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Research article

Foods provided at shelters during a heavy rain disaster: comparison of weighed food records between different numbers of days

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Abstract: Dietitians working at evacuation shelters conduct weighed food records (WFRs) for multiple days for dietary assessment. Because the menus in evacuation shelters do not change much from day to day, this study examined whether one- and two-day WFRs are sufficient for dietary assessment at shelters and identified dietary components that can influence the number of assessment days. Overall, 26 WFRs were collected from 10 shelters in Kumamoto Prefecture, and the amounts of energy; protein; vitamins B_1, B_2 and C and salt were calculated. Correlation analysis and paired sample tests were conducted to examine significant differences between 'one- and two-consecutive- or nonconsecutive-day WFRs' and 'three-consecutive-day WFRs', which were set as the standard in this study. Additionally, the coefficients of variation (CV) for the categories by meal and dish were calculated to examine the variables that affected the large variations. As a result, one-day WFRs had significant positive correlations with the standard; thus, it could be used for the triage of shelters requiring nutrition assistance as a substitute for three-day WFRs. Two-consecutive-day and nonconsecutive-day WFRs showed a stronger correlation with the standard compared with the one-day WFRs. For energy and nutrients and dish categories, ready-to-eat foods had larger CV than boxed meals or foods from hot meal services. Whenever the meals included ready-to-eat foods, a two-nonconsecutive-day WFR is recommended considering large between-day variations. Salty soup or beverages affected the variation of some nutrients. Our result would help municipalities to consider the number of WFRs during emergency.

Keywords: administrative dietitian; evacuation shelter; natural disaster; variation; weighed food record

Abbreviations: CV, coefficients of variation; MHLW, Ministry of Health, Labor, and Welfare; RV, Nutritional Reference Values for Feeding at Evacuation Shelters; WFR, weighed food record

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1. Introduction

Japan frequently experiences natural disasters, such as earthquakes and typhoons[1]. To prepare for such situations, local government stockpile foods for evacuees[2]. Within few days following a disaster onset, hot meals or order boxed meals are to be distributed to the evacuees[3]. Carbohydrate-based foods, such as instant noodles and bread, were previously reported to be in excess[4], and the consequential increased salt intake in evacuation shelters was associated with the risk of hypertension among the evacuees[5].

To sustain evacuees' health, the nutritional supply of meals served in evacuation shelters must be estimated. The Ministry of Health, Labor and Welfare (MHLW) released the notice 'Nutritional Reference Values for Feeding at Evacuation Shelters' [reference values (RVs)][6] for the prefectural governments of the affected areas. In general, registered dietitians and dietitians who provide support in evacuation shelters conduct dietary assessments of the provided meals[7]. The survey results are assessed based on the RVs and are used as scientific bases to change the contents of the meals provided at the shelters for nutritional improvement[2].

Among various dietary assessment methods, the weighed food record (WFR) is considered the gold standard because it provides a high degree of accuracy in assessing food and nutrient intakes, without estimating the amount of food and recalling previous diets[8,9]. This method was conducted in evacuation shelters in the post-disaster period in Japan[10,11]. Unlike dietary assessments in normal settings, WFRs in shelters exhibit unique characteristics. First, an individual's nutrient intake is not measured; in evacuation shelters, one meal is measured before distribution[11] because it is provided to everyone regardless of their specific needs. Therefore, the nutrient content of one meal is measured regardless of the number of evacuees in the shelter. The aim is mainly to identify the shelters with the greatest need for improvement of meals rather than the individual nutritional assessment. Second, the meal contents following disasters tend to have less variety[12,13]. Consequently, food does not change much from one day to the next. Nishimura[14] found that the monotonous menu of hot meal services was served by self-defence forces. Although local governments conducted

WFRs for a maximum of three days in July 2020 Heavy Rainfall (original data from the previous study[11]), the difference may not be large between three-day and fewer-day WFRs.

Although the WFR is the most precise method for dietary assessment, it is time-consuming and could be burdensome for dietitians in emergency settings. In addition, to the best of our knowledge, no study has determined the number of days required for WFRs in evacuation shelters. Thus, this study aimed to examine whether one- and two-day WFRs for dietary assessment at shelters could replace the three-day WFRs conducted in disaster settings. In addition, the meal and dish categories that contributed to the potential variations were examined.

2. Experimental methods

2.1. Study background

Uniquely, Japan has consistently followed its annual National Health and Nutrition Survey since 1946 by applying WFR. Unlike Western countries that use a 24-h dietary recall for their national nutrition surveys[15-18], the WFR method is widely used by Japanese dietitians who work for local governments, not only for the National Health and Nutrition Survey but also for their periodic prefectural health and nutrition surveys[19].

During emergencies, it takes more time to order supplies from disaster-affected areas. Additionally, the concerned municipalities face difficulties in quickly procuring their basic supplies. Therefore, central government provide a ‘push-type relief’, including foods and beverages, without waiting for specific request from disaster-stricken municipalities[20]. Moreover, foods are excessively delivered to specific areas because of media coverage and information spread through social networking services[21]. Consequently, municipal agents cannot presume when and what type of foods they would receive beforehand. To collect promptly dietary information, WFR is also applied during emergencies for an instant dietary support since no additional training is required. Consequently, the use of alternative methods, such as the 24-h dietary recall, solely for emergency situations is not considered efficient.

2.2. Study setting

Kumamoto Prefecture, located in the southwest part of Japan, was lashed by heavy rainfalls in July 2020 (from 3rd to 4th July 2020)[22]. This prefecture mainly has electronics, transportation machinery and production machinery industries[23]. In this prefecture, heavy and torrential rains are often due to the warm and humid air flowing in from the Eastern China Sea. Substantial precipitation, particularly during the rainy season, can lead to natural disasters[24]. Consequently, its depopulation is progressing, whereas its older population is increasing; approximately 30% of the residents are >65 years old at the year of that disaster[25]. Owing to agricultural, forestry and fishery products, traditional dishes rooted in the local climate have been developed in each area[26]. As a nutritional issue, 80% of people in this prefecture consume excessive amounts of salt with lower consumption of vegetables than the recommended intake and the national average. Approximately 70% of men and 40% of women aged 40–74 years have high blood pressure or pre-hypertension[27].

Following the heavy rainfall, municipalities in Kumamoto Prefecture opened evacuation shelters and provided evacuees with food and water. In 12 evacuation shelters, administrative and/or volunteer dietitians dispatched from dietetic associations were asked to perform dietary assessments of shelter meals 16–20 days after the disaster. This period was classified as phase 2, which is not acute, and where hot meal services or boxed meals aim to be served. In this period, dietitians need to improve the deficiency of nutrients[3]. WFRs in the evacuation shelters were conducted for the prevention of life-style diseases due to unbalanced diets. For nutrition calculation, the prefectural government that had jurisdiction over the affected areas sent WFR sheets collected by the dietitians to the authors' institutions that voluntarily backed them up. Because two of the 12 shelters did not record the weights of food in the WFRs, we used data from 10 shelters for the analysis. These 10 shelters had operated for a median of 100 days (74–119, 25%–75%) since July 2020's Heavy Rainfall [28-31], so the survey was conducted in the beginning period of the shelter opening. The average number of evacuees in each of the 10 shelters during that period was 64 ranging between 15 and 300. Additionally, at least 18% of the evacuees were vulnerable individuals (the majority had

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hypertension, followed in order with diabetes, kidney diseases, allergies and others). However, only one generic type of meals was distributed regardless of any specific condition.

WFR was conducted as a public service under the direction of the prefectural government to improve the conditions of the shelters. However, since it was based on administrative decision, no scientific sampling was set in this study. For this study, we asked permission from the prefectural government to use WFR data collected from these shelters. Written approval was given provided that the shelters' names remain anonymous.

2.3. WFRs

The dietitians involved in this data collection were affiliated with various institutions, including health centres, local governments and dietetic associations within and outside the affected areas. For the WFR method, food record sheets, instructions for recorders and an example of recording were developed and sent to the prefectural nutrition officers who distributed these documents to the dietitians in charge.

During data collection, the dietitians in each shelter were instructed to weigh all food items served as breakfast, lunch and dinner. Basically, each food item was divided into individual ingredients and weighed using a digital scale so that the calculators could estimate the nutrition supply. Each meal was photographed using digital cameras or cell phones and placed on A4 paper, which was used as a scale. Data including product name, manufacturer's name and nutrition fact labelled on ready-to-eat foods or boxed meal packages were recorded as photographs.

Since April 2015, the Food Labelling Act requires to list the amount of energy, protein, fat, carbohydrate and salt on every processed food[32]. Ready-to-eat foods and boxed meals are usually prepared by stores or companies, so nutrients other than the mandated ones, especially vitamins on RVs, are generally not listed on their nutrition label and on their website. Therefore, the weight records of all the ingredients facilitates in estimation of the amount of all the nutrients on RVs that are not shown on the meals nutrition label.

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2.4. Nutrition calculation

Among the 10 shelters, six collected three-consecutive-day WFRs and the remaining four collected two-consecutive-day WFRs. In total, there were 26-day WFRs consisting of 79 meals.

Daily energy and nutrient contents in meals were calculated using Excel Eiyō Plus (in English, Nutrition Plus), which is a widely used add-in software for nutrition calculation, commercially available from Kenpaku sha, a Japanese publisher of academic books. The software is based on the latest Japanese standard food composition tables published by the Ministry of Education, Culture, Sports, Science and Technology[(33)]. It also provides typical recipes with the weight ratio of ingredients and seasoning for commonly consumed dishes, so simmered vegetables or fried chicken, for example, could be nutritionally calculated using these typical recipes based on their weight record.

RVs, nutritional reference values for evacuation shelters set by MHLW, consist of energy, protein and vitamins B_1, B_2 and C[(6)]. A previous study granted by MHLW revealed the feasibility of the revised RVs (draft), which added salt value considering hypertension[(34)]. Because the current study examines whether one- or two-day WFRs could be used for dietary assessment in shelters, we decided to calculate the energy and four nutrients in RVs along with salt content.

For nutritional calculation of ready-to-eat foods, such as instant noodles and miso soup, we prioritised the nutritional information published in the manufacturers' nutrition label or through their website. In case of any missing data regarding the amount of nutrients, especially vitamins, we selected similar food items on '18 Food Group (Prepared and processed foods)' in Standard Tables of Food Composition in Japan 2020 (The Eighth Version)[(33)], followed by typical recipes in 'Excel Eiyō Plus' to fill the amount of these nutrients. Similarly, we referred to the nutrition label or website for nutritional information of boxed meals. Even when dishes could not be found in the Standard Tables of Food Composition, we calculated the nutrients using typical recipes in 'Excel Eiyō Plus'. Foods from hot meal services were also referred to the 18 Food Group in Standard Tables of Food Composition first, followed by typical recipes in ‘Excel Eiyō Plus’.

2.5. Data analysis

Using three-consecutive-day WFRs from six shelters (18-day WFRs in total), pairs were formed between one-day WFRs and the average of three-consecutive-day WFRs (standard) in each shelter. Correlation coefficients of the total 18 pairs were then calculated to check whether only a one-day WFR could identify the shelters with relatively poor diets (Fig. 1a). In addition, two-consecutive- and two-nonconsecutive-day WFRs were compared with the standard to test whether a two-day WFR had larger correlation coefficients than a one-day WFR (Fig. 1b and 1c). After conducting the Shapiro–Wilk test, Pearson’s correlation coefficient was calculated for normally distributed data. Otherwise, Spearman’s correlation coefficient was used.

To compare the two-consecutive and two-nonconsecutive-day WFRs, the average of the three-consecutive-day WFRs was also used as a standard (Fig. 1b and 1c). When the amounts of energy and nutrients followed a normal distribution, a paired *t*-test was conducted; otherwise, the Wilcoxon signed-rank test was run.

Furthermore, the coefficients of between-day variation of energy or nutrients by meal category were calculated using all WFRs from the 10 shelters (26-day WFRs in total). First, 79 meals from 26-day WFRs were grouped between two; ready-to-eat foods and boxed meals or foods from hot meal services. The former consisted of food aids mainly consisting of a carbohydrate-based diet with less food variety, whereas the latter usually included a main and/or a side dish. The coefficients of variations (CVs) of energy and nutrients were then calculated by meal category, in addition to the following three categories; staple, main and side dishes to identify the dietary components that contributed to the large variation. The staple dish was defined as the carbohydrate source (cereals), the main dish as the protein source (beans, fish and shellfish, meats and eggs) and the side dish as the vitamin, minerals and dietary fibres source (potatoes and starches, vegetables, fungi and algae) based on the Japanese Food Guide Spinning Top[35].

Because ready-to-eat carbohydrate-based foods were reported to be oversupplied[4], we examined whether the provision quantity affected the energy and nutrients supply within the ready-to-eat foods. In this study, the number of ready-to-eat staple foods was not balanced. Therefore, they were divided ready-to-eat foods based meals into two groups ('more than one' and 'one or less' staple foods) based on the median, and the Mann–Whitney U test was conducted. In addition, some meals were provided with a salty soup or beverage, so those nutritional effects were investigated by grouping 'meals with soup/beverage' or 'others'. In this study, only one type of beverage was served twice. However, because they would not contribute to energy and nutrient supply compared with the meals, they were categorised into 'others'. The Mann–Whitney U test was used for their analysis.

All statistical analyses were performed using IBM SPSS Statistics for Windows version 28. The significance level was set at 5%.

2.6. Ethical consideration

The government of Kumamoto Prefecture conducted this dietary survey as part of shelter management following disasters. Because it is based on the secondary use of data collected by local governments, this study was deemed not applicable for review by the Ethical Review Committee of the Ochanomizu University Research in Humanities and Social Sciences. The authors obtained permission for the secondary use of data from the government of Kumamoto Prefecture (Permission notice: Kenzusui No. 885). Consent to participate does not apply to this study. All methods were conducted in accordance with the relevant guidelines and regulations of the institution and the Declaration of Helsinki.

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3. Results

3.1. Correlation and comparison of energy and nutrients between WFRs for different number of days

Energy and nutrients estimated from the one-day WFR had a strong positive correlation (r > 0.6) [36] with the average of three-consecutive-day WFRs (Table 1). However, stronger correlations in energy and nutrients were obtained with two-consecutive- and nonconsecutive-day WFRs; most of them had >0.8, which is a very strong correlation coefficient [36]. Overall, the amount of energy in the analysed food items showed a very strong positive correlation (r > 0.9)[36]. Although vitamin C and salt in one-day WFR had relatively lower correlation coefficients (r = 0.668 and 0.634) among energy and all nutrients, their values in the averages of two-consecutive or nonconsecutive-day WFRs had very strong positive correlation coefficients.

Although both averages of two-consecutive- and nonconsecutive-day WFRs had very strong positive correlation coefficients in amounts of energy and nutrients, which had stronger correlation with the standard was uncertain. To determine whether consecutive or nonconsecutive days were preferable, two-paired tests were conducted between the averages of two-consecutive- or nonconsecutive-day WFRs and the average of three-consecutive-day WFRs. For energy and nutrients other than salt, no significant difference between each pair was observed (Table 2).

3.2 Meal characteristics

The combinations of foods in the daily meals were divided into five patterns (Table 3). In the four shelters with two-day WFRs, breakfast and lunch were all ready-to-eat foods of monotonous carbohydrate-based foods, such as rice balls and sweetbreads (types 1–3 in Table 3). As for the dinner, these shelters served boxed meals or foods from hot meal services consisting of rice, main and/or side dishes. The shelters also served snacks, including coffee, vegetable juice, beer and crunchy chocolate, for three days.

In six shelters with three-day WFRs, breakfast consisted of carbohydrate-based ready-to-eat foods were served for 14 days (type 4 in Table 3). All three meals (breakfast, lunch and dinner) were a combination of rice and main and/or side dishes for four days (type 5 in Table 3).

All meals were divided into ready-to-eat foods (n = 31) and boxed meals or foods from hot meal services (n = 48). As shown in Table 4, the average amounts of energy and nutrients per meal were higher in boxed meals or foods from hot meal services than in ready-to-eat foods. In contrast, CVs for energy and all nutrients in ready-to-eat foods were larger than those in boxed meals or foods from hot meal services. In both meals, vitamin C had the largest CV. Salt was the second (boxed meals or foods from hot meal services) or third (ready-to-eat foods) nutrient with large CVs. In addition, the CV of staple dish was the smallest, followed by the main and side dishes in both meal categories.

Ready-to-eat foods containing carbohydrate-based foods, such as rice balls or bread, were almost always served. However, the number of carbohydrate-based foods supplied was different for each meal. Out of 31 meals, 16 consisted of ready-to-eat foods containing more than one carbohydrate-based food such as a combination of rice and bread. Eleven meals based on ready-to-eat foods contained one carbohydrate-based food, whereas the remaining four contained none. Table 5 shows the results of the Mann–Whitney U test of two groups divided by the number of carbohydrate-based foods; ‘more than one’ and ‘one or less’. Significant differences were detected in energy, protein, vitamin B_1 and salt between meals with more than one carbohydrate-based food and meals with one or less those foods.

Table 6 shows the results of the Mann–Whitney U test of the effect of the provision of soup or beverage on the supply of energy and nutrients in meals. In this study, soup from instant noodles [57–75 g (without water); n = 4], instant miso soup [42–54 g (without water); n = 2] and Japanese or Chinese style soup from hot meal services made from granule soup stock or miso [124–400 g; n = 6] were provided with meals. Consequently, meals with soup contained significantly higher amounts of vitamin B_1 and salt. Some meals were also served with beverages such as vegetable juice (200–265 g; n = 6), bottled green tea (500 g; n = 5),

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lactic acid bacteria beverage (84 g; n = 3), milk (206 g; n = 1) and sports beverage (500 g; n = 1). Table 6 shows that the amounts of vitamin C significantly increased in meals with beverages, which was about five times as meals without beverages.

4. Discussion

4.1. Recommended number of WFRs

As shown in Table 1, strong positive correlations were observed between standard (average of three-consecutive-day WFRs) and one-day WFRs. According to the report of the Great East Japan Earthquake, dietary surveys must be conducted efficiently, and their results must be sent promptly to the local government to improve the nutritional status in shelters(37). Because no study has revealed the necessary number of days for WFR in emergency settings, this study was the first to show that only one-day WFR could contribute to the relative evaluation to identify shelters with poorer nutrition supply as a substitute for three-day WFRs. This might serve as a rationale for local governments to promptly assist shelters that needed the most help. Table 1 also reveals that the energy amount had a very strong positive correlation with the standard. Therefore, a highly accurate assessment would be expected for energy supply, a necessary nutritional source for the immediate post-disaster(3).

As shown in Table 1, the average of two-consecutive- or two-nonconsecutive-day WFRs showed a stronger positive correlation with a standard comparing to one-day WFR. Although one-day WFR can be used for assessing nutrition supply, two-day WFRs would be preferable for more accurate nutritional assessment if the dietitians in the evacuation shelters are willing to commit. No significant differences were shown in energy and most nutrients in both pairs (Table 2), but previous studies(38,39) have revealed that nonconsecutive-day data were more preferable than data collected on adjacent days because the former considered the changes in meal contents over an extended period. In addition, the dietary surveys for several days might reduce the motivation to continue consecutive-day WFRs(40). Consequently, nonconsecutive-day WFRs are preferable when local governments ask dietitians to conduct

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two-day WFRs. If several nonconsecutive-day WFRs are needed in shelters, the survey period should be within the same phase, such as phase 2 (four days to one month after the disaster) or phase 3 (over one month after the disaster)[3]. These phases focus on dealing with the nutritional issues under conditions where food availability is relatively improved[3].

4.2. CVs of energy and nutrients in meal categories and food groups

We further analysed how meals or food categories affect the number of necessary days for WFRs. Compared with boxed meals or foods from hot meals services, meals consisting of ready-to-eat foods provided smaller average amounts of energy and all nutrients with larger CVs (Table 4). In addition, ready-to-eat foods based meals with higher number of carbohydrate-based foods showed significantly higher levels of energy and some nutrients (Table 5). According to previous studies, rice balls, bread and biscuits[4.41,42] were often provided in disaster-affected areas. Although boxed meals or foods from hot meal services can increase some food categories[43], differences in the number of carbohydrate-based foods in ready-to-eat foods based meals appear to significantly contribute to CVs in terms of energy and nutrients. Because CVs of ready-to-eat foods might be larger than those of other meal types, two-day WFRs, preferably nonconsecutive-day WFRs, should be conducted instead of one-day WFR considering variations when ready-to-eat foods are mainly served in the surveyed shelters.

Regarding food groups, staple dishes had the smallest CVs (Table 4). In Japan where rice is usually consumed in a relatively stable amount, CVs of cereals are relatively small[44,45]. Therefore, our results were consistent, although the food environment in emergencies is different from that in normal situations. On the contrary, previous studies[44,45] on side dishes have shown that fungi and algae require multiple days for estimation; >2 years within 10% of their true value because of their large within-individual variations. Vegetables took >1 month within 10% of their true value[44,45]. Similar results were observed in this study, making it difficult to assess the nutritional supply (Table 4).

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4.3. Other factors affecting large CVs of energy and nutrients

Soup or beverages with meals can affect CVs in terms of energy and nutrients (Table 6). For salt, meals with soup had significantly higher amounts than those without soup; the difference in quantity was approximately twice as much. Previous study has shown that the salt supply in evacuation shelters was high in food aids such as instant noodles[4]. In addition, hypertension risk due to increased salt intake was reported after disasters[5]. Therefore, the salty soup might contribute to the relatively large variations (Table 6). Beverages served with meals had significantly higher levels of vitamin C, approximately five times. The main dietary factors may be vegetable juice and bottled green tea, which are reported to be important sources of vitamin C[11]. In general, the addition of vegetables in meals, which are generally vitamin C sources, is difficult because of their scarcity[46]. Therefore, estimating the accurate vitamin C supply might be hard given the limited number of WFRs when vitamin C rich beverages are served.

4.4. Implementation of nutritional assessment in evacuation shelters

Conducting nutritional surveys in disasters might reduce Japan's vulnerability. The results of this study would provide insights into the nutritional improvement in evacuation shelters. It would also be useful for understanding dietary issues during disasters in countries with very high vulnerability, such as Africa, Asia and Central America. For example, in Puerto Rico, after Hurricane María, a federal distribution centre provided snacks and sweets at a high frequency, whereas fruits, vegetables, proteins and grains accounted for only approximately 10% of all foods provided[47]. In the aftermath of disasters in Iran, food aid was reported to be inappropriate because it contained high amounts of sodium and sugar, with limited amounts of fibre[41]. Although such dietary issues have been reported, no evidence shows that other countries have conducted dietary surveys for accurate nutritional assessment in times of disaster. Therefore, this study presents the validity of one- or two-day WFRs and the important notice for assessment.

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5. Strengths and Limitations

This study has several limitations. First, the number of shelters included in this study was relatively small compared with those in studies conducted in normal settings. While previous studies have collected data from 35 volunteers[39], the present study focused on assessing shelters rather than individuals, which led to a smaller number of facilities. In addition, the July 2020 Heavy Rainfall affected a few regions, which further limited the number of shelters that could be included. For example, while there were 2417 shelters during the Great East Japan Earthquake in 2011[48], only a maximum of 212 shelters were available[49]. However, food and nutrition assistance during disasters was strengthened after the Great East Japan Earthquake such as issuing RVs[6] and developing food and nutritional assistance manuals for professionals[3]. Although the scale of damage was not as large as that of the Great East Japan Earthquake, the July 2020 Heavy Rainfall had the largest number of human casualties following that earthquake[50] and these new food and nutrition assistance system was applied at that time. Therefore, the WFRs in this study would reflect the latest food and nutritional assistance, and the analysis results are useful for future disaster management.

Second, a maximum of three-consecutive-day WFRs is available for this study. Although this approach is commonly used in disaster settings because of the limited time available for data collection, it may not provide the same level of accuracy as the seven-day dietary records used in a previous study[39]. However, the Disaster Relief Act limits the duration of evacuation shelters to a maximum of seven days in general, which makes it challenging to collect data over a longer period unless a rare catastrophic disaster occurs. Whenever evacuation shelters are open for a longer period in the future, more research-based WFRs might be collected to estimate the necessary number of days.

6. Conclusions

This study showed that even one-day WFRs could substitute the three-day WFRs in identifying shelters in immediate need of nutrition support. If the dietitians agree, two-nonconsecutive-day WFRs are recommended as it gives better degree of accuracy to assess the nutritional supply. Considering the large CVs, two-day WFRs, preferably nonconsecutive-day WFRs, are recommended especially when the meals included ready-to-eat foods. Salty soup or beverages, which are rich in specific nutrients, can also affect the variation. To demonstrate the robustness and generalizability of these findings, a study, particularly one that spans larger areas should be conducted after large-scale disasters in the future.

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9. Declaration of interest

The author(s) declare none.

10. All authorship contribution

NS and NT-K contributed to the funding acquisition. NS and NT-K conceived and designed the research. NS, NT-K and SN-S contributed to the data collection. HS and NS contributed to the data interpretation. HS conducted data analysis and wrote the results. Major contributors to the manuscripts were HS and NS. All authors critically revised and commented on the previous versions of the manuscript. After revisions, the final version of the manuscript was approved by all the authors. NS was responsible for submitting the manuscript.

11. Availability of data and materials

Due to the nature of the study, the Kumamoto prefectural government did not allow us to share their data publicly. However, these data are available from the corresponding authors upon reasonable request.

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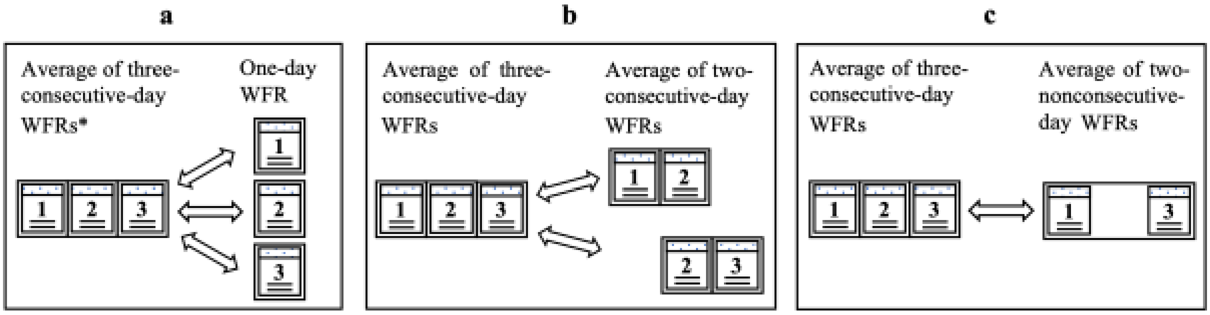

Figure 1. Diagram of data used in the correlation analyses and paired sample tests

WFR: weighed food record

* standard

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Table 1. Correlation coefficients for the amounts of energy and nutrients with the average of three-consecutive-day WFRs

	Energy and nutrients	Correlation coefficients	P value
One-day WFR (n = 18)	**Energy**	0.901	<0.001[a]
	Protein	0.743	<0.001[b]
	Vitamin B_1	0.776	<0.001[b]
	Vitamin B_2	0.738	<0.001[b]
	Vitamin C	0.668	0.002[b]
	Salt	0.634	0.005[b]
Average of two-consecutive-day WFRs (n = 12)	**Energy**	0.974	<0.001[a]
	Protein	0.792	0.002[b]
	Vitamin B_1	0.980	<0.001[a]
	Vitamin B_2	0.938	<0.001[a]
	Vitamin C	0.862	<0.001[b]
	Salt	0.951	<0.001[a]
Average of two-nonconsecutive-day WFRs (n = 6)	**Energy**	0.983	<0.001[a]
	Protein	0.878	0.021[a]
	Vitamin B_1	0.933	0.007[a]
	Vitamin B_2	0.853	0.031[a]
	Vitamin C	0.886	0.019[b]
	Salt	0.946	0.004[a]

WFR: weighed food record

[a] Pearson's correlation coefficient, [b] Spearman's correlation coefficient

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Table 2. Comparison for energy and nutrients between two-paired groups

Energy and nutrients		**Average of two-consecutive-day WFRs (12 WFRs)**		**Average of three-consecutive-day WFRs (Standard for comparison)**		**P value**	**Average of two-nonconsecutive-day WFRs (6 WFRs)**		**Average of three-consecutive-day WFRs (Standard for comparison)**		**P value for paired t-test**
Energy	**(kcal)**	1797	(323)*	1805	(297)*	0.728[a]	1820	(282)*	1805	(312)*	0.586
Protein	**(g)**	62.2	(10.6)*	60.5	(59.9–65.8)**	0.690[a]	63.6	(9.0)*	62.7	(9.5)*	0.651
Vitamin B_1	**(mg)**	0.72	(0.24)*	0.70	(0.20)*	0.183[a]	0.66	(0.14)*	0.70	(0.21)*	0.304
Vitamin B_2	**(mg)**	0.82	(0.17)*	0.82	(0.15)*	0.814[b]	0.81	(0.17)*	0.82	(0.16)*	0.543
Vitamin C	**(mg)**	65.3	(31.2–127.0)**	74.1	(30.0–122.1)**	0.530[b]	56.4	(37.6–138.4)**	103.8	(100.6)*	0.672
Salt	**(g)**	8.1	(1.6)*	8.5	(1.7)*	0.013[a]	9.3	(2.2)*	8.5	(1.8)*	0.047

WFR: weighed food record

[a] Paired t-test, [b] Wilcoxon signed-rank test

* Mean (standard deviation), ** Median (interquartile range)

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Table 3. Observed daily meal patterns and their frequencies

<table>
<tr><th>Daily meal patterns</th><th>Breakfast</th><th>Lunch</th><th>Dinner</th><th>Snack</th></tr>
<tr><td rowspan="2">Type 1 (2 days)[a]</td><td>Ready-to-eat foods</td><td>–*</td><td rowspan="2">Boxed meals or foods from hot meal services</td><td>–*</td></tr>
<tr><td>–*</td><td>Ready-to-eat foods</td><td>–*</td></tr>
<tr><td>Type 2 (3 days)[a]</td><td>Ready-to-eat foods</td><td>Ready-to-eat foods</td><td>Boxed meals or foods from hot meal services</td><td>–*</td></tr>
<tr><td>Type 3 (3 days)[a]</td><td>Ready-to-eat foods</td><td>Ready-to-eat foods</td><td>Boxed meals or foods from hot meal services</td><td>Ready-to-eat foods</td></tr>
<tr><td>Type 4 (14 days)[b]</td><td>Ready-to-eat foods</td><td>Boxed meals or foods from hot meal services</td><td>Boxed meals or foods from hot meal services</td><td>–*</td></tr>
<tr><td>Type 5 (4 days)[b]</td><td>Boxed meal or foods from hot meal service</td><td>Boxed meals or foods from hot meal services</td><td>Boxed meals or foods from hot meal services</td><td>–*</td></tr>
</table>

WFR: weighed food record

[a] Data from four shelters with two-consecutive-day WFRs

[b] Data from six shelters with three-consecutive-day WFRs

Table 4. Average amounts and coefficients of variation of energy and nutrients by meal category

Meal category			Average amount		Coefficient of variation (CV) %
Ready-to-eat foods (mainly carbohydrate-based foods) (31 meals)	**Energy and nutrients**				
	Energy	**(kcal)**	465	(310–562)**	59.5
	Protein	**(g)**	10.1	(6.9–16.9)**	58.9
	Vitamin B_1	**(mg)**	0.11	(0.08–0.19)**	108.5
	Vitamin B_2	**(mg)**	0.14	(0.08–0.19)**	58.0
	Vitamin C	**(mg)**	4.6	(1.9–10.4)**	256.4
	Salt	**(g)**	2.1	(1.4–3.0)**	78.0
	Dish category				
	Staple dish	**(g)**	167	(75–201)**	69.1
	Main dish	**(g)**	0	(0–27.7)**	148.4
	Side dish	**(g)**	0	(0–20.6)**	240.8
Boxed meals or foods from hot meal services (48 meals)	**Energy and nutrients**				
	Energy	**(kcal)**	683	(146)*	21.4
	Protein	**(g)**	24.5	(6.5)*	26.6
	Vitamin B_1	**(mg)**	0.27	(0.11)*	39.8
	Vitamin B_2	**(mg)**	0.32	(0.13)*	39.6
	Vitamin C	**(mg)**	14.4	(10.5–27.1)**	153.7
	Salt	**(g)**	3.2	(1.4)*	44.4
	Dish category				
	Staple dish	**(g)**	213.6	(41.8)*	19.6
	Main dish	**(g)**	90.9	(34.0)*	37.4
	Side dish	**(g)**	40.9	(22.7–64.2)*	117.0

* Mean (standard deviation), ** Median (interquartile range)

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Table 5. Association between meals with 'more than one' and 'one or less' ready-to-eat staple foods in energy and nutrients' supply

		More than one*		One or less**		Mann–Whitney U test
		(16 meals)		(15 meals)		p value
Energy	**(kcal)**	603	(248) †	292	(150–389) ††	0.001
Protein	**(g)**	14.6	(5.0) †	7.3	(2.5–8.6) ††	0.005
Vitamin B_1	**(mg)**	0.14	(0.12–0.22) ††	0.09	(0.05–0.11) ††	0.010
Vitamin B_2	**(mg)**	0.17	(0.07) †	0.09	(0.06–0.16) ††	0.149
Vitamin C	**(mg)**	6.6	(4.3–11.9) ††	2.3	(0.0–6.6) ††	0.084
Salt	**(g)**	2.9	(2.1–4.4) ††	1.2	(0.4–2.1) ††	<0.001

* Number of carbohydrate-based dishes: four (n = 1), three (n = 3) and two (n = 12)

** Number of carbohydrate-based dishes: one (n = 11) and none (n = 4)

†Mean (standard deviation), ††Median (interquartile range)

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Table 6. Association between 'meals with soup/beverage' and 'others' in energy and nutrients' supply

		Meals with soup*		Others		Mann–Whitney U test
		(12 meals)		(67 meals)		P value
Energy	**(kcal)**	686	(268) †	576	(218) †	0.144
Protein	**(g)**	23.4	(11.6) †	18.5	(8.4) †	0.148
Vitamin B_1	**(mg)**	0.33	(0.19–0.41) ††	0.20	(0.14–0.26) ††	0.031
Vitamin B_2	**(mg)**	0.33	(0.16) †	0.22	(0.16–0.30) ††	0.074
Vitamin C	**(mg)**	10.8	(4.4–19.0) ††	11.6	(4.4–19.0) ††	0.881
Salt	**(g)**	5.0	(4.3–4.8) ††	2.5	(2.0–3.2) ††	<0.001
		Meals with beverage**		**Others**		**Mann–Whitney U test**
		(16 meals)		**(63 meals)**		**P value**
Energy	**(kcal)**	612	(138) †	588	(246) †	0.262
Protein	**(g)**	20.0	(5.2) †	19.2	(10.4–26.4) ††	0.323
Vitamin B_1	**(mg)**	0.24	(0.11) †	0.20	(0.13–0.30) ††	0.520
Vitamin B_2	**(mg)**	0.35	(0.11) †	0.21	(0.14–0.27) ††	0.068
Vitamin C	**(mg)**	43.5	(21.8–152.2) ††	9.4	(3.4–14.2) ††	<0.001
Salt	**(g)**	2.7	(0.9) †	2.7	(2.0–3.5) ††	0.187

* Meals with soup: instant noodle [57–75 g (without water); n = 4], instant miso soup [42–54 g (without water); n = 2] and Japanese or Chinese style soup from hot meal services made from granule soup stock or miso (124–400 g; n = 6)

** Meals with beverage: vegetable juice [200–265 g] (n = 6), bottled green tea [500 g] (n = 5), lactic acid bacteria beverage [84 g] (n = 3), milk [206 g] (n = 1) and sports beverage [500 g] (n = 1)

†Mean (standard deviation), ††Median (interquartile range)

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