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Japanese school children's intake of selected food groups and meal quality due to differences in guardian's literacy of meal preparation for children during the COVID-19 pandemic

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ABSTRACT

In 2020, a state of emergency (SOE) was enforced by the Japanese government, which included temporary school closures with the aim of overcoming COVID-19 spread, which prevented access to school lunches. We evaluated the relationship between meal quality and guardians' literacy of meal preparation for a nationally representative sample of 1107 Japanese schoolchildren (aged 10–14 years) before, during, and after the SOE on the basis of 7 questions scored using a 5-point Likert scale. The guardians' literacy of meal preparation for children was divided into quartiles, with Q1 and Q4 including participants with the lowest and highest scores on food literacy, respectively. School lunch menu was handed out monthly to each household by their classroom teacher. The consumption of (i) meat, fish, or eggs and (ii) vegetables at least twice a day indicated "well-balanced dietary intake", which was less frequent in all four quartiles, especially for Q1 and Q2, during compared to before the SOE. The relative risk increases (95% CI) were Q1: −40.6% (−41.4% to −39.8%; $p < 0.001$), Q2: −34.0% (−34.7% to −33.3%; $p < 0.001$), Q3: −13.1% (−13.8% to −12.4%; $p < 0.001$), and Q4: −15.3% (−16.0% to −14.7%; $p < 0.001$), adjusted for sex, age, BMI, equivalent income adjusted for the number of household members, and educational level of parents. The interaction p was < 0.001 for Q1–3 vs. Q4. Guardians with low total scores were significantly more likely to have less time, mental capacity, and financial ability to prepare meals after the SOE. Therefore, schoolchildren's meal quality deteriorated during the SOE, particularly among those with guardians with low food literacy even after adjustment for household income level and guardians' educational level.

1. Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) caused the coronavirus disease 2019 (COVID-19) pandemic (World Health Organization, 2020) that has damaged the healthcare and socioeconomic systems worldwide (International Monetary Fund, 2021a; World Health Organization, 2021a, 2021b). As per the Act on Special Measures for Pandemic Influenza and New Infectious Diseases Preparedness and Response (Act No. 31 of 2012), Japan entered a state of emergency (SOE) on April 16, 2020 (Prime Minister of Japan and His

Cabinet, Japan, 2020). Between 16 April and 6 May 2020, the prefectures were instructed to close educational facilities to overcome the COVID-19 pandemic, leading to the temporary closure of 95% of Japanese elementary and junior high schools on 22 April 2020 (Ministry of Education Culture, Sports, Science and Technology, Japan, 2021a, 2021b). During the period of school closure, children did not have access to school lunches. From 1 June 2020, approximately 98% of closed Japanese schools have reopened (Ministry of Education Culture, Sports, Science and Technology, Japan, 2021a, 2021b). However, as of 2022, the continuity of school lunches in Japan is again uncertain because of

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the ongoing outbreak of the Omicron variant.

According to the records for the financial year 2018, 99.1% and 88.9% of Japanese schoolchildren in the elementary years (aged 6–11 years) and junior high years (aged 12–15 years), respectively, were provided lunches by the government on weekdays (i.e., almost 190 days/year) (Ministry of Education, Culture, Sports, Science and Technology, Japan, 2018a, 2018b). The schools provide lunches to all children, except those who require special meal requirements that cannot be fulfilled by the school. During the temporary school closure, children did not attend the schools and lunches were not provided. In 1954, the government passed the School Lunch Program Act with the aim to enhance the nutritional status of children (Asakura and Sasaki, 2017; Ishida, 2015; Ministry of Education, Culture, Sports, Science and Technology, Japan, 2018a, 2018b). The standard of lunches is regulated by the School Lunch Program, which dictates that the meals fulfil a minimum of one-third of the daily energy and nutritional requirements of children, including that of vitamins A, B₁, and B₂ ($\geq 40\%$ for all), calcium ($\geq 50\%$), iron ($\geq 40\%$), and fiber ($\geq 40\%$) (Ministry of Education, Culture, Sports, Science and Technology, Japan, 2018a, 2018b). As a result of this, it is crucial to evaluate the meal quality being provided to the schoolchildren during the period when school lunch was replaced by home meals.

Food literacy for preparing meals is related to the nutritional intake status (Azevedo Perry et al., 2017; Vogel et al., 2019). Typical examples of food literacy for meal preparation include food and nutrition knowledge (i.e., information regarding the ideal content and quality of food for having well-balanced nutrient intake); food skills (i.e., techniques to purchase, cook, and store foods); and attitude (i.e., one's willingness for having well-balanced nutrients intake) (Azevedo Perry et al., 2017; Vogel et al., 2019). Dietary habits, feeding strategies, and food literacy of the guardians/parents are some of the most significant factors that affect the dietary behaviour and choices of children (Scaglioni et al., 2018; Wijayarathne et al., 2022). Additionally, under the COVID-19 pandemic, due to the restrictions on the use of many facilities as well as the family's choice, the meals, including lunches, were usually prepared and consumed at home (Branaccio et al., 2021; Ministry of Health, Labour and Welfare, Japan, 2021); these meals were usually prepared by the guardians/parents and depended on their food literacy. Therefore, it is important to evaluate whether poor meal quality was provided to children whose meals were prepared by guardians with low level of food literacy during the period with no provision of school lunches.

Therefore, we investigated whether the meal quality eaten by schoolchildren differed on the basis of food literacy for preparing meals of their guardians before, during, and after the COVID-19 SOE. In addition, we evaluated the association of food literacy of guardians for preparing meals with their burden of preparing meals during the pandemic.

2. Materials and methods

2.1. Study participants

We performed a nationwide cross-sectional study of Japanese school children. We used stratified two-stage clustering for the identification of Japanese households that were representative of the general population from the resident registration system for the fiscal year 2020. In accordance with the Residential Basic Book Act, registration is mandatory for Japanese residents. To stratify the households, we selected eight Japanese regions (i.e., Hokkaido and Tohoku, Hokuriku koushinetsu, Kanto, Chubu, Kinki, Chugoku, Shikoku and Kyushu, and Okinawa). In the first stage, we randomly selected 6–7 municipalities from each prefecture to select 50 municipalities in total. In the next stage, we randomly selected 30 households with children in the fifth grade of elementary school (aged 10–11 years) or second grade of junior high school (aged 13–14 years) from each municipality; therefore, we extracted data from a total

of 3000 households. In December 2020, the guardians of these children were sent the questionnaires that were to be returned within 3 weeks. The guardians were sent reminder letters 7 days after the questionnaires were sent and gift card equivalent to 600 JPY (\$5.3 or €6.0 as of 1 December 2020 (International Monetary Fund, 2021b)) after the completed questionnaires were received. We followed the tenets of Declaration of Helsinki and Ethical Guidelines for Clinical/Epidemiological Studies of the Japanese Ministry of Health Labor and Welfare. The Ethics Committee of the National Center for Child Health, Japan (No. 2020-168) and the University of Niigata Prefecture, Japan (No. 2025) approved the study protocol. The participants provided written informed consent. Out of 3000 households who were sent the questionnaires, 1551 (51.7%) agreed to participate and sent back the questionnaires, among which 1107 (36.9%) with complete information were included in the final analysis, while 454 (14.8%) had missing information on some items. Thus, among the recruited participants, 1893 (63.1%) were not included in the analysis. Our previous study reporting on the association between economic status and food intake used the same data as described in this study (Horikawa et al., 2021).

2.2. Literacy of meal preparing for children

Based on previous reports about food literacy (Azevedo Perry et al., 2017; Kakutani et al., 2015; Koyama et al., 2016; Poelman et al., 2018), we constructed a new literacy scale of meal preparation for children in Japanese. The scale included nine questions related to food preparation (Table 1); these questions related to knowledge of a healthy diet (questions no. 1–2), ability to prepare meals for children (questions no. 3–5), attitudes toward providing a healthy diet for children (questions no. 6–7), affordability of healthy foods (question no. 8), and ability to plan meals for children (question no. 9). We asked the participants to provide responses on a 5-point Likert scale (1: No/not at all, 2: No/not so much, 3. Unsure, 4. Yes/sometimes, 5 Yes/Always) for questions 1–4. The scoring for question nos. 3–5 and 8 was reversed. The total score was obtained by adding the individual scores. These variables were treated as numerical. Importantly, we did not objectively assess the meal preparation ability of guardians; instead, we used their self-reported ability to prepare meals, which may not be accurate.

We performed exploratory factor analysis (EFA) with the maximum likelihood factor method and Promax rotation for evaluating the correlation between factors and investigate the dimensionality of meal preparing skills as well as identify problematic items with poor fit in any dimension (Knekt et al., 2019). We constructed a scree plot for the identification of the appropriate number of factors in the analysis prior to rotation (Cattell, 1966). Subsequently, we performed confirmatory

Table 1
Meal preparation literacy scale for guardians of schoolchildren.

Knowledge of a healthy diet (2 items)
Do you know about the
1 diet with well-balanced nutrient intake?
2 dishes that are the staple food, main dish, and side dishes in the Japanese-style diet?
Ability to prepare meals for children (3 items)
Do you find it difficult to prepare a meal for your child/children
3 with more than five fresh ingredients?
4 with well-balanced nutrient intake?
5 consisting of a staple food, main dish, and side dishes in a Japanese-style diet even using delicatessen food?
Attitude towards providing a healthy diet to children (2 items)
6 Is a diet with well-balanced nutrient intake important for the growth of children?
7 Do you try to prepare a meal for your child/children consisting of a staple food, main dish, and side dishes in a Japanese-style diet for your child/children?
Affordability of healthy foods (1 item)
8 Have you ever reduced your amount spent on purchasing healthy foods (e.g., vegetables or fruits) because of their cost?
Ability to plan meals for children (1 item)
9 If you prepare a meal for your child/children, do you take into account what they have eaten earlier that day or will eat later that day?

factor analysis (CFA) using structural equation modeling (SEM) to determine the model fit due to the comparative fit index (CFI), Tucker-Lewis index (TLI), and with the root mean square error of approximation (RMSEA).

EFA results showed that the questions loaded to mainly three factors (Table 2). One factor included two items related to knowledge regarding a healthy diet (no. 1–2). The second had three items related to the ability to prepare meals for children (no. 3–5). The third had two items related to the attitude toward preparing healthy meals (nos. 7 and 9). The remaining two questions referred to the meal preparation attitude (no. 6) and food affordability (no. 8), and were independent from other factors. We named the first, second, and third factors as “knowledge”, “skills”, and “attitude”. Fig. 1 presents the CFA results for this model. For this model, the RMSEA was 0.048 (95%CI = 0.035–0.062), suggesting a close fit (Barrett, 2007; Hu and Bentler, 1999), with CFI of 0.992 and TLI of 0.984, which indicated relatively good model–data fit (Barrett, 2007; Hu and Bentler, 1999). The answers to the seven questions categorized as knowledge, skills, and attitude were calculated as a total score, with higher scores indicating better literacy regarding meal preparation for children. Table 3 demonstrates the sum of the total scores of the seven questions by quartiles. The total scores of each group were as follows: Q1, ≤ 21 ; Q2, 22–25; Q3, 26–29; and Q4, ≥ 30 scores.

2.3. Intake of selected food groups of school children and burden of meal preparation

We evaluated the consumption of the following selected food groups at least twice a day among schoolchildren before, during, and after COVID-19 SOE: 1. milk and dairy products, 2. meat, fish, or eggs, 3. vegetables, and 4. fruits. Additional information regarding the questions has been reported elsewhere (Horikawa et al., 2021). The Japanese-style diet predominantly involves grains, protein-rich foods (e.g., fish and meat), and vegetables (Kakutani et al., 2015; Koyama et al., 2016). Rice forms a key component of the Japanese diet (Food and Agriculture Organization of the United Nations, 2014; Kumakura, 2014), whereas fruits are eaten less frequently (almost one-third to half) compared to the Western countries (Food and Agriculture Organization of the United Nations, 2014). We defined “well-balanced dietary intake” as intake of meat, fish, or eggs and vegetables in one meal. In addition, we evaluated the prevalence of consumption of all of the aforementioned food groups, which should ideally be at least twice a day. We defined well-balanced dietary intake as noted above, as a previous research reported that individuals with high consumption (≥ 1.75 times/day) of such a diet were found to have increased levels of protein, n-6 and n-3 polyunsaturated fats, total, soluble, and insoluble dietary fibers, vitamins A, K, C, B₁, B₂, B₅, and B₉, K, Ca, Mg, Fe, and Cu, whereas they had lower intake of carbohydrate (Kakutani et al., 2015). Another previous study reported that individuals with high consumption of a well-balanced diet were at a reduced risk of having inadequate dietary intake compared to the recommended dietary allowance for vitamins A and C, and Ca, and had an adequate intake of K compared to individuals with less consumption of a

Table 2

Questions related to food preparation loaded to 3 factors by exploratory factor analysis.

No. of question	Factor 1 Knowledge	Factor 2 Skills	Factor 3 Attitude	Uniqueness
No. 1	0.9740	0.0151	-0.0511	0.0795
No. 2	0.8313	0.0136	0.0444	0.2628
No. 3	-0.0103	0.7957	-0.0191	0.3894
No. 4	0.0260	0.8951	-0.0507	0.2210
No. 5	0.0311	0.6879	0.0862	0.4356
No. 6	-0.0146	-0.1507	0.0876	0.9819
No. 7	-0.0234	-0.0294	0.9932	0.0618
No. 8	-0.0529	0.2831	0.0250	0.9245
No. 9	0.0916	0.1218	0.3142	0.8031

well-balanced diet (Koyama et al., 2016). The Ministry of Environment in Japan reported that an average of 6.9% of school lunch food is wasted (Ministry of Environment in Japan, 2015), which equates to a single serving of a well-balanced diet (Ministry of Education, Culture, Sports, Science and Technology, Japan, 2018a, 2018b); the school lunches provide schoolchildren with vegetables as well as meat, fish, or eggs (Ministry of Education, Culture, Sports, Science and Technology, Japan, 2018a, 2018b). Menus of school lunch are handed out monthly to their children’s households by their classroom teacher so that parents are aware of what their children are eating at school (National Institute for Educational Policy Research, 2013).

The burden of preparing meals was measured using the following questions: (i) I have less time to prepare meals than before the SOE, (ii) I have more time to prepare meals than before the SOE, (iii) I have less mental capacity to prepare meals, (iv) I have more mental capacity to prepare meals, (v) I have a lower economic capacity for choosing or consuming foods and meals, and (iv) the above situations are not applicable to me. These questions were developed for use in this study.

2.4. Socioeconomic, sociodemographic, and anthropometric data

We categorized household income for the year 2020, including salary, benefits, family allowance, and rental income, into (i) < 1 million JPY, (ii) 1–2 million JPY, (iii) 2–3 million JPY, (iv) 3–4 million JPY, (v) 4–5 million JPY, (vi) 5–6 million JPY, (vii) 6–7 million JPY, (viii) 7–8 million JPY, (ix) 8–10 million JPY, (x) ≥ 10 million JPY, or (xi) do not wish to answer. We determined the equivalent household income as household income divided by the square root of the number of household members (Horikawa et al., 2021). The representative income used for analysis was the midpoint for each category (0.5, 1.5, 2.5, 3.5, 4.5, 5.5, 6.5, 7.5, 9, and 11 million JPY) (Poelman et al., 2018). The equivalent household income was categorized into quartiles for the respective municipality (i.e., Q1, Q2, Q3, and Q4) with mean incomes of 5.0 ± 1.0 , 3.6 ± 0.7 , 2.8 ± 0.9 , and 1.7 ± 0.9 million JPY, respectively. According to the Ministry of Health, Labour and Welfare of Japan, in 2018, poverty was defined as income of less than 1.3 million JPY, with 15.4% people living below this level (Ministry of Health and Labour and Welfare of Japan, 2019). Therefore, the household income of Q4 was close to the poverty line.

We also recorded the sex, economic status after COVID-19 SOE, and educational level of the guardians. The state of life after the COVID-19 SOE was categorized as worse, similar, or better than before the SOE. The educational level of guardians was categorized as (i) less than high school, (ii) high school, (iii) vocational, (iv) junior college, (v) university/graduate school, (vi) the father/mother do not live with the child, or (vii) do not know/do not want to answer. Body mass index (BMI) of children was calculated based on the height and body weight reported by the guardian according to the status in December 2020. The height, weight, and BMI percentiles were based on the values recommended by The Japanese Society of Pediatric Endocrinology and The Japanese Association for Human Auxology [32–24].

2.5. Statistical analysis

The weights of participants were grouped into their municipality so that the different areas of residence were used to represent the general population. Categorical data are presented as percentages and numerical data are presented as means with standard deviation (SD) or 95% confidence interval (CI). Categorical and numerical data were compared using χ^2 test and one-way ANOVA, respectively. We evaluated for differences in meal preparation based on the literacy regarding meal preparation for children before and after the COVID-19 SOE. We used Poisson regression analysis (PRA) for the calculation of relative risk increases (RRIs) and 95% CIs by conducting a quartile analysis with the highest total scores of literacy of meal preparation for children (Q4) as the referent. To evaluate the differences in schoolchildren’s intake of

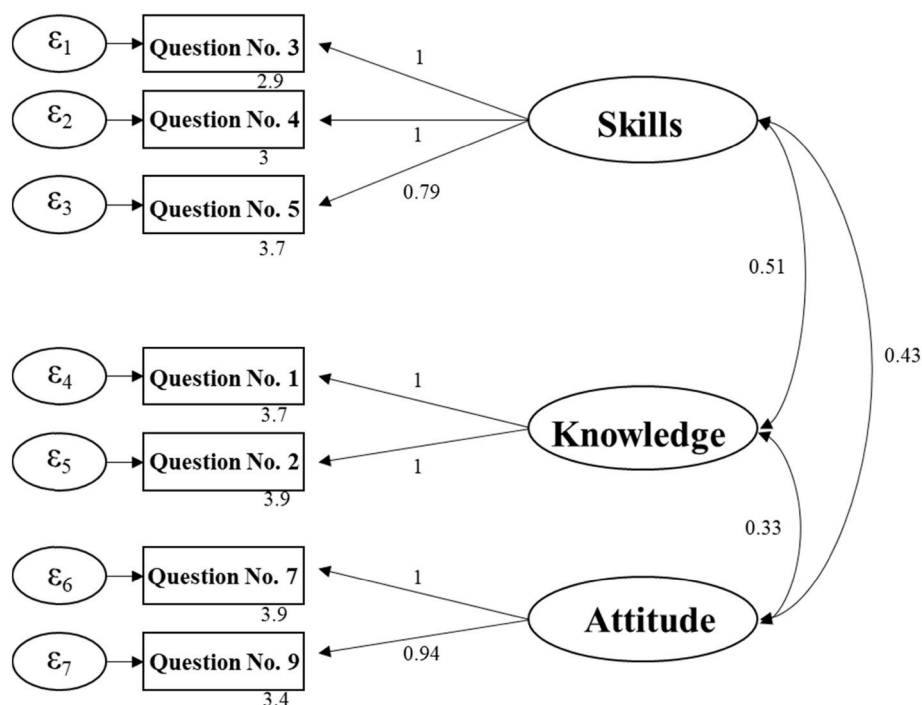


Fig. 1. Questions related to food preparation loaded to 3 factors by confirmatory factor analysis.

Table 3

Prevalence of total scores of knowledge, skills, and attitude for meal preparation among guardians of 10–14-year-old Japanese pupils after COVID-19 SOE.

Total scores		N	%
Q1	≤21 scores	294	26.6
Q2	22–25 scores	271	24.5
Q3	26–29 scores	271	24.5
Q4	≥30 scores	271	24.4

Participants were weighted by the population of the municipality where each participant resides.

well-balanced dietary intake between different levels of guardians' food literacy for meal preparation for children during and after COVID-19 SOE, we used PRA to calculate the RRI and 95% CIs by dividing total scores of literacy of meal preparation for children into quartiles. The proportions of school children's intake of well-balanced dietary intake during and after COVID-19 SOE were compared to the point before COVID-19 SOE (i.e., the reference). Data were adjusted for sex, age (10–11 or 13–14 years old), BMI (continuous), quartiles of equivalent income adjusted for the equivalent income and number of household members, and educational attainment levels of guardians. Two-sided p-values < 0.05 indicated statistical significance. Statistical analysis was performed using SPSS software (version 27; IBM Corp., Armonk, NY, USA).

3. Results

A total of 1107 schoolchildren aged 10–14-year-old were included in the analysis. Their mean BMI was 18.6 ± 3.1 kg/cm² and the proportion of boys was 49.0%. The comparison of percentage distribution of annual household incomes of respondents for 2020 with representative data from similar households for 2019 (Ministry of Health and Labour and Welfare of Japan, 2019) showed that 1.1 and 1.8%, 3.2 and 4.4%, 5.4 and 5.7%, 7.7 and 6.4%, 12.1 and 9.7%, 11.4 and 12.4%, 10.9 and 13.0%, 12.1 and 11.0%, 15.1 and 15.3%, and 20.8 and 20.3% earned <1 million JPY, 1–2 million JPY, 2–3 million JPY, 3–4 million JPY, 4–5 million JPY, 5–6 million JPY, 6–7 million JPY, 7–8 million JPY, 8–10

million JPY, and ≥10 million JPY, respectively. The annual household incomes of the study participants did not differ from those of the Japanese households in 2019.

There were significant differences between the quartiles of total scores of knowledge, skills, and attitude for preparing meals in terms of sex, number of family members, annual household income, equivalent income adjusted for the number of household members, economical status after COVID-19 SOE, and educational level of the guardians (all $p < 0.001$) (Table 4). Participants with lowest quartile of equivalent income adjusted for the number of household members had prevalences of 15.6%, 18.2%, 22.1%, and 26.8% among those in Q1 (lowest score group), Q2, Q3, and Q4 (highest score group), respectively. Significant differences were observed in participants with different total scores of knowledge, skills, and attitude for preparing meals in terms of height, weight, and BMI ($p < 0.001$), however, the differences between quartiles were small.

Table 5 and Fig. 2 present the meal quality of pupils by quartiles of total scores of knowledge, skills, and attitude for meal preparation before, during, and after the COVID-19 SOE. In pupils with all total score levels, the intakes of vegetables, meat, fish, or eggs, milk and dairy products, and fruits was lower during compared to before the COVID-19 SOE. The intake did not differ between before and after the SOE in the four total score levels.

Table 6 and Fig. 3 present the associations between quartiles of total scores of knowledge, skills, and attitude for meal preparation and frequency of well-balanced dietary intake in Japanese pupils before, during, and after the COVID-19 SOE. Compared to before the SOE, significantly less percentage of children consumed a well-balanced diet during the SOE in all quartiles (RRI [95% CI], Q1: -40.6% [-41.4% to -39.8%], $p < 0.001$; Q2: -34.0% [-34.7% to -33.3%], $p < 0.001$; Q3: -13.2% [-13.9% to -12.6%], $p < 0.001$; and Q4: -15.3% [-16.0% to -14.7%], $p < 0.001$; using confounder-adjusted PRA). In addition, lower total scores correlated with greater decline from before the SOE (p [vs. Q4] of Q1–Q3 were all < 0.001). The proportion of individuals eating a well-balanced diet at least twice a day in all total score quartiles was significantly different after compared to before the SOE; however, the differences were small (Q1: 3.7% [3.0% – 4.5%], $p < 0.001$, Q2: 3.0% [2.3% – 3.6%], $p < 0.001$, Q3: 0.8% [0.2% – 1.4%], $p = 0.012$, and Q4:

Table 4

Characteristics of participants according to quartiles of total scores of knowledge, skills, and attitude for meal preparation: 10–14-year-old schoolchildren in Japan.

		Total scores				p †
		Q1	Q2	Q3	Q4	
		≤21 scores	22–25 scores	26–29 scores	≥30 scores	
		N = 294	N = 271	N = 271	N = 271	
		%	%	%	%	
Sex	Boys	53.0%	47.3%	46.0%	49.4%	<0.001
	Girls	47.0%	52.7%	54.0%	50.6%	
Number of family members	2	7.2%	4.2%	7.7%	3.8%	<0.001
	3	13.0%	19.1%	10.2%	21.1%	
	4	41.1%	41.3%	48.4%	39.9%	
	5	24.7%	24.3%	21.9%	27.2%	
	6	10.4%	7.6%	9.7%	4.7%	
	7 and over	3.6%	3.5%	2.0%	3.3%	
Household annual income (million yen)	<1	1.1%	3.0%	0.1%	0.2%	<0.001
	1 to < 2	6.4%	2.6%	2.1%	1.5%	
	2 to < 3	6.9%	6.9%	6.0%	1.6%	
	3 to < 4	12.0%	7.7%	6.2%	4.8%	
	4 to < 5	17.8%	16.0%	7.0%	7.6%	
	5 to < 6	15.2%	13.0%	7.6%	9.8%	
	6 to < 7	14.1%	9.0%	13.9%	6.7%	
	7 to < 8	9.3%	9.7%	17.9%	11.5%	
	8 to < 10	7.9%	19.1%	14.3%	20.0%	
	≥10	9.3%	12.9%	25.0%	36.4%	
Equivalent income adjusted for the number of household members	Q1 (highest)	20.4%	25.4%	34.0%	44.2%	<0.001
	Q2	24.2%	19.2%	22.6%	23.8%	
	Q3	28.7%	33.2%	25.2%	16.3%	
	Q4 (lowest)	26.8%	22.1%	18.2%	15.6%	
Economical circumstance of life after COVID-19 SOE	Worse than before the SOE	35.7%	27.3%	22.3%	17.6%	<0.001
	No different than before the SOE	58.4%	64.3%	74.2%	78.9%	
	Better than before the SOE	2.8%	5.5%	3.5%	2.1%	
	Don't want to answer	3.1%	2.9%	0.0%	1.4%	
Educational level of mother	Less than high school	5.7%	1.2%	1.5%	4.6%	<0.001
	High school	35.3%	23.9%	20.0%	15.9%	
	Vocational	20.7%	24.9%	17.1%	14.0%	
	Junior college	18.8%	25.9%	20.9%	19.3%	
	University/graduate school	18.3%	23.9%	40.0%	46.1%	
	Not living with the child/Do not want to answer	1.3%	0.1%	0.6%	0.0%	
Educational level of father	Less than high school	8.5%	4.9%	4.6%	4.4%	<0.001
	High school	31.9%	32.6%	24.4%	18.0%	
	Vocational	14.2%	10.7%	14.1%	7.2%	
	Junior college	1.6%	2.6%	2.3%	0.7%	
	University/graduate school	36.2%	44.1%	51.0%	65.9%	
	Not living with the child/Do not know/Do not want to answer	7.6%	5.0%	3.6%	3.8%	
Physique of child ^a						
Height (cm)	Mean ± SD	149.8 ± 11.3	150.8 ± 11.5	150.8 ± 10.4	152.5 ± 11.7	<0.001 ‡
	<3%	2.3%	4.0%	4.0%	2.9%	<0.001
	3–10%	7.7%	5.9%	4.3%	5.1%	
	10–25%	15.1%	16.2%	15.9%	16.9%	
	25–50%	31.1%	24.3%	16.8%	25.2%	
	50–75%	22.8%	22.6%	30.4%	23.5%	
	75–90%	11.3%	15.4%	18.6%	11.4%	
	90–97%	5.3%	7.4%	8.7%	9.2%	
	≥97%	4.5%	4.2%	1.3%	5.7%	
Weight (kg)	Mean ± SD	42.6 ± 11.7	42.2 ± 10.8	43.2 ± 10.1	43.5 ± 10.7	<0.001 ‡
	<3%	1.7%	3.9%	3.5%	3.9%	<0.001
	3–10%	11.0%	11.1%	7.0%	8.0%	
	10–25%	16.5%	16.7%	13.5%	17.1%	
	25–50%	27.3%	25.2%	28.0%	27.7%	
	50–75%	21.5%	22.7%	26.7%	26.2%	
	75–90%	11.9%	13.0%	11.8%	12.0%	
	90–97%	6.4%	6.5%	6.6%	3.5%	
	≥97%	3.6%	0.9%	2.8%	1.6%	
BMI (kg/m ²)	Mean ± SD	18.8 ± 3.5	18.2 ± 2.6	18.8 ± 3.6	18.5 ± 2.6	<0.001 ‡
	<3%	6.8%	3.8%	3.0%	6.5%	<0.001
	3–10%	6.1%	8.9%	6.7%	5.1%	
	10–25%	18.6%	18.6%	17.3%	19.3%	
	25–50%	21.1%	26.1%	25.9%	24.6%	
	50–75%	22.8%	24.7%	23.8%	28.2%	
	75–90%	13.4%	12.3%	14.8%	13.5%	
	90–97%	7.9%	5.8%	7.0%	1.9%	
	≥97%	3.3%	0.0%	1.5%	0.9%	

Scores mean the prevalence of total scores of knowledge, skills, and attitude for meal preparation of the guardians of 10–14-year-old Japanese pupils after COVID-19 SOE. The details were shown in 2.2. Literacy of Meal Preparing for Children of Materials and Methods section.

†P-value for χ^2 test among quartiles of total scores of knowledge, skills, and attitude of burden of meal preparation.

‡P-value for one-way analysis of variance test among quartiles of total scores of knowledge, skills, and attitude of burden for meal preparation.

Participants were weighted by the population of the municipality where each participant resides.

^a Height, weight, and BMI percentiles were based on the values recommended by The Japanese Society of Pediatric Endocrinology and The Japanese Association for Human Auxology (Kato et al., 2004; Kato et al., 2011; The Japanese Society of Pediatric Endocrinology, 2011).

Table 5

Dietary intakes of participants according to the quartiles of total scores of knowledge, skills, and attitude for meal preparation: 10–14-year-old Japanese pupils before, during, and after COVID-19 SOE.

	Total Scores		Before the SOE		During the SOE		After the SOE		p
			N	%	N	%	N	%	
Milk and dairy products	Q1 (≤ 21 scores)	(N = 294)	202	68.6%	112	38.0%	212	72.1%	<0.001
	Q2 (22–25 scores)	(N = 271)	199	73.5%	119	43.8%	208	76.8%	<0.001
	Q3 (26–29 scores)	(N = 271)	223	82.4%	130	47.9%	234	86.2%	<0.001
	Q4 (≥ 30 scores)	(N = 271)	212	78.4%	153	56.6%	220	81.3%	<0.001
Meat, fish, or eggs	Q1 (≤ 21 scores)	(N = 294)	265	90.1%	199	67.6%	270	91.7%	<0.001
	Q2 (22–25 scores)	(N = 271)	256	94.5%	212	78.2%	262	96.6%	<0.001
	Q3 (26–29 scores)	(N = 271)	266	98.0%	243	89.8%	268	99.1%	<0.001
	Q4 (≥ 30 scores)	(N = 271)	270	99.7%	243	89.5%	271	99.9%	<0.001
Vegetables	Q1 (≤ 21 scores)	(N = 294)	243	82.6%	168	57.0%	246	83.5%	<0.001
	Q2 (22–25 scores)	(N = 271)	238	87.7%	179	65.9%	245	90.3%	<0.001
	Q3 (26–29 scores)	(N = 271)	267	98.5%	244	90.0%	268	98.8%	<0.001
	Q4 (≥ 30 scores)	(N = 271)	270	99.5%	251	92.7%	264	97.4%	<0.001
Fruits	Q1 (≤ 21 scores)	(N = 294)	75	25.5%	24	8.3%	89	30.2%	<0.001
	Q2 (22–25 scores)	(N = 271)	74	27.4%	17	6.2%	88	32.5%	<0.001
	Q3 (26–29 scores)	(N = 271)	105	38.9%	43	15.7%	118	43.4%	<0.001
	Q4 (≥ 30 scores)	(N = 271)	117	43.0%	52	19.4%	137	50.6%	<0.001
Do not eat any of the above	Q1 (≤ 21 scores)	(N = 294)	13	4.3%	64	21.6%	13	4.4%	<0.001
	Q2 (22–25 scores)	(N = 271)	12	4.4%	38	14.0%	6	2.3%	<0.001
	Q3 (26–29 scores)	(N = 271)	0	0.0%	9	3.5%	0	0.0%	<0.001
	Q4 (≥ 30 scores)	(N = 271)	0	0.1%	7	2.6%	0	0.1%	<0.001

P-value for χ^2 test among quartiles of total scores of knowledge, skills, and attitude of burden for meal preparation.

Participants were weighted by the population of the municipality where each participant resides.

SOE: state of emergency.

–1.9% [–2.6% to –1.3%], $p < 0.001$). Compared to Q2–4, before, during, and after the SOE, the proportion in Q1 of a well-balanced dietary intake was particularly low. Furthermore, the percentage of children with consumption of well-balanced dietary intake was significantly low in Q1 and Q2 during the SOE (Q1: 51.8%, Q2: 62.2%, Q3: 85.1%, and Q4: 85.2%). These results remained similar when the data were adjusted for equivalent income and educational level of schoolchildren's guardians.

Table 7 and Fig. 4 show the associations of total scores of knowledge, skills, and attitude for preparing meals with the burden experienced by guardians in meal preparation after the COVID-19 SOE. Those with lower total scores of knowledge, skills, and attitude for preparing meals (Q1–3) more frequently responded with “I have less time to prepare meals than before the SOE”, and those with Q1 and Q2 had particularly high rates (Q1: 98.1% [96.2%–100.0%], $p < 0.001$; Q2: 88.9% [87.0%–90.9%], $p < 0.001$; and Q3: 20.4% [18.2%–22.6%], $p < 0.001$, using PRA). Furthermore, the guardians responded less frequently with “I have more time to prepare meals than before the SOE” (Q1: –83.0% [–84.5% to –81.5%], $p < 0.001$; Q2: –54.0% [–55.4% to –52.6%], $p < 0.001$; and Q3: –37.1% [–38.4% to –35.8%], $p < 0.001$) and “I have more mental capacity to prepare meals” (Q1: –125.1% [–127.0% to –123.3%], $p < 0.001$; Q2: –141.7% [–143.8% to –139.7%], $p < 0.001$; and Q3: –61.5% [–63.0% to –59.9%], $p < 0.001$). In Q1 and Q2, respondents more frequently responded with “I have less mental capacity to prepare meals” (Q1: 63.0% [61.4%–64.6%], $p < 0.001$ and Q2: 80.7% [79.1%–82.2%], $p < 0.001$); in comparison, respondents in Q3 responded less frequently with Q4 (–7.1% [–9.0% to –5.2%], $p < 0.001$). Respondents in Q1–3 responded more frequently with “I have a lower economic capacity for choosing or consuming foods and meals” (Q1: 138.4% [136.3%–140.6%], $p < 0.001$; Q2: 129.2% [127.0%–131.4%], $p < 0.001$; and Q3: 78.2% [75.9%–80.6%], $p < 0.001$) compared to those with high total scores (Q4). These results remained similar when the analyses were adjusted by equivalent income and educational level of schoolchildren's guardians.

4. Discussion

The daily life worldwide has been influenced by the COVID-19 pandemic (International Monetary Fund, 2021a; World Health Organization, 2021a, 2021b). In Japan, provision of school lunches was disrupted due to the temporary school closures implemented by the COVID-19 SOE (Ministry of Education Culture, Sports, Science and Technology, Japan, 2021b). To the best of our knowledge, we are the first to evaluate the association of meal quality provided to schoolchildren and food literacy for meal preparation of their guardians before, during, and after the COVID-19 SOE. Compared to before the SOE, the consumption of well-balanced dietary intake was less frequent during the SOE in Japanese schoolchildren, which improved after the SOE ended, irrespective of the total scores of knowledge, skills, and attitude for meal preparation. Fruits, meat, fish, or eggs, vegetables, and milk and dairy products were consumed less frequently during compared to before the SOE in all four total score levels; in addition, the consumption pattern improved to the same value as before the SOE once the state was over. The aforementioned decline was larger for pupils with low total scores during the SOE. We found that the meal quality for schoolchildren declined during the SOE, thereby highlighting the importance of school lunches in providing adequate nutritional intake (Asakura and Sasaki, 2017).

Changes in dietary intake of schoolchildren before and during the COVID-19 pandemic have been reported from several countries, with inconsistent results. With the exception of our study, no study to date has examined the dietary intake of children after the declaration of SOE. According to previous studies of differences in dietary intake of schoolchildren before and during the COVID-19 SOE, schoolchildren had more frequent consumption of fruits and vegetables while attending the classes remotely during compared to before the COVID-19 pandemic (Kolota and Głabaska, 2021; Ruiz-Roso et al., 2020). Half of the Italian population aged 4–14 years old reported unchanged dietary habits (50.9%), but 20.5% of participants had greater consumption of sweets during the COVID-19 lockdown (Docimo et al., 2021). Palestinian research showed that food quantity and quality were reduced during compared to before the COVID-19 pandemic (Radwan et al., 2021).

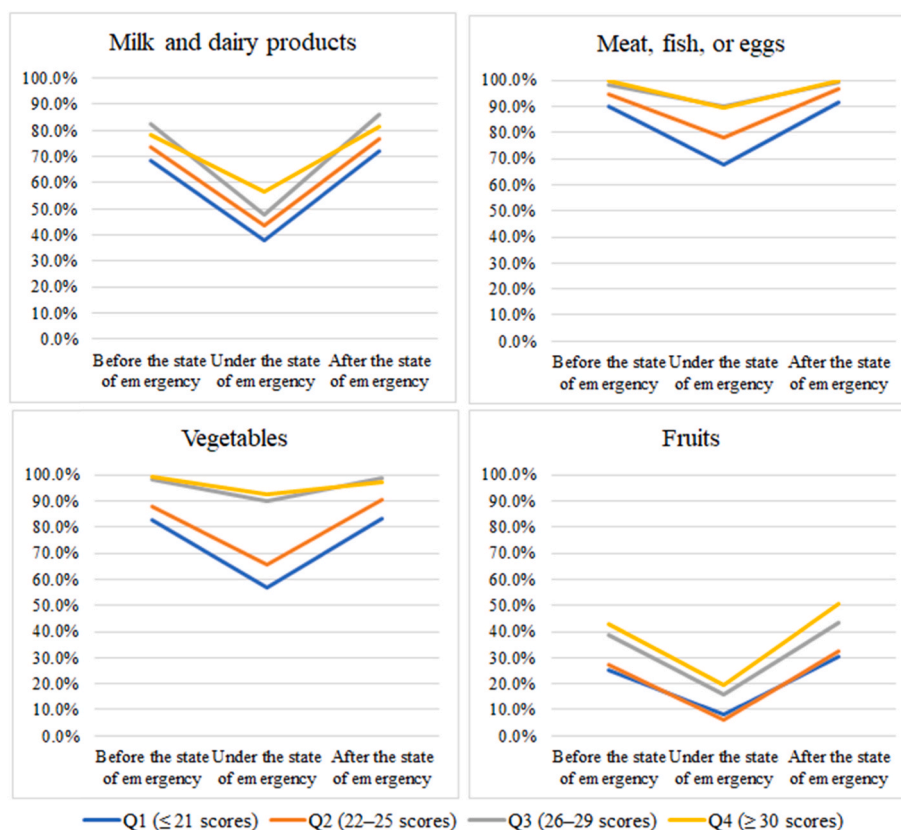


Fig. 2. Total scores of knowledge, skills, and attitude for meal preparation and prevalence of dietary intake at least twice a day: 10–14-year-old Japanese pupils before, during, and after COVID-19 SOE.

Conversely, several studies pointed out that socioeconomic disparity is one of the main factors influencing the difference in the degree of change in children's dietary intake before the COVID-19 pandemic and during the SOE. Our previous research showed significantly reduced percentage of Japanese schoolchildren with well-balanced dietary intake in the lower-income than higher-income households before and during the SOE adjusted by sex, age, BMI, household size, and parents' educational level (Horikawa et al., 2021). This study suggested that children in low-income households during the SOE were consuming poor quality lunches as an alternative to school lunches and had greater difficulty in obtaining healthy foods compared to the children in high-income households. A study from Palestine (Radwan et al., 2021) found that participants aged 6–18 years from the higher income group had better food quality compared to the low and moderate-income groups; in addition, the food quality improved during the COVID-19 pandemic in the group with the lowest and highest income groups. Diet quality was higher in the group with smaller household size and increased during the COVID-19 pandemic. As for the scores for food quantity, the lower household income groups had a lower score, which decreased significantly during the COVID-19 pandemic. The scores for food quantity also decreased during the COVID-19 pandemic in the group with low parental educational level. This study implied that some students shifted from unhealthy foods to healthy foods due to the government-led health initiatives in the schools before and during the COVID-19 pandemic, including providing education regarding consuming healthy foods and home-cooked meals, while students with

low socioeconomic level had difficulty in consuming healthy foods. A study from Italy reported that the participants with low socioeconomic status, including low income, parental unemployment or furlough, poor economic status, and low education level, had significantly increased risk of worrying about food supplies, running out of food, and increasing quantity of food intake (Dondi et al., 2020). This study shows the importance of measures to avoid food insecurity, especially among low socioeconomic status families.

Our current study showed that schoolchildren had less frequent well-balanced dietary intake at least twice a day in case of low-food literacy of guardians during compared to before the SOE, even after adjustment for household income level and guardians' educational level. Low food literacy is associated with low socioeconomic status (Azevedo Perry et al., 2017; Krause et al., 2018). However, socioeconomic status does not always indicate the health literacy (Carbone and Zoellner, 2012). Our results suggest that, beyond economic disparity, parental low food literacy itself leads to low food quality among children. Additionally, parental dietary habits and feeding strategies, including food literacy, are one of the major determinants of a child's eating behaviour and food choices (Scaglioni et al., 2018; Wijayarathne et al., 2022). Thus, a high level of parental food literacy contributes to the healthy physical and mental growth of children (Eccles, 1999; Westenhoefer, 2002). Educating and providing a supportive environment to guardians for improving their food literacy for meal preparation, including food knowledge, skills, and attitude, are needed, especially for those with low food literacy, to ensure that schoolchildren receive adequate food and

Table 6

Poisson regression analysis of total scores of knowledge, skills, and attitude for meal preparation and prevalence of “well-balanced dietary intake” at least twice a day: 10–14-year-old Japanese pupils before, during, and after COVID-19 SOE.

Total Scores		Before the SOE	During the SOE			Interaction P (vs. Q1)	After the SOE			Interaction P (vs. Q4)
			RRI, % (95% CI)		<i>p</i>		RRI, % (95% CI)	<i>p</i>		
Q1 (≤21 scores)	Prevalence (%)	77.7%	51.8%				80.7%			
	Not adjusted	Ref	−40.6%	(−41.4% to −39.9%)	<0.001	–	3.7%	(3.0% to 4.3%)	<0.001	–
	Adjusted ^a	Ref	−40.6%	(−41.4% to −39.9%)	<0.001	–	3.7%	(3.0% to 4.3%)	<0.001	–
Q2 (22–25 scores)	Further adjusted ^b	Ref	−40.6%	(−41.4% to −39.8%)	<0.001	–	3.8%	(3.0% to 4.5%)	<0.001	–
	Prevalence (%)	87.4%	62.2%				90.1%			
	Not adjusted	Ref	−34.0%	(−34.7% to −33.3%)	<0.001	<0.001	3.0%	(2.3% to 3.6%)	<0.001	<0.001
Q3 (26–29 scores)	Adjusted ^a	Ref	−34.0%	(−34.7% to −33.3%)	<0.001	<0.001	3.0%	(2.3% to 3.6%)	<0.001	<0.001
	Further adjusted ^b	Ref	−34.0%	(−34.7% to −33.3%)	<0.001	<0.001	3.0%	(2.3% to 3.6%)	<0.001	<0.001
	Prevalence (%)	97.1%	85.1%				97.9%			
Q4 (≥30 scores)	Not adjusted	Ref	−13.2%	(−13.9% to −12.6%)	<0.001	<0.001	0.8%	(0.2% to 1.4%)	0.012	<0.001
	Adjusted ^a	Ref	−13.2%	(−13.9% to −12.6%)	<0.001	<0.001	0.8%	(0.2% to 1.4%)	0.012	<0.001
	Further adjusted ^b	Ref	−13.1%	(−13.8% to −12.4%)	<0.001	<0.001	0.8%	(0.1% to 1.4%)	0.019	<0.001
Q4 (≥30 scores)	Prevalence (%)	99.3%	85.2%				97.4%			
	Not adjusted	Ref	−15.3%	(−16.0% to −14.7%)	<0.001	<0.001	−1.9%	(−2.6% to −1.3%)	<0.001	<0.001
	Adjusted ^a	Ref	−15.3%	(−16.0% to −14.7%)	<0.001	<0.001	−1.9%	(−2.6% to −1.3%)	<0.001	<0.001
	Further adjusted ^b	Ref	−15.3%	(−16.0% to −14.7%)	<0.001	<0.001	−2.0%	(−2.6% to −1.3%)	<0.001	<0.001

“Well-balanced dietary intake” was defined when as consumption of meat, fish, or eggs and vegetables at least twice a day.

Participants were weighted by the population of the municipality where each participant resides.

SOE: state of emergency; RRI: relative risk increase.

^a Adjusted for sex (boys and girls), age (10–11 or 13–14 years old), and BMI (continuous).

^b Adjusted for sex (boys and girls), age (10–11 or 13–14 years old), BMI (continuous), equivalent income adjusted for the number of household members (quartile), educational level of mother (less than high school, high school, vocational, college, and university/graduate school), and educational level of father (less than high school, high school, vocational, college, and university/graduate school).

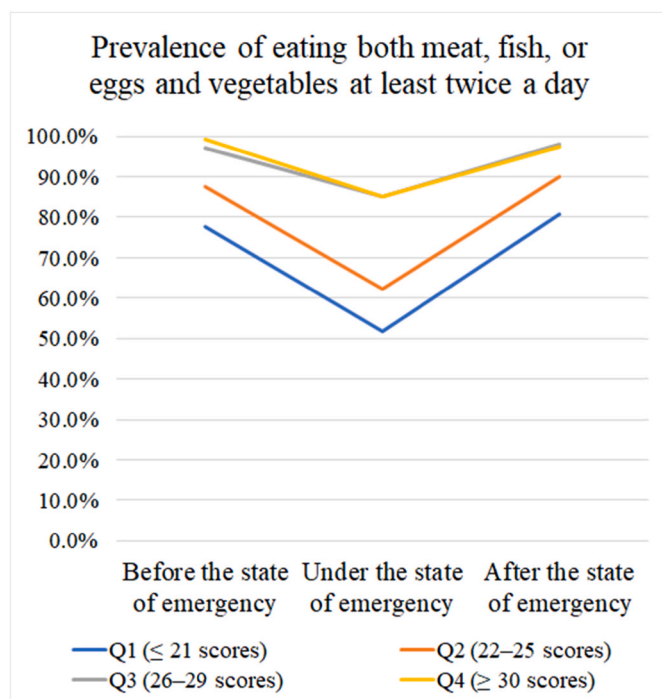


Fig. 3. Total scores of knowledge, skills, and attitude for meal preparation and prevalence of well-balanced dietary intake at least twice a day: 10–14-year-old schoolchildren in Japan before, during, and after COVID-19 SOE.

nutrient intake.

The COVID-19 pandemic is ongoing and many issues need to be addressed to control the current situation. Despite the poor quality of meal preparation by children's guardians during the SOE, schoolchildren whose guardians' food literacy levels were low had particularly inadequate dietary intakes compared to those whose guardians had high food literacy levels; this trend continued during the pandemic. After the SOE ended, meal quality returned to that before the SOE; however, lunches were often prepared and eaten at home (Brancaccio et al., 2021) despite school lunches being resumed (Ministry of Education Culture, Sports, Science and Technology, Japan, 2021b), due to ongoing restrictions and choices regarding the use of food facilities (Ministry of Health, Labour and Welfare, Japan, 2021).

Our study also revealed the relationship between food literacy for meal preparation by schoolchildren's guardians and their sense of burden for meal preparation after the COVID-19 SOE. Guardians with low level of food literacy for meal preparation had significantly reduced time, mental capacity, and financial ability to prepare the appropriate meals compared to those with high level of food literacy for meal preparation. In case of prolonged deterioration in living conditions, such as during the pandemic, schoolchildren, especially those whose guardians' have low food literacy levels, will have greater difficulties in maintaining adequate nutrient consumption necessary for physical and mental growth (Eccles, 1999; Westenhofer, 2002), and guardians will feel a heightened sense of burden of food preparation. To maintain health, prevent diseases, and avoid immune suppression during the pandemic, adequate food supply (Brooks et al., 2020) and consumption of adequate quantity of essential micronutrients, including vitamins and minerals (Scudiero et al., 2021), are necessary. These disparities between schoolchildren should be addressed by implementing effective nutritional policies, including uninterrupted provision of school lunches and food supplies despite school closure (U.S. Department of Agriculture, 2021). Further research is necessary to evaluate the impact of food literacy of schoolchildren's guardians on meal quality during the COVID-19 pandemic as well as methods to ensure adequate food and nutrient intake in schoolchildren, regardless of food literacy level of

their guardians. Furthermore, children, who will be the future parents, need to be educated regarding food literacy including the ability to make well-balanced meal choices and cooking skills to ensure better food security in the future.

Several limitations of this study should be discussed: First, the quantity of food, energy, and nutrient intake was not assessed because our objective was to determine the level of consumption of selected food groups. Second, we used self-reported values, which may have led to inaccurate results. Previous research has reported that because of obesity and the desire to lose weight, individuals sometimes under-report their energy intake and those with a high BMI may under-report their protein, sodium, and potassium intakes (Johansson et al., 1998; Murakami et al., 2008, 2016). Third, although 51.7% of the children and their guardians volunteered to complete the questionnaire, only 36.9% did so. However, we selected a nationally representative sample from Japan using stratified two-stage clustering and identified households with school children in the fifth (aged 10–11 years) and second grade of school (aged 13–14 years). Finally, the current study did not examine the interaction of food literacy with other variables, including income and education level. It has been reported that the number of parameters $\times 10$ is a reasonable number of participants for multiple regression analysis (Peduzzi et al., 1995). The additional adjusted analyses of the current study included the following parameters: total score of guardians' food literacy (quartile), sex (boys and girls), age (10–11 or 13–14 years), BMI (continuous), equivalent income adjusted for the number of household members (quartile), educational level of mother (less than high school, high school, vocational, college, and university/graduate school), and educational level of father (less than high school, high school, vocational, college, and university/graduate school). To further investigate the interactions between income and health literacy, we would require over 3000 participants with at least 200 samples in each strata. Therefore, we did not conduct stratified analyses because the number of subjects in each analysis was much smaller than the sample size required for analysis according to income quartiles.

In conclusion, the literacy of meal preparation for schoolchildren by their guardians was related to the meal quality before, during, and after the COVID-19 SOE. Food literacy level of guardians was also related to their sense of burden for preparing meals after the SOE. During the SOE, the proportion of well-balanced dietary intake in Japanese schoolchildren was less frequent than that prior to the SOE; however, after the SOE ended, the prevalence returned to that before the SOE in all food literacy levels. The proportion of pupils consuming a well-balanced dietary intake was particularly low among those with guardians with low total scores of food literacy before, during, and after the SOE compared to those with guardians with high scores of food literacy. Furthermore, the consumption of well-balanced dietary intake was particularly reduced in the lowest score group during compared to before the SOE. Guardians with low food literacy level had significantly greater proportion of inadequate time, mental capacity, and financial ability to prepare appropriate meals compared to before the SOE.

The meal quality was compromised in pupils during SOE; school lunches are crucial for the nutritional intake of schoolchildren, especially those with guardians who have low food literacy. These results highlighted the importance of school lunches. Providing the necessary education and environment for improving food literacy for meal preparation of the guardians, including food knowledge, skills, and attitude, are crucial to ensure that schoolchildren consume adequate quantities of food and nutrients. Future research should evaluate the relationship of food literacy level for meal preparation of the guardians with meal quality for schoolchildren during the COVID-19 pandemic. Teaching food literacy in schools, including making well-balanced meal choices and cooking skills is essential for children who will be the future parents to ensure better food security in the future.

Table 7
Poisson regression analysis of knowledge, skills, and attitude for meal preparation and the guardian's subjective sense of burden for meal preparation for 10–14-year-old Japanese pupils after COVID-19 SOE.

	Total Scores									
	Q1 (≤21 scores)		p	Q2 (22–25 scores)		p	Q3 (26–29 scores)		p	Q4 (≥30 scores)
	RRI, % (95% CI)			RRI, % (95% CI)			RRI, % (95% CI)			
I have less time to prepare meals than before the SOE										
Prevalence (%)	19.6%			18.2%			9.0%			7.4%
Not adjusted	97.1%	(95.3% to 99.0%)	<0.001	89.7%	(87.8% to 91.7%)	<0.001	19.8%	(17.6% to 21.9%)	<0.001	Ref
Adjusted ^a	98.1%	(96.2% to 100.0%)	<0.001	88.9%	(87.0% to 90.9%)	<0.001	20.4%	(18.2% to 22.6%)	<0.001	Ref
Further adjusted ^b	95.4%	(93.4% to 97.3%)	<0.001	88.1%	(86.2% to 90.1%)	<0.001	21.6%	(19.4% to 23.8%)	<0.001	Ref
I have more time to prepare meals than before the SOE										
Prevalence (%)	12.4%			15.8%			19.7%			26.7%
Not adjusted	−77.1%	(−78.5% to −75.6%)	<0.001	−52.5%	(−53.9% to −51.1%)	<0.001	−30.5%	(−31.8% to −29.2%)	<0.001	Ref
Adjusted ^a	−83.0%	(−84.5% to −81.5%)	<0.001	−54.0%	(−55.4% to −52.6%)	<0.001	−37.1%	(−38.4% to −35.8%)	<0.001	Ref
Further adjusted ^b	−66.3%	(−67.9% to −64.8%)	<0.001	−42.7%	(−44.2% to −41.3%)	<0.001	−33.7%	(−35.0% to −32.3%)	<0.001	Ref
I have less mental capacity to prepare meals										
Prevalence (%)	21.2%			25.4%			10.4%			11.1%
Not adjusted	64.3%	(62.7% to 65.9%)	<0.001	82.5%	(80.9% to 84.1%)	<0.001	−6.5%	(−8.4% to −4.6%)	<0.001	Ref
Adjusted ^a	63.0%	(61.4% to 64.6%)	<0.001	80.7%	(79.1% to 82.2%)	<0.001	−7.1%	(−9.0% to −5.2%)	<0.001	Ref
Further adjusted ^b	73.6%	(71.9% to 75.2%)	<0.001	86.5%	(84.9% to 88.1%)	<0.001	−5.1%	(−7.0% to −3.2%)	<0.001	Ref
I have more mental capacity to prepare meals										
Prevalence (%)	7.0%			5.7%			13.0%			23.5%
Not adjusted	−121.8%	(−123.6% to −120.0%)	<0.001	−141.0%	(−143.1% to −139.0%)	<0.001	−59.1%	(−60.6% to −57.6%)	<0.001	Ref
Adjusted ^a	−125.1%	(−127.0% to −123.3%)	<0.001	−141.7%	(−143.8% to −139.7%)	<0.001	−61.5%	(−63.0% to −59.9%)	<0.001	Ref
Further adjusted ^b	−110.6%	(−112.5% to −108.6%)	<0.001	−130.8%	(−132.9% to −128.7%)	<0.001	−56.1%	(−57.7% to −54.6%)	<0.001	Ref
I have a lower economic capacity for choosing or consuming foods and meals										
Prevalence (%)	21.2%			18.3%			11.5%			5.1%
Not adjusted	142.0%	(139.9% to 144.2%)	<0.001	127.5%	(125.3% to 129.7%)	<0.001	80.5%	(78.2% to 82.9%)	<0.001	Ref
Adjusted ^a	138.4%	(139.9% to 144.2%)	<0.001	129.2%	(127.0% to 131.4%)	<0.001	78.2%	(75.9% to 80.6%)	<0.001	Ref
Further adjusted ^b	92.9%	(90.7% to 95.0%)	<0.001	97.9%	(95.7% to 100.1%)	<0.001	68.3%	(65.9% to 70.6%)	<0.001	Ref
Not Applicable to any above situation										
Prevalence (%)	44.7%			46.2%			57.7%			53.0%
Not adjusted	−17.0%	(−17.8% to −16.1%)	<0.001	−13.8%	(−14.7% to −12.9%)	<0.001	8.5%	(7.6% to 9.3%)	<0.001	Ref
Adjusted ^a	−15.0%	(−15.8% to −14.1%)	<0.001	−12.8%	(−13.7% to −11.9%)	<0.001	10.0%	(9.2% to 10.8%)	<0.001	Ref
Further adjusted ^b	−16.3%	(−17.2% to −15.4%)	<0.001	−13.4%	(−14.3% to −12.5%)	<0.001	9.8%	(8.9% to 10.6%)	<0.001	Ref

Participants were weighted by the population of the municipality where each participant resides.

RRI: Relative risk increase.

^a Adjusted for sex (boys and girls), age (10–11 or 13–14 years old), and BMI (continuous).

^b Adjusted for sex (boys and girls), age (10–11 or 13–14 years old), BMI (continuous), equivalent income adjusted for the number of household members (quartile), educational level of mother (less than high school, high school, vocational, college, and university/graduate school), and educational level of father (less than high school, high school, vocational, college, and university/graduate school).

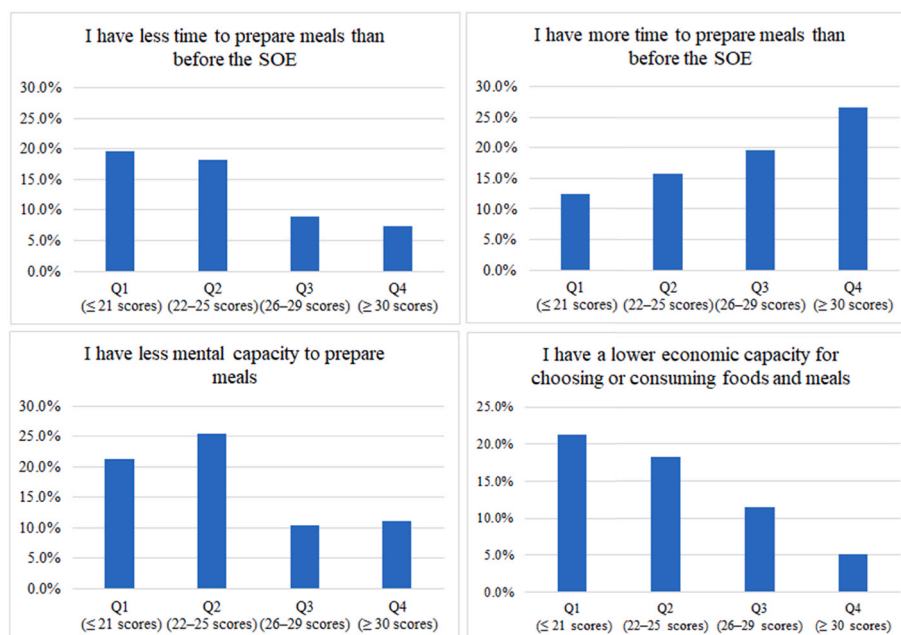


Fig. 4. Total scores of knowledge, skills, and attitude for meal preparation and prevalence of the guardian's subjective sense of burden for meal preparation: 10–14-year-old Japanese pupils before, during, and after COVID-19 SOE. Well-balanced dietary intake was defined as the intake of both meat, fish, or eggs and vegetables.

Ethical statement

Institutional Review Board Statement: The study adhered to the Declaration of Helsinki and was approved by the Ethics Committee of the National Center for Child Health, Japan (protocol code: No. 2020-168; date of approval: 28 September 2020) and the University of Niigata Prefecture, Japan (protocol code: No. 2025 and date of approval: 3 December 2020).

Author contributions

Conceptualization: C.H., N.M. (Nobuko Murayama), and N.M. (Naho Morisaki); data curation: C.H., N.M. (Nobuko Murayama), M.S., Y.K., H. T., and N.M. (Naho Morisaki); formal analysis: M.S., C.H.; funding acquisition: C.H., N.M. (Naho Morisaki); investigation: C.H., N.M. (Nobuko Murayama), M.S., and N.M. (Naho Morisaki); methodology: C. H., N.M. (Nobuko Murayama), M.S., and N.M. (Naho Morisaki); project administration: N.M. (Nobuko Murayama) and N.M. (Naho Morisaki); resources: N.M. (Nobuko Murayama); software: C.H., M.S., and N.M. (Naho Morisaki); supervision: N.M. (Nobuko Murayama) and N.M. (Naho Morisaki); validation: C.H., N.M. (Nobuko Murayama), M.S., and N.M. (Naho Morisaki); visualization: C.H., N.M. (Nobuko Murayama), M.S., and N.M. (Naho Morisaki); writing—original draft: C.H., N.M. (Nobuko Murayama), M.S., and N.M. (Naho Morisaki); writing—review and editing: C.H., N.M. (Nobuko Murayama), M.S., Y.K., H.T., and N.M. (Naho Morisaki). All authors have read and agreed to the published version of the manuscript.

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Data availability

The authors do not have permission to share data.

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