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Influence of the COVID-19 Pandemic on Household Food Waste Behavior in Japan

Kun Qian [1,2,*], Firouzeh Javadi [1,*] and Michikazu Hiramatsu [1,2]

[1] Institute of Decision Science for a Sustainable Society, Kyushu University, Fukuoka 8190395, Japan; mich.katz1965@gmail.com

[2] Research Department, Kyushu Open University, Fukuoka 8190395, Japan

* Correspondence: qk@kyudai.jp (K.Q.); javadisf@yahoo.com (F.J.)

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Abstract: The 2019 coronavirus disease (COVID-19) pandemic had various influences on people's ordinary lives, including their thoughts and behaviors related to food consumption. Food waste has been cited as a serious issue with environmental, social, and economic consequences. In this study, we investigated how the COVID-19 pandemic altered the social consciousness and behavior related to food waste in Japan. We conducted a nationwide online-based survey and collected a cross-sectional dataset from 1959 adult respondents. The results showed that people in regions highly impacted by the pandemic reported a clearer understanding of the situation of their household food waste, more careful food preparation and purchasing, and were more strongly influenced to change their behaviors due to COVID-19. Further analyses revealed that thoughts and behaviors related to food waste significantly differed by sociodemographic characteristics, such as gender, household size, and employment status. This study also implied that the COVID-19 pandemic encouraged some improvements in peoples' behaviors and thoughts with regard to food, such as paying attention to food waste, making efforts to reduce food waste, and attempting cooking by themselves at home.

Keywords: food waste; food management; food consumption; coronavirus; SARS-CoV-2; environmental impact

1. Introduction

Globally, nearly one-third of the food produced for human consumption is either lost or wasted, which is four times the amount of food needed annually for eliminating global hunger [1]. Food waste is imposing serious environmental, social, and economic consequences [2,3], and has been considered as one of the most important sustainability issues at the global level [4]. Consequently, food waste reduction has been included among the 17 Sustainable Development Goals (SDGs) of the United Nations' 2030 Agenda and is highlighted by SDG 12.3 that aims to: "halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains" by 2030 [5].

Food waste refers to food that is fit for consumption but left to spoil or discarded by consumers and retailers [6]. The consumer role (i.e., individuals and households) in the issue of food waste is thus crucial [7–9]. Food loss normally occurs in the first stages of the food supply chain and includes food that is spilled or spoilt before it reaches its final product or retail stage, which is the main problem in low- and middle-income countries [10,11].

The amount of food wasted depends on cultural habitats and sociodemographic factors, as well as on factors such as the consumers' food storage capacities, shopping behavior, cooking skills, and knowledge of date labeling [12,13]. In high-income countries, the wasteful practices of the food industry and consumers are the predominant drivers of food waste [14]. For example, food waste from U.K. households is approximately 6.6 million tons, 70% of which was intended to be eaten (30%

being the inedible parts). The edible portion of food loss and waste generated in Japan is 6.43 million tons annually. It is estimated that households waste 2.8 million tons each year [15,16]. It is widely acknowledged that minimizing food waste at home is the best way to reduce the impact of food waste on the environment [17]. For example, it has been argued that reducing consumer food waste would have significant impacts in countries such as the U.S.A., where consumer waste is high [14,18].

The COVID-19 pandemic continues to spread around the world, generating significant challenges that could result in risks to food security and nutrition, disruptions in supply chains, and quarantine measures, all of which result in significant increases in food loss and waste [19]. Today, it is more urgent than ever that food systems become sustainable. The COVID-19 pandemic has forced many countries to implement restrictions on population movements to slow the spread of COVID-19 and establish full or partial lockdowns, resulting in better air quality in urban cities due to lower air pollutant emissions [20]. However, people are urged to stay at home and go out only to meet the most urgent needs, such as buying food, during lockdowns. Therefore, COVID-19 lockdowns may have an effect on citizens' daily lives, including impacts on food behaviors, food waste habits, and household consumption [21]. For example, the way people purchase and consume food has changed, with some consumers even resorting to panic buying to mitigate the risk of future shortages [22]. Consumers in the United States increased stockpiles of home goods, such as food, during COVID-19 [23]. However, an absence of panic buying and food stockpiling has been reported in Qatar [24]. There is evidence that buying food items is a behavioral reaction to feelings of stress and uncertainty and leads consumers to restore control through product acquisition [25]. Household food waste generation can either increase due to overbuying or inappropriate food storage or decrease if consumers are making better use of stocked food and leftovers [26,27].

In the present study, we investigated how the COVID-19 pandemic altered people's thoughts and behaviors toward household food waste by conducting a cross-sectional questionnaire survey in Japan. Based on the previous research, in this questionnaire we focused on food purchasing, management, and cooking, as well as the concerns and perceptions about food waste. We hypothesized that these features would vary according to the regional pandemic condition. People in regions more impacted by the pandemic perceive more influence on food purchasing and supply, and consequently attend more to household waste and food management than those in less affected regions. Besides this main hypothesis, we also aimed to explore how demographic characteristics correlated with people's thoughts and behaviors, including the changing and unchanging aspects, with respect to food waste in the context of COVID-19. Considering that the COVID-19 pandemic continues almost one year after its outbreak, the outcomes of this study will be informative for the general public to know clearly about the situation of household food waste and improve their food consumption and management in a society expected to adapt to prolonged coexistence with COVID-19.

2. Materials and Methods

2.1. Ethical Information

Ethical approval for this study was obtained from the Ethics Committee for Psychological Studies at the Institute of Decision Science for a Sustainable Society, Kyushu University (No. 2020/1-7, No. 2020/2-4). All methods used in this study were conducted in accordance with the relevant guidelines of the ethics committee and the code of ethics and conduct of the Japanese Psychological Association. The questionnaire survey was conducted anonymously. The study protocol and data using policy were disclosed at the recruitment page and the beginning of the questionnaire. The survey commenced only if the participant accepted the data use policy and agreed to participate.

2.2. Participant Recruitment

We conducted a cross-sectional online survey through Yahoo! Crowdsourcing service (hereafter referred to as Yahoo), operated by Yahoo Japan Corporation. The participants were registered Yahoo users, adults (aged 20 years or older) living in all prefectures (the first level of administrative division) in Japan. Each participant who completed the survey was paid 6 T-points, which equals seven Japanese yen, via Yahoo. The survey commenced at 14:00 on 2 July 2020, and automatically ended at 20:40 on the same day, after reaching the targeted sample size (n = 2000).

The target sample size was determined by a priori power analyses using G * Power [28]. We planned to perform t-tests, analyses of variance (ANOVA), analyses of bivariate correlation, and simple linear regression. Considering the potential data noise of the online survey, we used smaller effect sizes and estimated the required sample sizes to be 788 for the t-test ($d = 0.2$, $\alpha = 0.05$, $1 - \beta = 0.8$), 969 for one-way ANOVA with three groups ($f = 0.1$, $\alpha = 0.05$, $1 - \beta = 0.8$), 592 for ANOVA of repeated measures and between factors ($f = 0.1$, $\alpha = 0.05$, $1 - \beta = 0.8$), 782 for bivariate correlation ($\rho = 0.1$, $\alpha = 0.05$, $1 - \beta = 0.8$), and 395 for simple linear regression ($f^2 = 0.02$, $\alpha = 0.05$, $1 - \beta = 0.8$). Furthermore, considering the potential abnormal and/or satisficing data [29], we doubled the biggest required sample size, 969, and eventually determined the target sample size to be 2000. This sample size is also considered to be satisfactory for factor analysis [30,31].

2.3. Survey Development

We developed a structured questionnaire consisting of 29 question items. The first nine questions were used to collect demographic data, including age (Q1), gender (Q2), household size (Q3), number of children in the household (Q4), household income (Q5), place of residence (Q6), employment status (Q7), education (Q8), and the most frequent meal preparer at home (Q9). Q1–4 and Q6–8 were replicated or slightly modified from a previous study related to the behavior in COVID-19 emergency status in Japan [32]. Q5 and Q9 were original questions created in this study. The following 20 questions consisted of 19 questions on thoughts and behavior on food purchase, management, consumption as well as food waste (hereafter referred to as food waste questions), and one attention check question (Q15). All 19 food waste questions were originally developed by referring to several previous studies on food waste [2,3,33,34]. Participants were requested to respond using a 5-point Likert scale ranging from "0 = Completely disagree" to "4 = Completely agree." The details of the food waste questions are shown in Table 1.

Table 1. The English version of food waste question items (Q10–14 and Q16–29).

	Item	Abbreviation	*M*	*SE*
Q10	Do you pay attention to date labels on food, such as "use by," "sell by" and "best before"?	Concerns about expiration date	2.77	0.022
Q11	Do you make different decisions about whether to eat foods depending on whether the date label says, "use by," "sell by," or "best before"?	Influence of expiration date	2.62	0.021
Q12	Are you concerned that the COVID-19 pandemic could lead to supermarkets running out of food?	Food shortage due to COVID-19	1.88	0.023
Q13	Do you think that the COVID-19 pandemic has changed your food choices?	Food choice changes due to COVID-19	1.51	0.023
Q14	Do you make a list of the food you want to buy prior to your shopping trip?	Shopping list	1.95	0.028
Q16	Do you check your food inventories/storage/refrigerator prior to your shopping trip?	Checking storage	2.47	0.024
Q17	Have you bought too much food (more than you need or can eat) when you went shopping during the last three months?	Excessive food purchase	1.56	0.025
Q18	Have you bought food items that you did not intend to buy during the last three months?	Unintended food purchase	1.77	0.025

Table 1. *Cont.*

	Item	Abbreviation	*M*	*SE*
Q19	Are you making an effort currently to minimize the amount of food you throw away?	Effort to reduce food waste	2.93	0.020
Q20	Do you think that you are not concerned about throwing away food? (R)	Indifference to food waste	1.13	0.021
Q21	Do you feel guilty when you throw away food?	Guilt about food waste	3.25	0.019
Q22	Are you able to cook and prepare exactly the amount of food that your household needs?	Preparing amount	2.37	0.022
Q23	Are you able to buy exactly the amount of food that your household needs?	Purchasing ability	2.40	0.022
Q24	Do you know exactly how much food is thrown away every day in your family?	Waste amount	2.19	0.027
Q25	Do you know exactly what kind of food is thrown away in your family?	Waste type	2.38	0.025
Q26	Are you aware of how much money you pay weekly for food that was finally thrown away?	Waste cost	1.65	0.026
Q27	Do you consider that food waste is not an environmental issue because food is natural and biodegradable? (R)	Misunderstanding of food waste	1.10	0.020
Q28	Did you cook by yourself before the COVID-19 pandemic?	Cooking at home before COVID-19	2.96	0.025
Q29	Have you cooked by yourself since the COVID-19 pandemic?	Cooking at home during COVID-19	3.04	0.024

The average values of the answers to the questions and their standard errors of mean (*SE*) are also presented in the table ($n = 1959$). The original version, which was used in the surveys was in Japanese. (R) at the end of the items indicates reverse code.

2.4. Data Analysis

Firstly, we screened abnormal and/or unexpected data by the following steps: (1) verifying answers to the attention check question (Q15); (2) checking age, gender, household size, number of children, and place of residence (Q1–4, Q6); and (3) ensuring that all responses to the food waste questions were assigned different values ($SD \neq 0$). All abnormal data were excluded from statistical analysis. To ensure data quality, we referred to several previous studies for the data exclusion method [35,36].

After eliminating invalid data, we conducted exploratory factor analysis to extract factors from the 19 food waste questions. We calculated the mean response values for each factor and conducted a series of analyses including *t*-tests, two-way ANOVA, analysis of bivariate correlation, and analysis of simple linear regression to examine the determinants of thoughts and behavior related to food waste in the context of the COVID-19 pandemic. For *t*-tests and simple linear regression, demographic features were used as independent variables, and the factors extracted from the response data to food waste questions were employed as dependent variables.

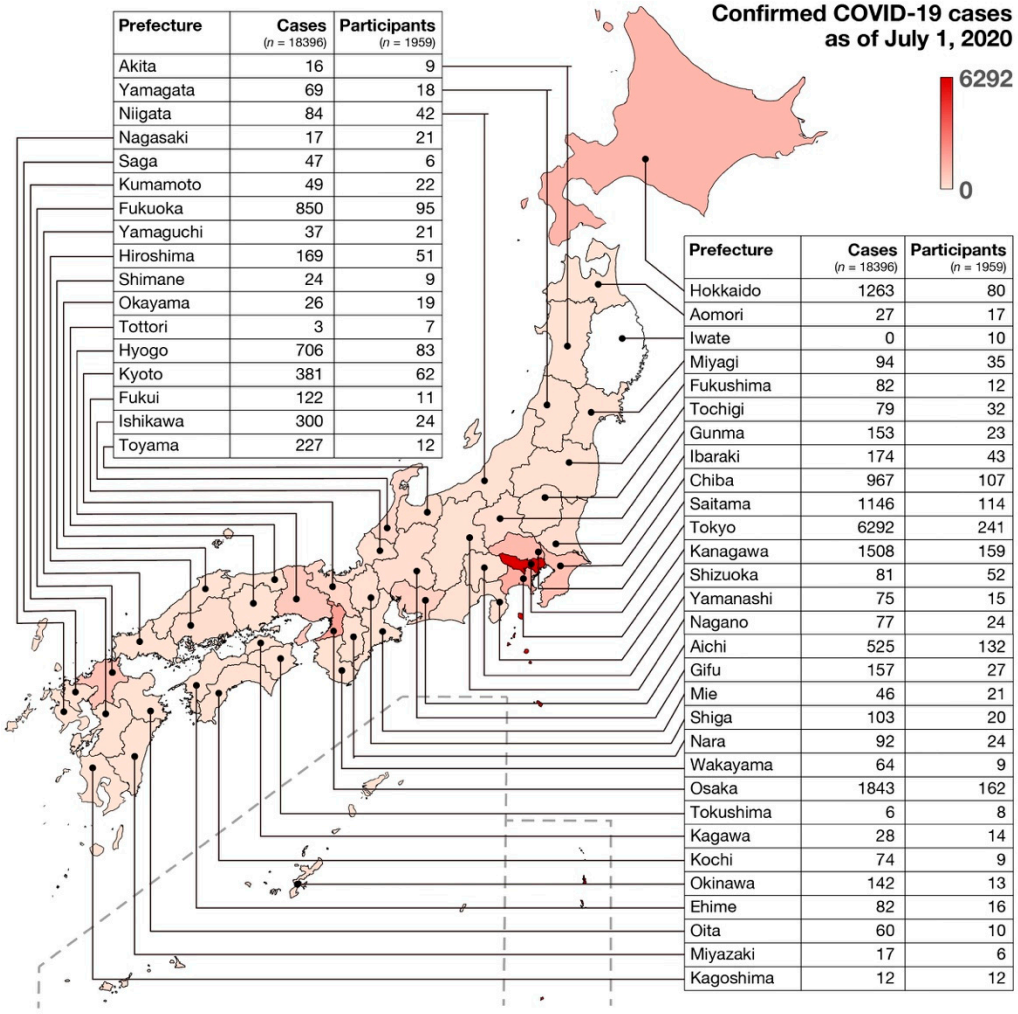
Detection and elimination of non-normal respondents and calculation of the mean values and *SD* were performed using Microsoft Excel for Mac (Version 16.41). Factor analysis and simple linear regression analyses were conducted using IBM SPSS Statistics Base (Version 25). *T*-tests were performed using Jamovi (Version 1.2.16.0; The Jamovi Project, 2020; R Core Team, 2019). All software operated on an Apple iMac Pro (Model A1862, MacOS Catalina Version 10.15.6).

3. Results

3.1. COVID-19 Infection Condition in Japan

The adopted data of COVID-19 infections were based on the statistics of the MHLW (Ministry of Health, Labour and Welfare) of Japan (MHLW, 2020) on July 1, 2020, which is one day prior to the day we conducted the questionnaire survey. There were 18,396 COVID-19 infected persons in Japan. Tokyo (6292 infections), Osaka (1843), Kanagawa (1508), Hokkaido (1263), Saitama (1146), Chiba (967), Fukuoka (850), and Hyogo (706) were the prefectures that had the highest number of COVID-19 cases. These eight prefectures had also been politically declared as having emergency status on or before

April 7, earlier than other prefectures in Japan. Detailed data on the COVID-19 infection condition for 47 prefectures are shown in Figure 1.



Prefecture	Cases (*n* = 18396)	Participants (*n* = 1959)
Akita	16	9
Yamagata	69	18
Niigata	84	42
Nagasaki	17	21
Saga	47	6
Kumamoto	49	22
Fukuoka	850	95
Yamaguchi	37	21
Hiroshima	169	51
Shimane	24	9
Okayama	26	19
Tottori	3	7
Hyogo	706	83
Kyoto	381	62
Fukui	122	11
Ishikawa	300	24
Toyama	227	12

Prefecture	Cases (*n* = 18396)	Participants (*n* = 1959)
Hokkaido	1263	80
Aomori	27	17
Iwate	0	10
Miyagi	94	35
Fukushima	82	12
Tochigi	79	32
Gunma	153	23
Ibaraki	174	43
Chiba	967	107
Saitama	1146	114
Tokyo	6292	241
Kanagawa	1508	159
Shizuoka	81	52
Yamanashi	75	15
Nagano	77	24
Aichi	525	132
Gifu	157	27
Mie	46	21
Shiga	103	20
Nara	92	24
Wakayama	64	9
Osaka	1843	162
Tokushima	6	8
Kagawa	28	14
Kochi	74	9
Okinawa	142	13
Ehime	82	16
Oita	60	10
Miyazaki	17	6
Kagoshima	12	12

Figure 1. Frequency distribution of confirmed COVID-19 cases in Japan as of 1 July 2020, the day before our questionnaire survey and the participants of the survey.

3.2. Data Collection and Demographics

Data from 41 participants were excluded after screening. One of them was under the age of 20 years. One was living overseas. Thirteen reported mistaken demographic data, incorrectly identifying the number of children equal to family size. Seventeen were excluded due to *SD* checking. In addition, to assure the data balance for statistical analysis, we also excluded data from six participants who reported gender other than male/female, and three who reported a family size larger than 11. Thus, data collected from 1959 participants (1187 males, 772 females; mean age = 46.7 years; *SD* = 10.6 years) were used for statistical analysis.

Table 2 summarizes the detailed data on sociodemographic characteristics, except for the information on residence and age. The majority of respondents were male (60.6%), with a household size of 3 (28.1%), living without children (63.2%), with a yearly family income of 3 to 6 million Japanese yen (37.5%), full-time permanent employees (37.8%), and college graduates (44.8%). Regarding place of residence, almost half of the participants were residents of the eight prefectures with the highest infected cases in Japan (total = 53.1%; Tokyo = 12.3%, Osaka = 8.3%, Kanagawa = 8.1%, Saitama = 5.8%, Chiba = 5.5%, Fukuoka = 4.8%, Hyogo = 4.2%, and Hokkaido = 4.1%). Details of the frequency distribution of participants' residence area are shown in Figure 1.

Table 2. Sociodemographic characteristics of the collected samples (n = 1959). The original version of question items and options used in the present survey was in Japanese. Grouping labels of statistical analysis were shown in bold and italics.

Demographics	Option	*n*	(%)
Gender	Male	1187	60.6
	Female	772	39.4
Household size	1	357	18.2
	2	525	26.8
	3	550	28.1
	4 and more	527	26.9
Number of children in the household	0	***1239***	***63.2***
	(Without children)		
	1	334	17.0
	2	321	16.4
	3 and more	65	3.4
	(With children)	***720***	***36.8***
Household yearly income (million JPY)	less than 1	150	7.7
	1 and more, less than 2	128	6.5
	2 and more, less than 3	244	12.5
	3 and more, less than 4	244	12.5
	(Lower income)	***766***	***39.1***
	4 and more, less than 5	244	12.5
	5 and more, less than 6	231	11.8
	6 and more, less than 7	161	8.2
	(Middle income)	***636***	***32.5***
	7 and more, less than 8	176	9.0
	8 and more, less than 9	96	4.9
	9 and more, less than 10	93	4.7
	10 and more, less than 12	89	4.5
	12 and more, less than 15	55	2.8
	15 and more, less than 20	18	0.9
	20 and more, less than 30	15	0.8
	30 and more	15	0.8
	(Higher income)	***557***	***28.4***
Employment status	Company officer/executive	32	1.6
	Company employee (permanent)	740	37.8
	Public employee (permanent)	63	3.2
	Teachers/researchers	9	0.5
	(Employed full-time)	***844***	***43.1***
	Company employee (temporary)	102	5.2
	Public employee (temporary)	2	0.1
	Agriculture/forestry/fisheries	7	0.4
	Self-employed/freelance	203	10.4
	Employed part-time	279	14.2
	Work at home	18	0.9
	(Part-time/self-employed)	***611***	***31.2***
	Housewife/househusband	202	1.03
	Student (college or postgraduate)	20	1.0
	Retired with annuity	87	4.4
	Unemployed	160	8.2
	Other	35	1.8
	(Unemployed)	***504***	***25.7***

Table 2. *Cont.*

Demographics	Option	*n*	(%)
Education	Junior middle school or under	30	1.5
	Senior middle school (high school)	518	26.4
	Colleges of technology (*Kōsen* in Japanese)	20	1.0
	Specialized training college (*Senmon gakkō* in Japanese)	244	12.5
	Junior college	157	8
	Other	11	0.6
	(Basically educated)	***980***	***50.0***
	Bachelor	878	44.8
	Master	83	4.2
	Doctorate	13	0.9
	(Highly educated)	***979***	***50.0***
Most frequent meal preparer at home	Yourself ***(Preparing meal at home)***	***949***	***48.4***
	Spouse/Partner	592	30.2
	Parents	387	19.8
	Children	2	0.1
	Other	29	1.5
	(Not preparingmealat home)	***1010***	***51.6***

3.3. Exploratory Factor Analysis

As planned, we first conducted exploratory factor analysis on the response data to the 19 food waste questions to extract latent variables for further analysis. Factor analysis was conducted using the principal factor method with varimax rotation. Based on the eigenvalues in the scree plot (eigenvalues larger than 1.0), seven factors were extracted with a good fit ($\chi^2 = 1013$, $df = 131$, $p < 0.001$; "CFI" = 0.935). The cumulative proportion of up to seven factors was 55.1%. Table 3 shows the factor loadings of the items after varimax rotation. According to these results, we extracted seven latent variables: (I) food waste situation (Cronbach's $\alpha = 0.829$), indicating the present situation and perception of the participants' household food waste; (II) food preparation ($\alpha = 0.710$), denoting how the participants reduce the possibility of food waste when preparing food, purchasing food, and cooking; (III) cooking at home ($\alpha = 0.946$), showing how often the participants cooked by themselves before and during the COVID-19 pandemic; (IV) expiration date concerns ($\alpha = 0.859$), suggesting whether the participants take note of, and are influenced by, the expiration dates printed on food productions; (V) food waste concerns ($\alpha = 0.590$), indicating how the participants attach importance to the food waste issue and want to make efforts to reduce food waste; (VI) excessive food purchase ($\alpha = 0.673$), showing whether the participants had purchased excessive or unnecessary food in the past three months (from the time the emergency status was declared in Japan); and (VII) influence of COVID-19 ($\alpha = 0.560$), on participants' shopping behavior and concerns about food shortage. We calculated the mean rating scores of the items in each factor for further statistical analysis.

Table 3. Factor loadings after varimax rotation revealed in the exploratory factor analysis.

Item	Factor						
	I	II	III	IV	V	VI	VII
Q24_Waste amount	**0.841**	0.193	0.132	0.015	0.104	−0.019	0.008
Q25_Waste type	**0.784**	0.204	0.209	0.025	0.191	0.011	0.024
Q26_Waste cost	**0.624**	0.184	0.064	−0.003	−0.017	−0.039	0.119
Q22_Preparing amount	0.280	**0.793**	0.183	0.051	0.131	−0.096	−0.045
Q23_Purchasing ability	0.279	**0.776**	0.130	0.026	0.093	−0.149	−0.036
Q16_Checking storage	0.140	**0.390**	0.089	0.239	0.108	−0.018	0.197
Q14_Shopping list	0.071	**0.317**	0.094	0.241	0.041	0.039	0.193
Q29_Cooking at home during COVID-19	0.193	0.196	**0.883**	0.071	0.176	0.046	0.076
Q28_Cooking at home before COVID-19	0.215	0.201	**0.878**	0.049	0.189	0.045	0.060
Q11_Influence of expiration date	−0.034	0.090	0.006	**0.876**	0.024	−0.012	0.088
Q10_Concerns about expiration date	0.028	0.101	0.061	**0.827**	0.053	0.010	0.091
Q21_Guilt about food waste	0.152	0.207	0.120	0.070	**0.651**	0.028	0.069
Q19_Effort to reduce food waste	0.293	0.301	0.129	0.052	**0.473**	−0.121	0.101
Q20_Indifference to food waste (R)	−0.007	−0.036	0.032	0.028	**0.439**	0.012	−0.067
Q27_Misunderstanding of food waste (R)	0.015	0.041	0.058	−0.011	**0.426**	−0.048	−0.013
Q18_Unintended food purchase	−0.013	−0.113	0.042	0.024	0.025	**0.732**	0.100
Q17_Excessive food purchase	−0.036	−0.031	0.019	−0.021	−0.092	**0.669**	0.162
Q13_Food choice change due to COVID-19	0.047	0.036	0.022	0.128	−0.086	0.192	**0.720**
Q12_Food shortage due to COVID-19	0.046	0.034	0.042	0.046	0.018	0.069	**0.476**
Percentage of explained variance (%)	11.014	9.724	9.081	8.452	6.293	5.694	4.845

(R) at the end of the items indicates reverse code. These reversed items were adjusted before conducting the factor analysis. Gray background color showed items summarized as the same factor.

3.4. Association of Household Food Waste Thoughts and Behavior with COVID-19 Pandemic Status

To investigate how the COVID-19 pandemic status affects people's thoughts and behavior regarding food waste, we divided the participants into two groups, based on the number of confirmed cases of COVID-19 in their living area. Based on the pandemic status shown in Figure 1, Tokyo, Osaka, Kanagawa, Hokkaido, Saitama, Chiba, Fukuoka, and Hyogo were summarized as high-impact regions (more than 700 confirmed cases). These eight prefectures were also designated regions of the first stage of emergency status on COVID-19 in Japan, before the nationwide emergency status was declared on 16 June 2020. The other 39 prefectures, whose confirmed cases were all less than 600, were summarized as low-impact regions. As to the collected data of our survey, 1041 participants (53.1%) were residents of high-impact regions, and the other 918 (46.9%) were residents of low-impact regions.

We conducted a series of *t*-tests between high and low-impact regions, with the mean rating scores of the seven extracted factors as dependent variables. The details of this series of analyses are shown in Figure 2. Significant differences were revealed in four factors: (I) food waste situation [t (1957) = 2.288, p = 0.022, Cohen's d = 0.104], (II) food preparation [t (1957) = 2.675, p = 0.008, Cohen's d = 0.121], (VI) excessive food purchase [t (1957) = −2.011, p = 0.044, Cohen's d = −0.091], and (VII) influence of COVID-19 [t (1957) = 2.352, p = 0.019, Cohen's d = 0.106]. There were no significant differences for the other three factors, (III) cooking at home [t (1957) = 0.196, p = 0.844, Cohen's d = 0.009)], (IV) expiration date concerns [t (1957) = 1.591, p = 0.112, Cohen's d = 0.072], and (V) food waste concerns [t (1957) = 1.091, p = 0.276, Cohen's d = 0.049].

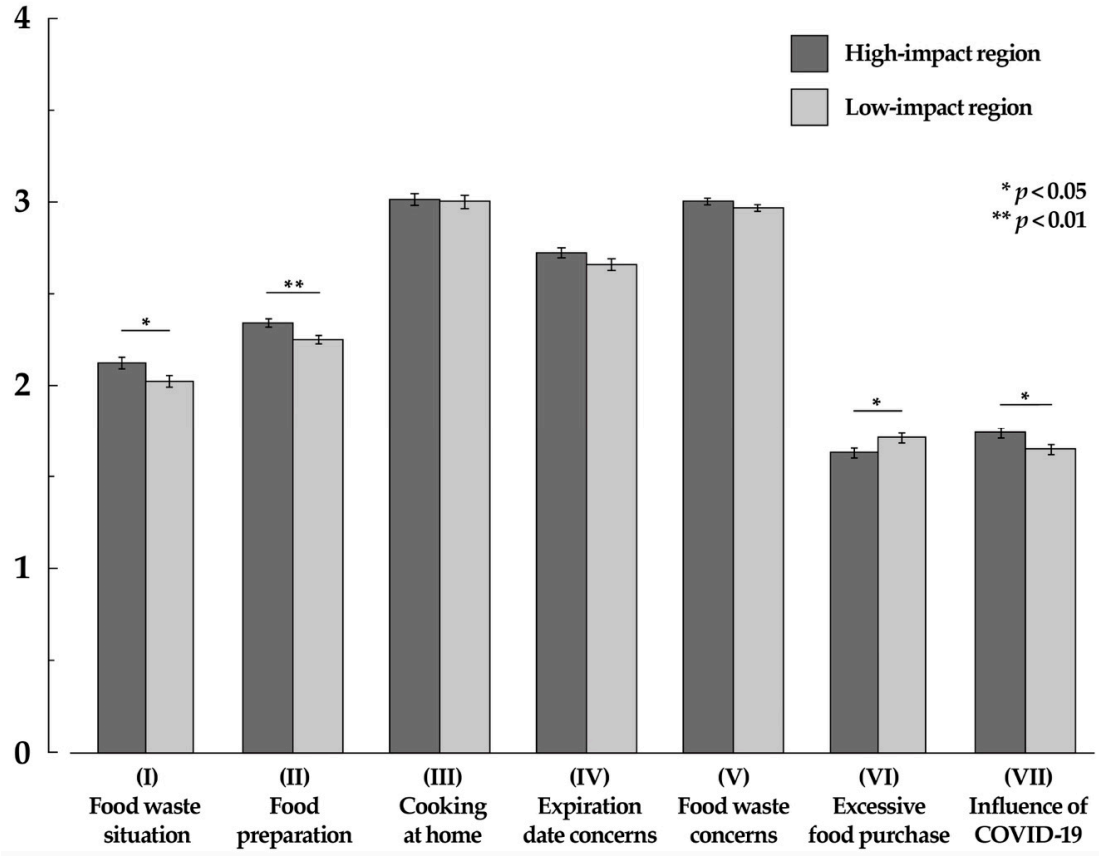


Figure 2. Results of *t*-tests conducted between high- and low-impact regions during the pandemic in Japan, with the mean rated scores summarized by factors as dependent variables. Error bars denote standard errors of the mean.

Considering that (III) cooking at home included a recalling question, we also conducted a two-way ANOVA with one factor of repeated measures (cooking status before and during the COVID-19 pandemic) and one between-subject factor (region). The results revealed significant within-subjects effect [F (1, 1957) = 42.315, $p < 0.001$, $\eta^2_p = 0.021$], which indicated that the participants did more *cooking by themselves at home* during the COVID-19 pandemic than before. However, the between-subjects effect on residence region [F (1, 1957) = 0.039, $p = 0.844$, $\eta^2_p < 0.001$], and the interaction between the two factors [F (1, 1957) = 0.456, $p = 0.499$, $\eta^2_p < 0.001$] were not significant.

3.5. Association of Household Food Waste Thoughts and Behavior with Demographic Characteristics

Besides the COVID-19 pandemic status, we also explored how demographic characteristics influenced food waste thoughts and behavior in the context of the COVID-19 pandemic. Firstly, we performed a series of simple linear regression analyses with age as a predictor, and the seven factors as dependent variables. The results showed that age had a significant positive effect on (I) food waste situation [F (1, 1957) = 13.387, $p < 0.001$; $R^2 = 0.007$, $\beta = 0.082$] and (V) food waste concerns [F (1, 1957) = 7.041, $p = 0.008$; $R^2 = 0.004$, $\beta = 0.060$], and a significant negative effect on (VI) excessive food purchase [F (1, 1957) = 4.479, $p = 0.034$; $R^2 = 0.002$, $\beta = -0.048$] and (VII) influence of COVID-19 [F (1, 1957) = 28.241, $p < 0.001$; $R^2 = 0.014$, $\beta = -0.119$].

Results of a series of *t*-tests for gender, number of children in the household, education status, and meal preparation at home are shown in Table 4. All seven factors revealed significant differences between males and females ($p < 0.001$). Several factors also revealed significant differences for number of children in household, education, and meal preparation at home ($p < 0.01$).

Table 4. Significant differences ($p < 0.05$) revealed by independent sample *t*-tests with demographic characteristics as dependent variables ($n = 1959$).

Variables	Group A		Group B		*p*	Cohen's *d*
	M	*SE*	*M*	*SE*		
Gender (Q2)	**Male ($n = 1187$)**		**Female ($n = 772$)**			
(I) Food waste situation	1.93	0.029	2.29	0.034	<0.001	−0.364
(II) Food preparation	2.19	0.022	2.47	0.026	<0.001	−0.373
(III) Cooking at home	2.78	0.032	3.34	0.032	<0.001	−0.547
(IV) Expiration date concerns	2.62	0.027	2.80	0.030	<0.001	−0.201
(V) Food waste concerns	2.92	0.018	3.09	0.020	<0.001	−0.299
(VI) Excessive food purchase	1.57	0.027	1.81	0.034	<0.001	−0.253
(VII) Influence of COVID-19	1.59	0.024	1.86	0.030	<0.001	−0.322
Children in household (Q4)	**Without ($n = 1239$)**		**With ($n = 720$)**			
(I) Food waste situation	2.12	0.029	2.00	0.036	0.007	0.126
(III) Cooking at home	2.90	0.031	3.19	0.036	<0.001	−0.276
(VI) Excessive food purchase	1.61	0.027	1.76	0.035	<0.001	−0.156
(VII) Influence of COVID-19	1.65	0.023	1.78	0.032	0.001	−0.150
Education (Q8)	**Basically ($n = 980$)**		**Highly ($n = 979$)**			
(I) Food waste situation	2.14	0.031	2.01	0.032	0.005	0.128
Meal preparation at home (Q9)	**No ($n = 1010$)**		**Yes ($n = 949$)**			
(I) Food waste situation	1.72	0.029	2.45	0.030	<0.001	−0.790
(II) Food preparation	2.14	0.024	2.47	0.024	<0.001	−0.443
(III) Cooking at home	2.63	0.036	3.40	0.027	<0.001	−0.775
(V) Food waste concerns	2.94	0.019	3.04	0.020	<0.001	−0.173
(VI) Excessive food purchase	1.58	0.029	1.75	0.031	<0.001	−0.181
(VII) Influence of COVID-19	1.60	0.026	1.80	0.028	<0.001	−0.233

The other three demographic variables, household size (Q3), household yearly income (Q5), and employment status (Q7) have more than three levels (Table 2). Thus, we conducted a series of one-way ANOVAs to test the main effect of these variables. The main effect of household size was significant for all the seven factors: (I) food waste situation [F (3, 1955) = 35.2, $p < 0.001$, $\eta^2_p = 0.051$], (II) food preparation [F (3, 1955) = 6.23, $p < 0.001$, $\eta^2_p = 0.009$], (III) cooking at home [F (3, 1955) = 7.34, $p < 0.001$, $\eta^2_p = 0.011$], (IV) expiration date concerns [F (3, 1955) = 3.27, $p = 0.020$, $\eta^2_p = 0.005$], (V) food waste concerns [F (3, 1955) = 5.94, $p < 0.001$, $\eta^2_p = 0.009$], (VI) excessive food purchase [F (3, 1955) = 3.56, $p = 0.014$, $\eta^2_p = 0.005$], and (VII) influence of COVID-19 [F (3, 1955) = 3.55, $p = 0.014$, $\eta^2_p = 0.005$]. The main effect of household yearly income was only significant for the factor (I) food waste situation [F (2, 1956) = 425, $p = 0.014$, $\eta^2_p = 0.004$]. The main effect of employment status was significant for the following factors: (I) food waste situation [F (2, 1956) = 20.4, $p < 0.001$, $\eta^2_p = 0.020$], (II) food preparation [F (2, 1956) = 18.4, $p < 0.001$, $\eta^2_p = 0.018$], (III) cooking at home [F (2, 1956) = 12.6, $p < 0.001$, $\eta^2_p = 0.013$], (IV) expiration date concerns [F (2, 1956) = 12.6, $p < 0.001$, $\eta^2_p = 0.013$], and (V) food waste concerns [F (2, 1956) = 6.65, $p = 0.001$, $\eta^2_p = 0.007$]. Details of the post-hoc tests (multiple comparisons based on Tukey's method) for the significant main effects are available in the Supplementary Materials (Table S1).

4. Discussion

This study investigated how people's thoughts and behaviors on food waste were influenced by the COVID-19 pandemic. The results indicated that people in regions highly impacted by the pandemic attend more to the amount, types, and cost of daily household food waste, prepared more precisely in terms of food purchasing and management, and perceived more influence on food choice and possible shortage than regions less impacted by the pandemic. In contrast, residents in low-impact regions had bought more excessive amounts of food and unnecessary food in the past three months (since the pandemic was declared) than the residents in high-impact regions. Most of the regions more impacted

by the pandemic are also the biggest metropolitan areas in Japan, which means a larger population, higher cost of food, smaller storage space in households, and a comparatively riskier food supply because of the distance to food producing areas and higher dependency on logistics. Thus, the residents in high-impact regions are not able to purchase excessive food as residents in lower pandemic-affected regions do. Another possible interpretation is that the perception of excessive food purchasing was different for residents in high-impact regions, who were experiencing the pandemic more severely, than those in low-impact regions. People in high-impact regions may not have considered their food purchasing as "excessive" in the context of the pandemic, even though they bought much more than those in low-impact regions. Based on these results, our hypothesis was partially demonstrated, in that people in regions more impacted by the pandemic perceived more influence on food purchasing and supply and attended more to household waste and food management than those in regions where the pandemic was not as severe. We also found insignificant differences in cooking at home and food waste concerns between high- and low-impact regions. It appears that this behavior and concern were persistent and difficult to change in a short period of time.

In this study, we also explored how thoughts and behavior concerning food waste differ among sociodemographic features. The results suggested that older people have a clearer perception and are more concerned about household food waste. In contrast, younger people tend to purchase excessive food and are more influenced by COVID-19 when it comes to their food choices and consumption of food. These results were partially consistent with the findings of a previous study before the outbreak of COVID-19 [37].

The difference in gender was more evident. The evaluated values of all factors on food waste from female participants were significantly higher than those from males, with high effect sizes. We suppose that this is due to the cultural situation in Japan, where in most families women are in charge of cooking, as well as food and household management. A post-hoc analysis showed that 62.5% of the meal preparers were female, while 82.3% of the people who do not prepare meals at home were male. Thus, women have higher consciousness and ability to detect and manage food issues. These results supported the findings of Jribi et al. [27] which showed that women tended to produce fewer leftovers than men during COVID-19 in Tunisia. Frequent meal preparers at home is another important determinant. People who cooked exhibited a clearer understanding of household food waste, higher concerns about food waste, more influence due to COVID-19, and naturally, higher ratings to their food preparation and cooking behaviors.

In addition to gender and meal preparation, ANOVA analyses suggested that household size and employment status also affected most of the factors. The significant differences among household sizes also coincide with the results of the *t*-test on children numbers in households; smaller families understood the situation of household food waste better than larger families, while larger families showed more tendencies of excessive food purchase and influence of COVID-19 than smaller families. The difference in employment status implies variance of income and lifestyle, whereas the main effect of household yearly income was insignificant for most of the factors. The post-hoc comparisons suggested that for all factors, part-time/self-employed participants were not significantly different from unemployed participants, while these two groups had significantly higher scores than the full-time-employed group. Thus, we suppose that the significant main effects on employment status were mainly caused by lifestyles (e.g., regular daily schedule and dietary habits of the self-employed and unemployed participants).

The first study on food waste correlated with the COVID-19 pandemic in Japan, therefore these findings clearly indicated that consciousness, concerns, and behaviors related to food waste were modulated by the ongoing pandemic. The modulation was altered with the regional pandemic situation as well as the demographic characteristics of people. The results also showed some positive changes due to the pandemic, such as enhanced awareness and concern about food waste, more discreet preparation, and better management of food. The positive effects of the COVID-19 lockdown brought to food management and waste have also been clarified by a demonstrative study in Italy [38]. Moreover,

the findings also were consistent with previous studies which showed that the COVID-19 pandemic has led to a positive behavioral change regarding food waste in Qatar [24], Tunisia [27], and also improved household skills and management practices in the United States [39].

Notably, the promotion of cooking behavior was observed during the COVID-19 lockdown. This behavior could be a double-edged sword because it was revealed as an inducer of excessive food purchase, despite the fact that people who cooked show significantly higher consciousness and concerns about food waste. Analyzing the factors that enhance or suppress anxiety related to food shortage and panic buying is an interesting topic for future research. Furthermore, the results of the present study revealed that people who cooked showed more interest in and concern for food management and food waste than non-cooking people. In the future, studies focusing on people who cook may provide more insight into the behavior of food waste.

This study has several limitations. Firstly, the present study was based on a self-reported questionnaire survey. As reported in several studies, a questionnaire survey is considered too subjective to measure the actual situation of food waste [40–42]. People tend to declare less food waste in the survey than has actually been wasted. Although one way to uncover people's intentions is by asking them, more approaches to collecting behavior data, e.g., [43,44] and the standardized methodology, e.g., [45] for assessing food waste quantity should be introduced in future psycho-behavioral studies. Secondly, a regional comparison was conducted between high- and low-impact pandemic areas, which also meant comparatively urban and rural areas in Japan. It is difficult to determine whether between-group differences were essentially due to the pandemic status or the basic lifestyle and habits caused by urbanization. Further detailed explorations should be conducted to address this question. A longitudinal within-group analysis of high-impact areas may be informative because the pandemic situation is fluctuating while urbanization is comparatively stable. Thirdly, regarding the persistence of changes in consumer attitudes, the behavioral changes revealed in the present study might be temporary during the pandemic or could be continuous even after the pandemic. This issue can also be verified using longitudinal surveys. Lastly, this study was based on an online survey, which considerably limited the participants to current Yahoo users. The accessibility of the survey to either young or old people in society was comparatively weak. These limitations require further investigations in the future, with more precisely designed surveys and a wider range of participants. The aim of the present study was to provide immediate data in the ongoing pandemic. However, further surveys should be conducted not only online, but also face-to-face, when possible, depending on the pandemic situation. Besides psychobehavioral investigations, a case study on food waste management during the COVID-19 pandemic was conducted in Spain from a holistic climate, economic, and nutritional approach [26]. Suggestions for improving the issue of consumer food waste from the viewpoints of economics and policy have also been raised [39]. A detailed report on the food waste generation during the movement control period in Malaysia has provided macroscopic and objective data on the change in food waste amount during the COVID-19 pandemic [46]. These studies explored the relationship between the food waste issue and the COVID-19 pandemic from different disciplinary backgrounds, based on data obtained in different countries. However, future studies using a multidisciplinary approach and comparative perspective among different societies would be informative and useful for better understanding how the COVID-19 pandemic affects and alters the global situation of food waste.

Supplementary Materials: The following are available online at http://www.mdpi.com/2071-1050/12/23/9942/s1, Table S1: Results of post-hoc multiple comparisons for the significant main effects of household size, household yearly income, and employment status.

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