Increased Risk of Developing Anemia Among 1 Older Survivors of the Great East Japan Earthquake: A Longitudinal Observational Study

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Research article

Keywords: anemia, disaster areas, older adults, relocation, survivors

Posted Date: August 31st, 2020

DOI: https://doi.org/10.21203/rs.3.rs-60244/v1

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ABSTRACT

Background: This study investigated the association between residential status and the risk of developing anemia in older adult survivors of the 2011 Great East Japan Earthquake.

Methods: A total of 3,244 individuals (mean age: 72.2 years) free from disability or anemia at baseline who participated in at least one follow-up questionnaire between 2012 and 2015 in the Research project for prospective Investigation of health problems Among Survivors of the Great East Japan Earthquake were included. Residential status was categorized into “no relocation,” “relocated to temporary housing,” or “relocated to other residences.” Anemia was defined as hemoglobin concentrations <13.0 g/dL in males and <12.0 g/dL in females. Multilevel regression models with repeated measurements were used to estimate the adjusted odds ratio (OR) and 95% confidence intervals (CIs) of the association between residential status and the risk of anemia.

Results: During the survey, 313 men and 387 women developed anemia at least once. Women who were forced to live in temporary housing had a significantly higher risk of developing anemia (OR 1.42, 95% CI 1.09–1.85). Among the men, no association between the development of anemia and residential status was observed.

Conclusions: The development of anemia may reflect an increased vulnerability to future health outcomes in older adults. Continued monitoring and health support for older people forced to live in temporary housing is necessary to prevent future health deterioration.

Keywords: anemia, disaster areas, older adults, relocation, survivors

BACKGROUND

Anemia is quite frequently diagnosed in older individuals, and the prevalence of anemia increases with age[1-4]. The etiology of anemia is not well established; however, recent evidence has indicated that anemia reflects poor health status and an increased vulnerability to adverse outcomes in older persons, such as the increased risk of all-cause mortality[5-8], functional decline[9-11], cognitive decline and dementia[12, 13], and increased fracture risk[14].

In March 2011, a massive earthquake and tsunami caused extensive damage in eastern Japan[15]. Most survivors lost not only family members and their property and land but were also disconnected from existing communities after being relocated to temporary or other housing in an inconvenient area. Concurrently, there is concern of an increased disability risk for older people, particularly in the serious damage disaster-stricken area[16, 17]. Implementing early preventative measures before irreversible hypofunction and organ damage may contribute to preventing future deterioration in functional and cognitive impairments[18, 19]. This includes understanding health risks at early stages and providing support according to changes in the residential status of survivors. Several factors have been identified as a risk for anemia[20, 21], however, until now, no report has examined the risk of anemia among older adults living in disaster-stricken areas while considering the post-disaster living situation.

This study investigated whether post-disaster residential status is associated with an increased risk of anemia among older adult survivors of the Great East Japan Earthquake (GEJE).

70 **METHODS**

71 **Study Design**

72 This study included participants in the Research project for prospective
73 Investigation of health problems Among Survivors of the GEJE (RIAS). The RIAS is a
74 longitudinal observational study whose details have been described elsewhere[22]. In
75 brief, all residents living in the disaster-stricken area who wished to participate were
76 allowed to receive annual health checkups in the RIAS. We sent questionnaires and
77 notifications of our health survey to all residents of Yamada town, Ohtsuchi town, and
78 Rikuzentakata city in Iwate Prefecture in the Tohoku district of northeastern Japan who
79 were ≥18 years old in September 2011, which was six months after the disaster, and
80 in January 2012. We used a standard self-administrated questionnaire to collect
81 information on participant health and lifestyle habits during scheduled health
82 checkups[23]. Follow-up surveys were repeated annually. This study was approved
83 by the Institutional Review Board of Iwate Medical University (approval no. H23-69).
84 The participants were informed of the potential risks and benefits of the study, and all
85 provided written informed consent.

86 **Study Population**

87 Figure 1 shows the flow of the 10,560 people ≥18 years old with baseline health
88 data and the 10,203 (96.6%) who participated in the RIAS study. Of the 4,743 RIAS
89 participants who were ≥65 years old, 1,041 were excluded for the following reasons:
90 incomplete questionnaires (n = 4), not fully independent (a certified need for
91 certification of long-term care insurance (LTCI); n = 175), and had anemia (a
92 hemoglobin concentration <12 g/dL in women and <13 g/dL in men, and/or undergoing
93 treatment for anemia: n = 862) [24]. For this analysis, we limited the sample to 3,232

of the remaining 3,702 eligible participants with at least one completed follow-up questionnaire between 2012 and 2015 (mean age 72.2 years; men, n = 1390 (43.0%)). Supplementary table 1 displays the differences in characteristics between the 3,232 participants who were followed-up and the 470 who were not followed-up in the present analysis. Both male and female participants who were not followed-up were significantly older, and after adjustment for age, included a significantly higher proportion of smokers. Compared to the men who were followed-up, those who were not followed-up were more likely to have lower serum albumin levels and a lower frequency of fruit intake, whereas the women who were not followed-up had a lower social network level than the women who participated in the follow-up survey.

Residential status

Since the query on residential status changed according to the stage of the disaster, we revised these responses into three categories—no relocation, relocated to temporary housing, or relocated to other residences—based on two questions: “How many times were you displaced after the disaster? (0, 1, 2, or >2 times)” and “Which residence do you mainly live in now?” (responses obtained in 2011: own home, home of relative or acquaintance, prefabricated temporary housing, evacuation center, rented accommodation or new home, or other residence; responses obtained in 2015: own home, home of relative or acquaintance, prefabricated temporary housing, private temporary housing, rented accommodation, reconstructed in the same place, reconstructed in another place, or other residence).

Anemia

Fasting venous blood samples were obtained from the participants at least 4 hours after the last meal and while in a sitting position. Blood hemoglobin was

118 analyzed using the sodium lauryl sulfate-hemoglobin method, and red blood cell and
119 hematocrit levels were determined by the sheath flow direct current detection method.
120 Anemia was defined using the World Health Organization definition as hemoglobin
121 concentrations below 13.0 g/dL in men and below 12.0 g/dL in women[24] and/or
122 undergoing treatment for anemia. The values for the mean corpuscular volume (MCV)
123 were calculated according to the following formula: MCV (fL) = hematocrit (%) × 10/red
124 blood cell count (millions/mm3 blood). MCV is defined a priori as microcytic if <80 fL,
125 normocytic if between 80 and 100 fL, and macrocytic if >100 fL.

126 **Other characteristics**

127 We selected the following potential confounding variables based on our
128 previous studies[22]: age, sex, municipality, standard of living, body mass index (BMI),
129 history of stroke and myocardial infarction, hypertension, diabetes mellitus,
130 hypercholesterolemia, current smoking, current drinking, dietary intake[22, 25],
131 habitual exercise[26], sedentary lifestyle, self-rated health, psychological distress[27-
132 29], and social networks[30, 31]. These variables were obtained from the
133 questionnaire and standardized anthropometric and biochemical measurements. We
134 assessed the standard of living by asking “How do you feel about your current
135 economic situation?” The four responses were classified into two groups: difficult
136 (severely difficult, difficult, and slightly difficult) and acceptable. BMI (kg/m2) was
137 stratified as <18.5, 18.5–24.9, and ≥25.0 kg/m2. Current smoking and alcohol drinking
138 (yes/no) were obtained by asking “Are you a habitual smoker/drinker?” Hypertension
139 was defined as a blood pressure of ≥140/90 mmHg and/or undergoing treatment for
140 hypertension by self-reporting. Diabetes mellitus was diagnosed as a random blood
141 glucose level ≥11.11 mmol/L (≥200 mg/dL), an HbA1c ≥6.5%[32], and/or undergoing
142 treatment for diabetes mellitus. Hypercholesterolemia was defined as a total

143 cholesterol level ≥5.68 mmol/L (≥220 mg/dL) and/or undergoing treatment for
144 hypercholesterolemia. Renal function was estimated by calculating the eGFR using a
145 modified Japanese equation based on inulin clearance, which is as follows: eGFR
146 (ml/min/1.73 m2) = 194 × (serum creatinine in enzymatic method)−1.094 × age−0.287
147 (×0.739, if women)[33]. Proteinuria was considered for a dipstick result from the spot
148 urine of ≥1+, corresponding to a urinary protein level of >30 mg/dl. Chronic kidney
149 disease (CKD) was defined as an eGFR of <60 ml/min/1.73 m2, positive
150 proteinuria[34] and/or undergoing treatment. Respondents who said that they
151 normally sit or lie down three or more hours/day were classified as having a sedentary
152 lifestyle.

153 **Statistical Analysis**

154 The analysis was performed separately for men and women because of the
155 significant interaction between residential status and sex (P <.001). Differences in
156 baseline demographic, lifestyle, and psychosocial characteristics according to
157 residential status in men and women were compared using a one-way analysis of
158 variance for continuous variables and the chi-square test for categorical variables. The
159 association of residential status with the development of anemia was analyzed in
160 multilevel regression models with repeated measurements nested within
161 individuals[35, 36]. The major advantages of using multilevel models in longitudinal
162 studies are that the technique takes into consideration the correlation between serial
163 measures obtained in the same individuals and the missing observations, which allows
164 all available data on each individual to be used. The analysis was completed using the
165 GLIMMIX procedure in SAS (version 9.4; SAS Institute, Cary, NC, USA). The results
166 are presented as odds ratios (ORs) and 95% confidence intervals (CIs) for each
167 comparable group, indicating the change in follow-up over time. The reference group

168 was separately defined for each risk factor in question. To determine the best model,
169 how each variable independently affected the risk of anemia was determined using
170 age- and BMI-adjusted analyses, and only variables with a P-value of ≤.20 were
171 included in the final models. The putative confounding variables were age (continuous),
172 BMI (<18.5 or ≥25.0 vs 18.5–24.9 kg/m2), diabetes mellitus (yes vs no), CKD (yes vs
173 no), current smoker (yes vs no), current drinker (yes vs no), protein-related food intake
174 (<2 vs ≥2 times/d), vegetable intake (<2 vs ≥2 times/d), dairy product intake (<1 vs ≥1
175 time/d), and poor self-rated health (yes vs. no) for men; and age, BMI, municipality
176 (Ohtsuchi or Rikuzentakata vs Yamada), history of myocardial infarction (yes vs no),
177 hypercholesterolemia (yes vs no), CKD (yes vs no), current drinking habits, physical
178 inactivity (<23 vs ≥23 METs·hour/week), protein-related food intake, fruit intake (<1 vs
179 ≥1 time/d), dairy product intake, and poor self-rated health for women.

180 Several sensitivity analyses were performed to identify influential risk factors
181 during follow-up[37, 38]: participants who were certified as needing LTCI, those with a
182 weight-loss of <2 kg in the preceding six months, and those with hypoalbuminemia
183 (serum albumin levels ≤3.8 g/dL) were excluded. Possible heterogeneity in the
184 relationship between the subgroups was tested by introducing a multiplicative term
185 into the main effect models. A subgroup analysis was further performed to evaluate
186 the effects of residential status on the risk of developing anemia. All statistical analyses
187 were performed using SAS, version 9.4 (SAS Institute, Inc., Cary, NC). For all analyses,
188 statistical significance was considered a two-tailed P <.05.

RESULTS

Anemia incidence

During the five years following the GEJE, 524 men (37.7%) and 709 women (38.5%) reported developing anemia at least once. In each follow-up survey year, the incident cases of anemia/number of participants in men were as follows: 89 (7.3%)/1226 in 2012, 118 (9.8%)/1081 in 2013, 119 (10.4%)/1150 in 2014, and 131 (11.8%)/1106 in 2015; in women, these values were: 135 (8.2%)/1649 in 2012, 164 (10.4%)/1583 in 2013, 157 (10.4%)/1512 in 2014, and 175 (12.0%)/1458 in 2015. Supplementary Table 2 indicates the percentage of hemoglobin levels according to survey year among the participants who completed all five years of the survey by sex, which shows that almost all cases of anemia were mild manifestations. Among the 885 male participants who attended all health checkups from 2011 to 2015, there were 57 (6.4%) incident cases of anemia in 2012, 78 (8.8%) in 2013, 92 (10.4%) in 2014, and 106 (12.0%) in 2015, whereas among the 1,192 women who attended all health checkups, there were 91 (7.6%) incident cases of anemia in 2012, 121 (10.2%) in 2013, 115 (9.7%) in 2014, and 138 (11.6%) in 2015. Of those who reported developing anemia, only 7.5% of participants over all five years had macrocytosis anemia, and 0.5% had microcytosis anemia.

Characteristics of the participants according to residential status

Table 1 shows the baseline characteristics of the participants according to residential status. Compared to living in other residences, those who relocated to temporary housing had a worse standard of living, less physical activity, a more sedentary lifestyle, and a higher prevalence of psychological distress. Men had a higher prevalence of history of stroke, myocardial infarction, and diabetes mellitus,

were more likely to be smokers and drinkers, and had a poor dietary balance, particularly regarding vegetable and fruit intake, than women, whereas women had less physical activity and more psychological distress than men.

Multivariable Adjusted Analyses

The multivariate analyses of the associations between residential status and the development of anemia are summarized in Table 2 for men and Table 3 for women. Only women who relocated to temporary housing displayed a significant and independent association with an increased risk of developing anemia. Women who did not relocate and those who relocated to other residences did not display an association with the risk of developing anemia. The results from an additional analysis performed with only those participants who participated in all the health checkups from 2011 through 2015 did not alter, and an increased risk of developing anemia among women who relocated to temporary housing was seen (OR, 95% CI:1.48, 1.08–2.04; data not tabulated). These associations were not observed among men living with every residential status.

Sensitivity Analyses

The risk of anemia among women living in temporary housing still remained significant after excluding women with preclinical cases during follow-up surveys, i.e., women who were certified as needing LTCI (risk for anemia after excluding women with cases; among women living in temporary housing: 1.34, 1.02–1.76), who reported having lost weight (1.65, 1.24–2.19), and who had hypoalbuminemia (1.42, 1.04–1.98). Even when women with CKD were excluded, which was known as the main cause of senile anemia, the significant risk of anemia among women living in temporary housing remained unchanged (1.42, 1.03–1.95). The risk of anemia among women living in

temporary housing was not altered after excluding women who were undergoing treatment for anemia (1.43, 1.10–1.86).

In this study, the risk analysis for anemia showed no significant interactions between age, lifestyle, underlined diseases, and dietary intakes in the risk of anemia (P >.50). A risk of anemia was only present in women older than 75 years of age and women who reported a normal BMI (<25 kg/m2).

Other characteristics associated with the risk of developing anemia

Among other characteristics that were examined as potential confounding factors, older age, diabetes mellitus, CKD and lower self-rated health for men; and older age, lower BMI, history of myocardial infarction, CKD and lower self-rated health for women were significantly associated with the risk of anemia (Supplementary Table 3). For food intakes, lower frequencies of protein-related foods and dairy products were marginally but not significantly associated with the risk of developing anemia. Meanwhile, current smokers and physical inactivity among women and current drinkers among both men and women were significantly associated with a lower risk of anemia.

DISCUSSION

To the best of our knowledge, this is the first study to describe the risk of anemia among survivors who were forced to live in temporary housing due to the GEJE disaster. Only women living in temporary housing in the post-disaster setting had a significantly increased risk of anemia, particularly older women. This significant risk remained after excluding preclinical cases during the follow-up. In men, no associations were found between the development of anemia and residential status.

In this study, a slightly lower percentage of anemia was reported than the prevalence reported in previous studies in the general population of Japan, even though the typical chronic comorbidities of these aging groups have similar tendencies[39]. Anemia with hemoglobin levels below 10 g/dl was rarely present in the participants, indicating that those who suffered from severe health conditions did not participate in this study.

Poor living environments and conditions among older women who were forced to live in temporary housing may have increased the risk of anemia, independent of other risk factors such as aging and underlying diseases. Several etiological-causes of anemia were reported in the review articles [20, 21], i.e., aging, iron deficiency, impaired iron delivery and utilization, chronic inflammation, chronic disease, and unexplained. Considering that most of the anemic persons in this study had mild and normocytic anemia, aging factors, but not nutritional deficiency, may be affected by hemoglobin levels reduction [40].

In this study, aside from residential status, increasing age and the presence of underlying chronic illnesses were independently associated with

the risk of anemia. Senile normocytic anemia is often suggested as a chronic disease that impairs renal function[40]; it is estimated that anemia caused by chronic diseases was found in approximately 25% of the community-dwelling older adults in the NHANES[21]; two or more chronic medical conditions such as CKD, congestive heart failure, rheumatoid arthritis, and recent surgery were identified among anemic older adults [4, 40, 41]. Although the presence of CKD was considered an independent risk factor for developing anemia in the present study, the significant anemia risk among women living in temporary housing remained unaltered after excluding women with preclinical cases and those with CKD.

Previous studies have pointed out that the risk of physical and cognitive decline among older people is higher in temporary housing, i.e., in the seriously damaged and disaster-stricken areas [16, 17]. Given that other residential statuses did not pose the risk of developing anemia, it may be suggested that older people living in temporary housing have a higher risk of developing anemia more frequently. Several possible explanations for the risk of temporary housing can be considered. Compared with other types of residences, temporary housing is constructed on unused or undeveloped land, so no facilities or public transport services are available in the surrounding areas. Therefore, those who were living in temporary housing face more difficulties in terms of food access [42] as well as walking[22] as a result of being restricted to the surround areas. Indeed, a higher prevalence of older adults living in temporary housing reported a lack of physical activity or a sedentary lifestyle than those in other forms of living in the present study. Previous studies have pointed out that residents of temporary housing have fewer meals per day[43] and have low dietary intakes of fruits and vegetables, meat, soybean products, and dairy products compared to other residents[22, 44, 45]. Decreasing food, particularly decreasing

intake of protein-related foods is considered to be related to loss of skeletal muscle mass, which leads to a greater risk of anemia [46] and functional decline [47, 48]. In addition, people living in temporary housing had only a limited and narrow living space and thus did not need to move as much to perform daily chores[22]. A previous study has reported that the longer the distance to retail stores, the higher probability of not going out [42]. A positive association was demonstrated with higher serum Hb levels being associated with better physical performance and muscle strength in previous studies [9, 10]. Although we did not observe an increased independent risk of anemia due to a low frequency of food intake, a lack of exercise, and sedentary lifestyle in the final model, these unfavorable surroundings should not be overlooked. Considering together with the abovementioned factors and the increasing evidence on the association between anemia and physical and cognitive performance in elderly[10, 49], enabling residents living in temporary housing to access facilities and retail stores might be effective for not only preventing anemia but also for preventing future physical and cognitive impairment.

Our study findings should be interpreted in light of some limitations. First, because we collected data at health checkups, the participants may not accurately represent the community in the GEJE area. Survivors with serious psychological and/or physical health problems may not have received health checkups. We excluded those with disabilities or those who had anemia at baseline. Consequently, independent people were more likely to have participated in this study, leading to an underestimation of health problems and future risks. Second, the generalizability of the results in the present study is limited because of the participants restricted to being survivors of the GEJE

only. The community environment of the survivors continues to change each year. Furthermore, the GEJE occurred in highly populated areas with declining populations, birthrates, and a rapidly aging population. Public facilities and transport were unable after the GEJE, and retailers suffered from population loss and closures because of changes in the surrounding area. Providing effective health support and interventions related to the surrounding environment will help early prevention of future health deterioration in Japan's aging population following an increased prevalence of anemia.

CONCLUSIONS

In conclusion, older women with living in temporary housing displayed a significantly increased risk of developing anemia. The development of anemia may reflect an increased vulnerability to future health outcomes in older adults. Continued monitoring and health support for older people forced to live in temporary housing are necessary to prevent future health deterioration. Additional studies of the affected residential areas and the surrounding environment are important for the effective prevention of health deterioration in older adult disaster survivors.

343 **List of abbreviations**

344 BMI: Body Mass Index

345 CKD: Chronic Kidney Disease

346 TC: Total Cholesterol level

347 GEJE: The Great East Japan Earthquake

348 HbA1c: Glycosylated hemoglobin

349 LTCI: certification of Long-Term Care Insurance

350 MCV: Mean Corpuscular Volume

351 METs: Metabolic Equivalents

352 OR: Odds Ratio

353 RIAS: The Research project for prospective Investigation of health problems Among

354 Survivors of the GEJE

355 95% CIs: 95% Confidential Intervals

Declarations

Ethics approval and consent to participate:

In the present study, participants provided written informed consent for participation and publication. This study was approved by the Institutional Review Board of Iwate Medical University.

Consent for publication

Not Applicable

Availability of data and materials:

The data that support the findings of this study are available from the Research project for prospective Investigation of health problems Among Survivors of the Great East Japan Earthquake (Iwate Medical University School of Medicine) but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the Research project for prospective Investigation of health problems Among Survivors of the Great East Japan Earthquake (Iwate Medical University School of Medicine).

Competing interest:

The authors declare that they have no competing interests

Funding

Source of Funding:

This study was supported by Grants for Scientific Research, Ministry of Education, Culture, Sports, Science and Technology, Japan (16H05243),; and A Grant-in-Aid from

the Ministry of Health, Labour and Welfare, Health and Labour Sciences Research Grants, Japan (H23-TokubetsShitei-002; H24-Kenki-Shitei-001, H25-Kenki-Shitei-001(Fukkou)). The role of the funding body is mainly in the study design of the Research Project for Prospective Investigation of Health Problems Among Survivors of the Great East Japan Earthquake and data collection.

Author's contributions:

All of the authors have made substantive intellectual contributions to the study. MT-U developed the study concept; designed the study's analytical strategy; directed its implementation, including quality assurance and control; and prepared the manuscript. KS and SK helped supervise the field activities and conduct the literature review. NM, RyS, ReS, KT, HS, and NN collected the data and helped conduct the literature review. All authors contributed to interpreting the data and writing and editing the manuscript.

Acknowledgments:

Not appreciable

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561 **FIGURE LEGENDS**

562 Figure 1. Flowchart of study participants in this RIAS, Japan, 2011–2015.

563 RIAS, Research project for prospective Investigation of health problems Among

564 Survivors of the Great East Japan Earthquake.

565

566 **ADDITIONAL FILES**

567 Supplementary Table 1. Characteristics in the elderly survivors who were or were not
568 followed-up: the RIAS study, 2011.

569

570 Supplementary Table 2. Incidence according to survey year among the participants for
571 all five years by sex: the RIAS study, 2011–2015.

572

573 Supplementary Table 3. Multivariate-adjusted odds ratio (95% confidence interval) for
574 residential status associated with the risk of anemia among male and female elderly
575 survivors: the RIAS Study, 2011–2015.

576

Table 1. Baseline characteristics of the study participants in terms of residential status according to male and female elderly survivors: The RIAS Study, 2011.

	Male (n = 1390)				**Female (n = 1842)**				
	No relocation	**Relocated to other residences**	**Relocated to temporary housing**	***P*-value** [a]	**No relocation**	**Relocated to other residences**	**Relocated to temporary housing**	***P*-value** [a]	***P*-value** [b]
Number of participants	727	351	312		910	528	404		
Age, mean ± SD	72.4 ± 5.0	72.7 ± 5.3	72.2 ± 4.9	*0.530*	72.1 ± 4.9	72.1 ± 4.9	72.0 ± 5.1	*0.898*	*0.037*
Age, ≥75 years %	30.7	32.8	29.5	*0.645*	29.3	28.0	27.0	*0.661*	*0.125*
Hemoglobin, g/dL, mean ± SD	14.6 ± 0.9	14.5 ± 0.9	14.5 ± 1.0	*0.208*	13.2 ± 0.7	13.1 ± 0.8	13.0 ± 0.7	*<.001*	*<.001*
Hematocrit, %, mean ± SD	43.7 ± 2.7	43.5 ± 2.7	43.7 ± 2.8	*0.303*	40.3 ± 2.2	39.9 ± 2.3	39.9 ± 2.2	*<.001*	*<.001*
MCV, fL, mean ± SD	94.2 ± 4.1	94.1 ± 3.9	94.1 ± 4.3	*0.934*	92.8 ± 3.7	92.6 ± 3.9	92.7 ± 3.8	*0.678*	*<.001*
Microcytosis, <80 fL, %	0.4	0.0	0.0	*0.254*	0.2	0.4	0.0	*0.469*	*0.994*
Macrocytosis, >100 fL, %	7.7	7.7	9.0	*0.765*	2.3	2.7	2.7	*0.874*	*<.001*
Serum albumin, g/dL, mean ± SD	4.51 ± 0.30	4.52 ± 0.31	4.52 ± 0.31	*0.899*	4.51 ± 0.28	4.50 ± 0.28	4.46 ± 0.27	*0.005*	*0.112*
Serum creatinine in mg/dl, mean ± SD	0.84 ± 0.17	0.87 ± 0.19	0.83 ± 0.16	*0.006*	0.64 ± 0.11	0.64 ± 0.11	0.63 ± 0.11	*0.541*	*<.001*
eGFR in ml/min/1.73 m2, mean ± SDb	72.0 ± 15.0	69.3 ± 14.2	73.0 ± 14.6	*0.004*	71.4 ± 13.9	71.4 ± 13.9	82.2 ± 13.4	*0.552*	*0.932*
Municipality				*<.001*				*<.001*	*0.346*

Yamada	27.5	27.9	24.7		24.6	28.4	20.5		
Ohtsuchi	15.1	33.3	21.2		14.4	33.1	20.5		
Rikuzentakata	57.4	38.8	54.2		61.0	38.5	58.9		
Standard of living, difficulty %	34.7	49.4	59.0	*<.001*	32.5	48.9	56.8	*<.001*	*0.451*
BMI, kg/m^2				*0.378*				*0.110*	*0.001*
<18.5	0.6	1.4	0.3		1.7	2.7	3.5		
≥25.0	38.0	38.8	35.9		38.1	33.9	33.4		
History of stroke, %	6.2	6.3	7.7	*0.649*	4.3	4.0	4.2	*0.961*	*0.003*
History of myocardial infarction, %	1.2	4.0	1.0	*0.003*	0.6	0.8	0.5	*0.846*	*<.001*
Hypertension, %	61.5	58.4	60.6	*0.625*	59.9	64.0	61.4	*0.301*	*0.605*
Diabetes mellitus, %	15.5	17.1	16.0	*0.810*	9.3	8.7	9.4	*0.909*	*<.001*
Hypercholesterolemia, %	24.5	26.5	26.0	*0.743*	34.6	35.4	36.6	*0.777*	*<.001*
CKD, %	21.5	26.4	18.3	*0.039*	19.7	19.4	17.6	*0.659*	*0.046*
Current smokers, %	18.7	18.5	22.1	*0.393*	0.9	1.5	2.0	*0.235*	*<.001*
Current drinkers, %	40.9	39.6	42.3	*0.779*	1.5	1.7	1.2	*0.845*	*<.001*
Physical inactivity, <23METs·hour/week %	55.9	65.9	67.7	*<.001*	64.1	73.1	73.3	*<.001*	*<.001*
Sedentary lifestyle, %	27.2	34.8	35.5	*0.007*	24.8	37.1	37.3	*<.001*	*0.965*
Poor dietary balance, %	45.0	46.3	50.3	*0.285*	35.1	36.9	37.0	*0.699*	*<.001*
Staple food, <3times/d	8.7	12.3	12.5	*0.075*	7.6	10.8	10.2	*0.085*	*0.193*
Protein-related food, <2 times/d	10.5	8.0	11.5	*0.282*	8.2	8.7	7.2	*0.697*	*0.056*
Vegetable, <2 times/d	19.0	24.7	23.5	*0.065*	10.3	11.2	13.7	*0.206*	*<.001*
Fruit, <1 time/d	6.3	7.0	7.6	*0.737*	2.2	2.9	2.3	*0.735*	*<.001*
Dairy product, <1 time/d	16.0	16.9	15.6	*0.901*	12.4	12.2	12.0	*0.976*	*0.002*
Self-rated health, poor %	11.9	15.1	16.5	*0.101*	13.8	17.7	16.7	*0.109*	*0.147*
Psychological distress, %	6.7	9.0	11.4	*0.037*	11.8	18.8	18.4	*<.001*	*<.001*

Low social networks, %	36.9	37.7	37.8	*0.958*	34.2	34.3	39.5	*0.153*	*0.260*

[a] Obtained using one-way analysis of variance for continuous variables and chi-square test for categorical variables, comparing those without relocation, those relocated to other residents, or relocated to temporary housing.
[b] Obtained using t-test for continuous variables and chi-square or fisher exact test for categorical variables, comparing male with female.
BMI: Body Mass Index; CKD: Chronic Kidney Disease; MCV: Mean Corpuscular Volume; SD: standard deviation

577

Table 2. Summary results of the Odds Ratio (95% Confidential Interval) for residential status associated with a risk of anemia among male elderly survivor (n = 1390): The RIAS Study, 2011–2015.

Variable	No relocation	Relocated to other residences	Relocated to temporary housing	*P* for interaction
Age and body mass index–adjusted	Reference	1.09 (0.82–1.44)	0.87 (0.62–1.21)	
Multivariate adjusted[a]	Reference	1.05 (0.79–1.41)	0.82 (0.58–1.18)	
Subgroup analyses				
Baseline age groups				*0.258*
< 75 years	Reference	1.01 (0.63–1.63)	0.74 (0.42–1.30)	
≥ 75 years	Reference	1.14 (0.80–1.63)	0.94 (0.60–1.46)	
BMI, kg/m^2				*0.779*
< 25	Reference	1.01 (0.72–1.42)	0.90 (0.61–1.32)	
≥ 25	Reference	1.25 (0.70–2.24)	0.86 (0.44–1.70)	
Sensitivity analyses (analyzed number)				
After excluding those who were certified as needing LTCI (n = 1318)	Reference	1.04 (0.77–1.40)	0.76 (0.52–1.10)	
After excluding those who reported having lost weight (n = 1217)	Reference	1.02 (0.74–1.41)	0.85 (0.58–1.25)	
After excluding those who had hypoalbuminemia (n = 835)	Reference	1.19 (0.82–1.72)	0.76 (0.47–1.22)	

a Adjusted for age (continuous), body mass index (<18.5, ≥25.0 vs 18.5–24.9 kg/ m2), diabetes mellitus (yes vs no), chronic kidney disease (yes vs no), current smoker (yes vs no), current drinker (yes vs no), protein-related food intake (<2 vs ≥2 times/d), vegetable intake (<2 vs ≥2 times/d), dairy product intake(<1 vs ≥1 time/d), and poor self–rated health (yes vs. no).

578

Table 3. Summary results of the Odds Ratio (95% Confidential Interval) for residential status associated with a risk of anemia among female elderly survivor (n = 1842): the RIAS study, 2011–2015.

Variable	No relocation	Relocated to other residences	Relocated to temporary housig	
Age and body mass index–adjusted	Reference	1.20 (0.93–1.55)	1.40 (1.08–1.80)	
Multivariate adjusted[a]	Reference	1.13 (0.87–1.47)	1.42 (1.09–1.85)	
Subgroup analyses				
Baseline age groups				*0.362*
< 75 years	Reference	0.82 (0.54–1.22)	1.31 (0.89–1.94)	
≥ 75 years	Reference	1.37 (0.98–1.92)	1.59 (1.15–2.22)	
BMI, kg/m^2				*0.400*
< 25	Reference	1.31 (0.95–1.80)	1.49 (1.09–2.04)	
≥ 25	Reference	0.86 (0.57–1.29)	1.40 (0.89–2.19)	
Sensitivity analyses (analyzed number)				
After excluding those who were certified as needing LTCI (n = 1748)	Reference	1.12 (0.86–1.47)	1.34 (1.02–1.76)	
After excluding those who reported having lost weight (n = 1611)	Reference	1.27 (0.96–1.69)	1.65 (1.24–2.19)	
After excluding those who had hypoalbuminemia (n = 1146)	Reference	1.16 (0.84–1.61)	1.42 (1.02–1.98)	

a Adjusted for age (continuous), body mass index (<18.5, ≥25.0 vs 18.5–24.9 kg/ m2), municipality (Ohtsuchi, Rikuzentakata vs Yamada), history of myocardial infarction (yes vs no), hypercholesterolemia (yes vs no), chronic kidney disease (yes vs no), current drinker (yes vs no), physical inactivity (<23 vs ≥23METs·hour/week), protein-related food intake (<2 vs ≥2 times/d), fruit intake (<1 vs ≥1 time/d), dairy product intake(<1 vs ≥1 time/d), and poor self-rated health (yes vs. no).

Figures

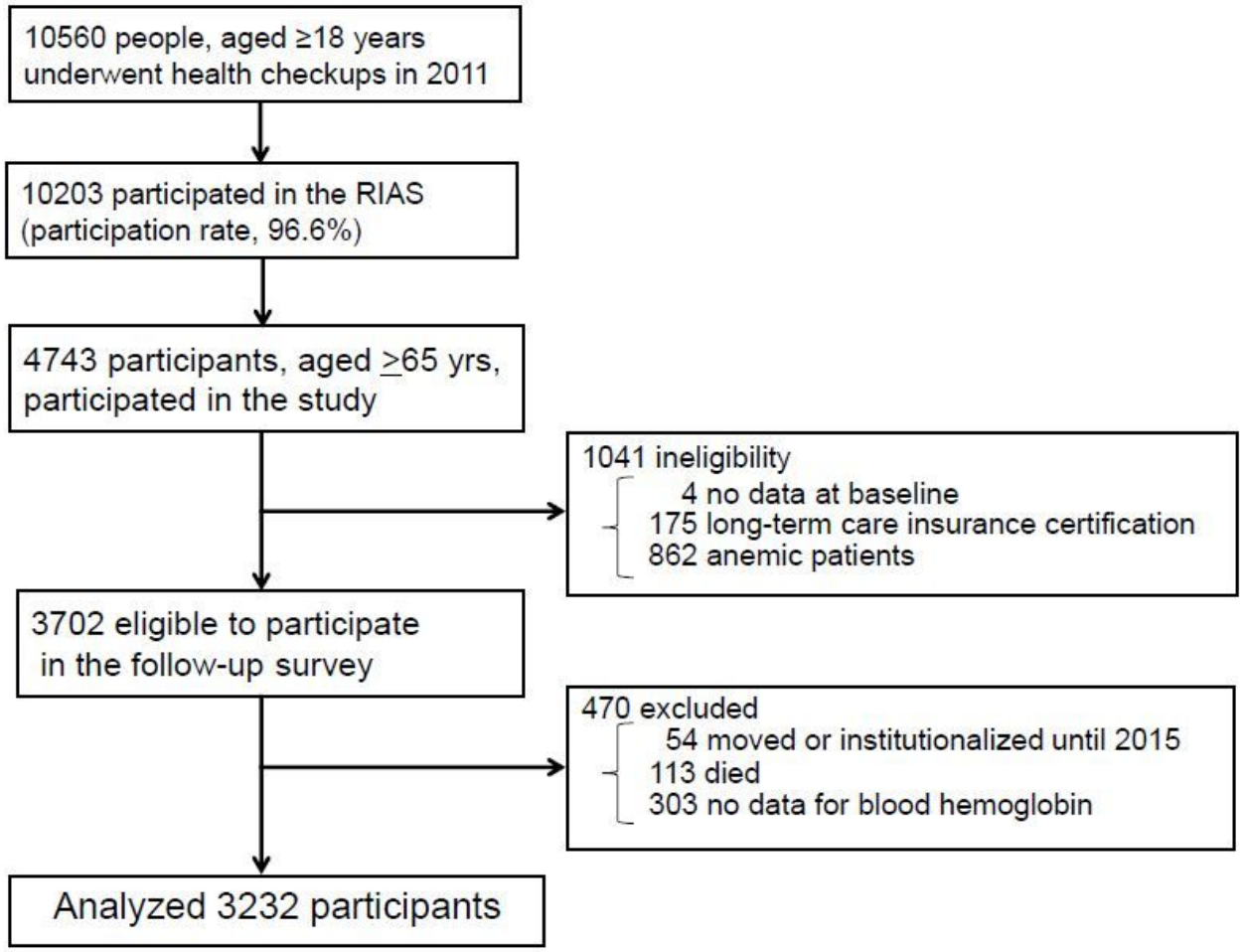

Figure 1

Flowchart of study participants in this RIAS, Japan, 2011–2015. RIAS, Research project for prospective Investigation of health problems Among Survivors of the Great East Japan Earthquake.

Supplementary Files

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