period?

The lower limit of the measurable dose of the Glass Badge was 0.1 mSv, while the minimum dose in the study participants was 0.14 mSv. The range of accuracy of the Glass Badge measurement of the

cumulative dose in 35 days was ±4%.1

To clarify this information, I edited the text in the methods section as follows:

" Note that the lower limit of the measurable dose of the Glass Badge was 0.1 mSv and the range of accuracy of the Glass Badge measurement of the cumulative dose in 35 days was ±4%.[17]" (line 11, page 8)

6. Did you measure only photon deep dose equivalent (no neutrons)?

Yes, we did. Dose was measured in terms of a dose equivalent at a tissue depth of 1 cm [Hp(10)].

7. How was mean air dose rate measured?

The mean air dose rates at a height of 1 m above the ground at home, on the school grounds, at the main gate, and at the entrance/exit of the school were 0.49, 0.11, 0.22, and 0.17 μSv/h, respectively. We added this information in the text as follows:

"The mean air dose rates at a height of 1 m above the ground at home, on the school grounds, at the main gate and at the entrance/exit of the school were 0.49, 0.11, 0.22, and 0.17 μSv/h, respectively." (line 7, page 12)

Bibliography

1. Chiyoda Technol Corporation . Glass Badge Technical Specification [Japanese]. Tokyo: Chiyoda Technol Corporation, 2012.

2. National Institute of Radiological Sciences. Additional research on the characteristics of an individual radiation dosimeter pertaining to the Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Plant accident - consideration of the estimation method of individual dose in children. http://www.nirs.go.jp/information/event/report/2015/03_16/houkokusho5.pdf. Accessed 10 Oct 2015.

VERSION 2 – REVIEW

REVIEWER	Alexander Romanyukha Naval Dosimetry Center, United States of America
REVIEW RETURNED	27-Oct-2015

GENERAL COMMENTS	The reviewer completed the checklist but made no further comments.