Influences of School Cooking and Catering Systems on Leftover Meals and Eating Behaviors of Children

Rie Horiuchi*, Yuko Maki†, Miki Tokunaga†, Yuko Yamamoto†, Keiichi Tsukinoki†, Ram B. Singh‡, Douglas W. Wilson*, Harpal S. Buttar‡, and Toru Takahashi$†

*Department of Food Sciences and Nutrition, Faculty of Human Environmental Sciences, Mukogawa Women’s University, 6-46 Ikebiraki-cho, Nishinomiya city, Hyogo prefecture 663-8558, Japan
†Department of Life and Culture Studies, Sonoda Woman’s University, 7-29-1 Minamitsukakuchi-cho, Amagasaki-shi, Hyogo 661-8520, Japan
‡School of Nutrition and Dietetics, Kanagawa University of Human Service, 1-16-1 Heiseicho, Yokosuka, Kanagawa prefecture 238-8522, Japan
$Department of Junior College, Kanagawa Dental University, School of Dental Hygiene, 82 Inaoka-cho, Yokosuka city, Kanagawa prefecture 238-8580, Japan
$Department of Oral Science, Division of Environmental Pathology, Kanagawa Dental University, Graduate School of Dentistry, 82 Inaoka-cho, Yokosuka city, Kanagawa prefecture 238-8580, Japan
$Department of Pathology & Laboratory Medicine, Faculty of Medicine, University of Ottawa, 451 Smyth Rd. Ottawa, OntarioK1H 8M5, Canada
$Graduate School of Human Environment Science, Fukuoka Women’s University, 1-1-1Kasumigaoka, Higashi-ku, Fukuoka city 813-8529, Japan

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*Corresponding author: Rie Horiuchi, Department of Food Sciences and Nutrition, Faculty of Human Environmental Sciences, Mukogawa Women’s University, 6-46 Ikebiraki-cho, Nishinomiya city, Hyogo prefecture 663-8558 Japan, Tel: 81-079-845-3769; Fax: 81-079-845-3769, E-mail: mhor9496@mukogawa-u.ac.jp

Abstract

School lunch in Japan provides an educational opportunity for children to learn about the ideal nutritional content and composition of dishes. There are two types of school lunch systems, the school cooking system and the catering system. Children leaving leftovers from their school lunch would be expected to underachieve academically. The objective was to elucidate the effects of the school cooking system and the catering system on leftovers and children’s eating behaviors in a nursery school. Participants were all children attending a nursery school and their parents (n = 66). Cross-sectional data were used. The quantity of leftovers from meals, child’s attitude to the school lunches, and eating behaviors during lunch were measured for lunches prepared in both of the school cooking system and the catering system. The quantity of leftovers in the school cooking system was lower than that observed in the catering system (p < 0.05). The amount of time playing with chopsticks, standing up, and looking away was lower in the school cooking system than in the catering system (p < 0.05). A Bayesian network showed that the causes of leaving leftovers were the temperature of the main dish, child’s attitude to the meals, use of the school cooking system, playing with chopsticks, and standing up during the meal. Increasing the temperature of the main dish, raising child’s attitude to meals, using the school cooking system, and reducing the time spent playing with chopsticks and standing up during the meal would reduce school lunch leftovers, and improve children’s educational achievement.

Keywords: Leftover of meals; Eating behavior; School cooking system; Catering system; Bayesian network

Abbreviations

The abbreviations are not used in the article.

Introduction

The lunch menu in Japan schools is designed to present near-ideal nutritional content and dishes to Japanese children [1]. Thus, the aim of school lunch in Japan is for Japanese children to learn about the ideal nutritional content and composition of dishes [1]. Furthermore, ideal eating history among children in nursery schools and students in the early years of elementary school has been shown to improve their eating habits in adulthood, which would reduce non-communicable diseases [2]. Thus, eating the school lunch in nursery school and students in early stage of elementary school would facilitate learning ideal eating habits, and which would control eating habit in adulthood [3]. Accordingly, if children in nursery school and students in the early years of elementary school fail to finish their meals, this would be expected to diminish the educational effects of the school lunch.

Leaving leftovers from their school lunch also causes undernutrition in elementary school children [4], which increase the risk of growth retardation during childhood and non-communicable diseases in adulthood [5]. Thus, leaving leftovers from their school lunch would be expected to induce negative effects in children in nursery and elementary school, such as educational underachievement, undernutrition, growth retardation, and non-communicable diseases [6]. Because of the positive educational effects attributed to school lunches, this meal is served in all elementary schools and some nursery schools in Japan [6]. There are two systems for preparing school lunches in Japan: the school cooking system and the catering system. In the school cooking system, the school lunch is made in the kitchen by dietitians and cooks in the school and then served. In the catering system, the school lunch is made in a school lunch center that is independent of the school, which then distributes the lunch to several schools. In Japan school cooking system, in addition to preparing the school lunch in schools, dietitians and cooks give instruction on nutrition for students [6]. In contrast, school students operating under the catering system hardly ever see the dietitians and cooks working in the catering system, because they do not work in the schools. Some schools use the school cooking system, others use the catering system, and only a few schools in Japan adopt both of these systems on a “day to day” basis.

Lunches cooked in schools have been shown to have higher child’s attitude in elementary schools compared to those prepared under the catering system [7]. Higher child’s attitude has also been shown to decrease leftovers from school lunches in elementary schools [8]. Thus, the school cooking system might produce a lower quantity of leftovers. However, the factors contributing to the effects of the school cooking system on school lunch leftovers are still unclear. The purpose of the present study was to elucidate

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the effects of using the school cooking and catering systems on leftovers from the meals and eating behaviors during school lunch in a nursery school.

Materials and Methods

School Selection

Cross-sectional data were used. We sought out schools in Nishinomiya and Amagasaki cities that adopted both the school cooking system and the catering system from day to day, using a network of dietitians working in nursery schools; this approach would enable us to compare data collected under both systems in the same participants. There was only one nursery school that met these conditions in the two cities, namely Kuise nursery school. This nursery school adopted the school cooking system on Tuesdays, Wednesdays, and Fridays, and the catering system on Mondays and Thursdays. We collected data for the present study on four different days: two days when the school cooking system was in operation, and two days when the catering system was in operation as shown in figure 1.

Prior to data collection, we checked all the school lunch menus for both school cooking and catering days for the next month. Using this information, we selected two pairs of menus for which the nutritional content, composition of dishes, and physical properties of the school lunch were similar pairs of menus, in order to minimize the effects of these variables. This menu-checking had already been carried out, in the same nursery school, as part of a previous study [2], and the same information was used to select the days for data collection in the present study. Data collection took place from February 26–28 and on March 5, 2014.

Participants

Participants were all 3–5 year old children (N = 66) attending Kuise nursery school, which is located in Amagasaki City, Hyogo Prefecture, Japan, at the time of the study, along with their parents. Of the 66 children, 56% were girls and 44% were boys (Table 1). We obtained informed consent from the parents of all 66 children. All 66 children constituted the participants for the measurement of school lunch leftovers, and none dropped out from this part of the study. All children ate their meal at their table at the same time. They ate school lunch with good friends at their own will.

Of the 66 participants, 12 children (6 girls and 6 boys) were randomly selected, using a table of random numbers, for observation of their eating behaviors. Children’s eating behaviors were observed at the same time of measuring leftovers on two days in the school cooking system and two days in the catering system. We could not observe all 66 participants because of a limited number of video recording systems.

The parents of all 66 children received a questionnaire asking them to assess the child’s attitude to school lunches served using the school cooking and the catering systems. Of these, the parents of 28 children did not respond to the assessment questionnaire. Accordingly, 38 parents (a response rate of 58%) were the

Participants of 66 children with 3-5 years old in a nursery school and 66 parents of the children at the time of examination.

Parents

All 66 children constituted the participants for the measurement of school lunch leftovers in the nursery school.

Parents of 28 who did not respond to the assessment questionnaire were excluded.

Children of 38 response to the assessment questionnaire.

Children of 12 were randomly selected for observation of eating behaviors because of limitation of the number of video recording systems.

Children of 54 were not selected.

Children of 12 participated in the observation of eating behaviors during lunch in the nursery school.

Figure 1: Data four different days of school cooking system, and catering system of schools in Nishinomiya and Amagasaki cities.

<table>
<thead>
<tr>
<th>Participants of leftover of meals</th>
<th>Girls</th>
<th>Boys</th>
<th>3 yrs*</th>
<th>4 yrs</th>
<th>5 yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children for assessments of questionnaires (n = 38)</td>
<td>58</td>
<td>42</td>
<td>29</td>
<td>34</td>
<td>37</td>
</tr>
<tr>
<td>Children for observation of eating behaviors (n = 12)</td>
<td>50</td>
<td>50</td>
<td>33</td>
<td>33</td>
<td>33</td>
</tr>
</tbody>
</table>

Table 1: Descriptive statics for children. Number in the table represent percent of persons.*years old.
participants for the child’s attitude assessment. In previous studies in Japan, collection rates for nursery school parents’ assessment questionnaires were 38–59% [9,10]. Of the participating parents, 34 were mothers (90%) and 4 were fathers (11%). We did not have missing value.

Weight and Composition of School Lunch Meals

We determined the weights of dishes served as school lunches under the school cooking and catering systems, in children aged 3, 4, and 5 years. We measured the weights of the dishes with and without plates using an electronic weighing scale (KD-171 m, Tanita Corporation, Tokyo, Japan). Then, for the meals prepared in the catering system, we determined the weights of the staple food, main dishes, and side dishes served to 3, 4, and 5 year-old children. In meals prepared in the school cooking system, the main and side dishes were served on a plate with staple food, so we were not able to weigh these dishes separately. Therefore, table 2 shows the weight of the combined dishes under the school cooking system. The total weights of the staple foods, main dishes, side dishes, served under the school cooking system were similar to those of the meals served under the catering system for 3, 4, and 5 year-old (Table 2). Green tea of 100 mL was served (Table 2). Water was not served.

We calculated the chemical compositions of the meals served under the school cooking and catering systems using the weights of the ingredients and seasonings of each dish served to 3, 4, and 5 year-old. We divided each dish into its component ingredients. Next, we measured the weights of these ingredients using an electronic weighing scale (KD-171 m, Tanita Corporation, Tokyo, Japan). The weights of seasonings in each meal were calculated using tables indicating the amounts of seasonings in the relevant dishes [11]. Finally, the chemical compositions of the meals were calculated according to the weights of ingredients and seasonings, using a software package for calculating the chemical composition of foods [12].

Although proteins, lipids, carbohydrates, calcium, vitamin C, vitamin B₃, shows differences between the systems, other nutritional contents were similar in both systems (Table 2). All nutritional contents were similar for children of all ages (Table 3). Sodium chloride in the school cooking was similar to that of the catering system (Table 3). Usually only curry powder and pepper in spices were used in both systems. However, spice was not used during this study in both systems. Normally, sugar, salt, soy sauce, consomme, mayonnaise, cheese, miso, cat-soup, Japanese sauce, and vinegar in seasonings were used in both systems. While, only sugar, salt, soy sauce, and mayonnaise were used in both systems during this study. Children’s attribute to these seasonings was high [2]. School lunch menus in Japan are designed according to target nutrient intakes, as described in the Introduction [13].

### Table 2: Comparison of the weights of meals from the school lunches in respective dishes between the school cooking and catering systems in children with 3, 4, and 5 years old

<table>
<thead>
<tr>
<th></th>
<th>School Cooking System</th>
<th>Catering System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 yrs*</td>
<td>4 yrs</td>
</tr>
<tr>
<td>Staple food, g</td>
<td>258</td>
<td>266</td>
</tr>
<tr>
<td>Main dish, g</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Side dish, g</td>
<td>105</td>
<td>105</td>
</tr>
<tr>
<td>Staple food + Main dish + Side dish, g</td>
<td>258</td>
<td>266</td>
</tr>
<tr>
<td>Fruit**, g</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Green tea, mL</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

*years old.

**Canned fruits in syrup were served after cutting.

Measurement of Leftovers from School Lunches

The proportion of leftovers remaining after meals was measured on two days when lunch was served using the school cooking system and two days in the catering system. The proportion of food left over in each case was measured for all 66 participating children by subtracting the weight of each dish after they had eaten lunch from its weight before they had eaten, as measured using an electronic weighing scale (KD-171 m, Tanita Corporation, Tokyo, Japan). The mean of the two measurements of each child’s proportion of leftovers on two different days was calculated for meals served under the school cooking and catering systems.

The duration that elapsed between starting and finishing eating their school lunch was also measured in 66 children, twice each for lunches served under both the school cooking and the catering systems, by direct observation using a clock in the classroom. These measurements were performed by nine research staff members engaged in the research project. Each researcher recorded the time of day when the children started and finished eating their school lunch for six to eight participants. Subsequently, the duration of eating was calculated by subtracting the start time from the end time. The children were not put under pressure to finish their lunch quickly.

Observation of Eating Behaviors Using a Video Recording System

A subset of children (N = 12) participated in observation of their eating behaviors during their school lunch in the classroom, for which we used six video camera systems (HC-C230, Panasonic corporation, Osaka, Japan), which were fixed on tripods. Each video camera system recorded the eating behaviors between starting and finishing their lunch of two participants who ate their meals at the same table at the same time. The eating behaviors observed using the video recording system were as follows: time spent playing with chopsticks, time spent standing up, time spent taking short breaks, and time spent looking away. The time spent engaging in each of these behaviors was calculated as the sum of the duration of each behavior in every 5-minute interval. Playing with chopsticks was defined as any behavior in which the child engaged in drumming on dishes or food with their chopsticks, or in playing with them in their mouth. Standing up was defined as any behavior in which the child left their chair. Looking away was defined as any behavior in which the child moved their eyes and stared at something without eating.
Taking short breaks was defined as any behavior in which the child paused their eating, while moving their arms and legs.

**Parental Questionnaire**

This component of the study was conducted between 26th February and 3rd March 2014. The parental questionnaire assessment was conducted by means of a self-completed questionnaire regarding the child’s attitude to school lunches, quantity of meals which children eat in the home and duration for which the child played outside at home on days when lunch was served under each of the school cooking and catering systems. The 10 questions used in the parental questionnaire (Table 4) were established in a previous study [15,16]. The questions collected scores for usual child’s attitude to the school lunches, usual quantity of breakfast, usual quantity of snack, usual quantity of dinner in children in the home, and for how long the child usually played outside at home on the days when lunch was served under each system.

**Measurement of Main Dish Temperatures**

The temperatures of all dishes were measured on two days under the school cooking system and two days under the catering system. There was no large difference between the temperatures of different hot dishes within each system. In this study, we employed the temperatures of the main dishes as representative values for those of all hot dishes in the school lunch. Temperatures were measured by thermometer (AD-5625, A&D Corporation, Tokyo, Japan). In the center of the food twice per lunch, for meals prepared under both systems, immediately before serving.

**Statistics**

The results were summarized using mean values and standard deviations, except for the temperatures of main dishes. Differences between the cooking and catering systems were analyzed using the Wilcoxon signed-rank test. Effects of the type of serving system and of time course on the time spent engaging in non-eating behaviors were analyzed using a two-way analysis of variance (ANOVA). Differences with \( p \leq 0.05 \) were considered significant.

Bayesian network show causation between variables using arrows in a graph. Causal effects were calculated using a Bayesian network [14]. A Bayesian network can indicate causal relationship using Bayes’ theorem between variables without dependence on graph theory. A Bayesian network is a directed acyclic graph that is composed of a set of variables \( X_1, X_2, \ldots, X_N \) and a set of directed edges between the variables [14]. A variable has several possible states, e.g. true and false. Bayesian networks are very successful in probabilistic knowledge representation and reasoning. In Bayesian networks, the joint probability distribution function of all nodes can be calculated as follows:

\[
P(X_1, X_2, \ldots, X_N) = \prod_{i=1}^{N} P(X_i | Pa_i)
\]

Where \( Pa \) is the set of random variables, whose corresponding nodes are parent nodes of \( X \), A Bayesian network contains two elements: structure and parameters. Each arc begins at a parent node and ends at a child node. \( Pa (X) \) represents the parent nodes of node \( X \). \( X_1 \) is the root node because it has no input arcs. Root nodes have prior probabilities. Each child node has conditional probabilities based on the combination of states of its parent nodes.

Statistical analysis was performed using SPSS Statistics with Advanced tool version 20 (IBM Japan ltd., Tokyo, Japan) and R version 3.2.0 (The R Project for Statistical Computing, Vienna, Austria).

**Ethical Consideration**

This study was reviewed and approved by Kanagawa Dental University Ethics Committee (No. 381). We got informed consent and child assent from their parents.

**Results**

**Differences between the School Cooking and Catering Systems**

Table 5 shows the temperature of the main dishes, proportion of leftovers, duration between start and end of eating lunch, and child’s attitude to the school lunches, in the school cooking and catering systems. The temperatures of the main dishes served under the school cooking and the catering systems were 67.5°C and 14.4°C, respectively (Table 5). The average proportion of leftovers after meals served under the school cooking system was smaller than that of meals served under the catering system \( (p = 0.02, \text{Wilcoxon signed-rank test, Table 5}) \). All children did not leave green tea. The average time between starting and finishing eating lunch under the school cooking system was shorter than the average under the catering system \( (p < 0.001, \text{Wilcoxon signed-rank test, Table 5}) \). The average child’s attribute to the school lunch of meals served under the school cooking system was higher than that of meals served under the catering system \( (p=0.05, \text{Wilcoxon signed-rank test, Table 5}) \).

**Children’s Eating Behaviors in the School Cooking and Catering Systems**

Figure 2 shows the amount of time children spent engaging in each type of behavior. Less time was spent during lunches prepared under the school cooking system, compared to those prepared using the catering system, engaged in playing with chopsticks \( (p = 0.006, \text{two-way ANOVA, Figure 2}) \), looking away \( (p = 0.003) \), and standing up \( (p = 0.04) \). However, more time was spent taking short breaks in the school cooking system than in the catering system \( (p = 0.001) \). Time spent during lunches putting one’s elbows on the desk in both systems was not significant \( (p = 0.5) \).

**Causal Relationships Involving Leftovers**

Figure 3 shows causal effects between the variables measured in the Bayesian network.
in the present study, as calculated using Bayesian network theory. Black circles represent discrete variables, and white circles represent ordinal variables. Arrowheads and lines indicate effects and causes, respectively. The Bayesian network indicates that causes of the proportion of leftovers from school lunch meals were the system under which the lunch was served, the temperature of the main dish, the child’s attitude to the meal, and the amount of time spent playing with chopsticks, standing up, and taking short breaks (Figure 3). The duration between the start and end of eating lunch was caused by the amount of time spent looking away (Figure 3).

**Discussion**

In the present study, we focused on the significance of leftovers from school lunches in a Japanese nursery school. The weights and chemical compositions of meals served under the school cooking system were similar to those of meals served under the catering system.
amount of leftovers from school lunches (Figure 3). Playing with chopsticks during their school lunch is a manifestation of children's poor concentration of effort on consuming their meal [18]. In a previous study as in this one, poor concentration by children increased the amount of leftovers they left [19]. Concentration on the meal during school lunch can be controlled by encouragement from teachers [19]. Such encouragement might reduce the time spent playing with chopsticks during school lunch by improving children's concentration on their meals. It is likely that decreasing the time children spend playing with chopsticks by means of this type of encouragement from their teachers might contribute to reducing the amount of leftovers from school lunches.

**Association between Taking Short Breaks and Leftovers**

The amount of leftovers from meals prepared under the school cooking system was decreased when children spent more time taking short breaks (Figure 3). Taking short breaks was defined as a behavior in which a child paused their eating while moving their arms and legs (see Methods). Thus, taking short breaks does not happen simultaneously with playing with chopsticks, standing up, or looking away. Therefore, when children eat meals prepared in the school cooking system, taking short breaks might function as a replacement for problem behaviors such as playing with chopsticks, standing up, and looking away. Therefore, it might be difficult to design interventions to control the amount of time spent taking short breaks, because an increase in taking short breaks is what allows a decrease in problem behaviors. Serving lunch using the school cooking system was the only factor influencing how much time children spent taking short breaks.

**Contribution of Dietitians and Cooks under the School Cooking System**

Serving lunch using the school cooking system directly reduced the amount of leftovers (Figure 3). One difference between the school cooking system and the catering system in the present study was the existence of dietitians and cooks at the school and their jobs. On days when the school cooking system was in operation, dietitians and cooks made the school lunch in the kitchen in the school and then served the meal to the children. More generally, dietitians and cooks also provide teaching on nutrition for children and students in their classes only under the school cooking system. One of the key factors in why the school cooking system reduces leftovers might be these lectures from the dietitians and cooks. However, a common primary reason for schools to employ the catering system is the cost of employing dietitians and cooks [20]. Schools preparing lunch using a school cooking system need to employ one dietitian or cook per 100 children, while outside catering centers employ 0.5 cooks per 100 children in Japanese nursery and elementary schools [21]. Thus, the cost of these employees in the school cooking system is twice that of their cost in the catering system, meaning that one way of reducing school lunch leftovers is to double the amount spent on employment in order to adopt the school cooking system. In turn, this would increase the educational benefits of the school lunch.

Such expenditure may be economically justifiable. Our previous study indicated that children who acquire ideal eating habits retain these habits even in adulthood [2]. Thus, the greater educational benefits of school lunch for children under the school cooking system should influence their eating habits in adulthood, which might reduce the incidence non-communicable disease [3]. Doubling expenditure on dietitians and cooks to employ them in schools could have the effect of preserving children's health into their adulthood. In a long-lived society, the cost of medical care is one of the most important issues [22].

**Factors Influencing the Amount of Leftovers**

The proportion of leftovers from school lunches served under the school cooking system was lower than that of lunches served under the catering system ($p = 0.02$, Table 5). A Bayesian network shows that the amount of leftovers was controlled by child's attitude to the meal, the temperature of the main dish, the system under which the lunch was served, and time spent engaging in eating behaviors such as playing with chopsticks, standing up, and taking short breaks (Figure 3). Figure 2 and 3 shows that the smaller proportion of leftovers was caused by higher child's attitude to meals, higher temperatures of the main dish, being prepared in the school cooking system, less time spent playing with chopsticks or standing up, and more time spent taking short breaks. Figure 2 and 3 also shows possible ways of controlling the amount of leftovers from school lunches. Serving the main dish at a higher temperature, increasing child's attitude to the meal, and preparing the meal using the school cooking system would reduce the amount of leftovers. Simultaneously, suppressing the amount of time children spend playing with their chopsticks and standing up could also reduce the amount of leftovers from school lunches.

**Effects of Standing up and Playing with Chopsticks on Leftovers**

Less time spent standing up decreased the amount of leftovers from school lunches (Figure 3). Previous research has found that instructing children not to stand up during their school lunch reduced the frequency of standing up in children in a nursery school [17]. Thus, giving such instructions might in turn reduce the amount of leftovers from school lunches [18].

Less time spent playing with chopsticks also decreased the amount of leftovers from school lunches (Figure 3). Playing with chopsticks during their school lunch is a manifestation of children's poor concentration of effort on consuming their meal [18]. In a previous study as in this one, poor concentration by children increased the amount of leftovers they left [19]. Concentration on the meal during school lunch can be controlled by encouragement from teachers [19]. Such encouragement might reduce the time spent playing with chopsticks during school lunch by improving children's concentration on their meals. It is likely that decreasing the time children spend playing with chopsticks by means of this type of encouragement from their teachers might contribute to reducing the amount of leftovers from school lunches.

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The amount of leftovers from meals prepared under the school cooking system was decreased when children spent more time taking short breaks (Figure 3). Taking short breaks was defined as a behavior in which a child paused their eating while moving their arms and legs (see Methods). Thus, taking short breaks does not happen simultaneously with playing with chopsticks, standing up, or looking away. Therefore, when children eat meals prepared in the school cooking system, taking short breaks might function as a replacement for problem behaviors such as playing with chopsticks, standing up, and looking away. Therefore, it might be difficult to design interventions to control the amount of time spent taking short breaks, because an increase in taking short breaks is what allows a decrease in problem behaviors. Serving lunch using the school cooking system was the only factor influencing how much time children spent taking short breaks.

**Contribution of Dietitians and Cooks under the School Cooking System**

Serving lunch using the school cooking system directly reduced the amount of leftovers (Figure 3). One difference between the school cooking system and the catering system in the present study was the existence of dietitians and cooks at the school and their jobs. On days when the school cooking system was in operation, dietitians and cooks made the school lunch in the kitchen in the school and then served the meal to the children. More generally, dietitians and cooks also provide teaching on nutrition for children and students in their classes only under the school cooking system. One of the key factors in why the school cooking system reduces leftovers might be these lectures from the dietitians and cooks. However, a common primary reason for schools to employ the catering system is the cost of employing dietitians and cooks [20]. Schools preparing lunch using a school cooking system need to employ one dietitian or cook per 100 children, while outside catering centers employ 0.5 cooks per 100 children in Japanese nursery and elementary schools [21]. Thus, the cost of these employees in the school cooking system is twice that of their cost in the catering system, meaning that one way of reducing school lunch leftovers is to double the amount spent on employment in order to adopt the school cooking system. In turn, this would increase the educational benefits of the school lunch.

Such expenditure may be economically justifiable. Our previous study indicated that children who acquire ideal eating habits retain these habits even in adulthood [2]. Thus, the greater educational benefits of school lunch for children under the school cooking system should influence their eating habits in adulthood, which might reduce the incidence non-communicable disease [3]. Doubling expenditure on dietitians and cooks to employ them in schools could have the effect of preserving children's health into their adulthood. In a long-lived society, the cost of medical care is one of the most important issues [22].
We propose that governments in such societies, such as Japan, should spend more to employ dietitians and cooks in nursery and elementary schools to reduce the future cost of medical care.

**Influence of Smell in the School Cooking System**

Preparing lunch under the school cooking system directly reduced the amount of leftovers (Figure 3). The children had opportunities to see their school lunch cooking and to smell the flavors emanating during cooking only on the days on which it was prepared under the school cooking system. Exposure to the smell of a food increases attitude to the food in humans [22]. Accordingly, cooking smells emanating from the school kitchen should increase the attitude to the school lunch. Figure 3 shows that higher child’s attitude to the school lunch decreased leftovers; cooking smells emanating from the school kitchen may thus play a role in decreasing school lunch leftovers. Considering that reduced leftovers from school lunch in nursery school children and elementary school students decreases the risk of growth retardation in childhood and non-communicable diseases in adulthood [4], cooking smells emanating from school kitchens when meals are prepared under the school cooking system might decrease the risk of non-communicable diseases by reducing school lunch leftovers.

**Influence of the Duration between the Start and End of Eating Lunch on the Amount of Time Spent Looking Away**

The duration between the start and end of eating lunch was caused by the amount of time spent of looking away (Figure 3). Time spent of looking away seems to be longest in the behaviors measured in the present study (Figure 2). Proportion of looking away in the lunch time would be high. Such high proportion of looking away would be a key factor of start and end of eating lunch.

**Considerations**

The present study aimed to elucidate the effects of school lunch cooking system on leftovers and children’s behaviors in a nursery school. Participants in this study were limited to a single nursery school, which is located in Amagasaki City, Hyogo Prefecture. Therefore, the generalizability of absolute values in our results to all populations should be evaluated with caution. However, our comparisons on several measures between the school cooking system and the catering system in the same participants can provide a fruitful source of evidence on the effects of cooking system. This study focused on relative values, which enhances its reliability. We think that this is a fruitful approach to elucidating the effects of each cooking system.

In this study, we obtained a response rate of 58% for the parental questionnaire (see Materials and methods). In previous studies conducted in nursery schools in Japan, response rates to parental questionnaires were 38 and 59% [10,11]; that is, rates similar to or lower than that of the present study. Response rates in questionnaire-based studies have been decreasing in Japan [23]. Furthermore, strict law governing personal information, the “Act on the Protection of Personal Information,” came into force in 2005 and in Japan. Nowadays, a response rate of 58% for questionnaires administered to parents of nursery school children would not be considered a low response rate in Japan.

**Conclusion**

The reduction in leftovers from school lunches observed in the school cooking system was due to the higher child’s attitude to the meals, higher main dish temperatures, preparation of the meals within the school cooking system, less time spent playing with chopsticks and standing up, and more time spent taking short breaks. Accordingly, increasing the temperature of main dishes (which may have a greater specific heat capacity than other dishes) and child’s attitude to the school lunch of the meals and preparing meals under the school cooking system would reduce the amount of leftovers from school lunches. Simultaneously, suppressing the amount time spent standing up, which can be controlled by instructing children, could also reduce leftovers. These candidate interventions to reduce leftovers from school lunches should contribute to the inculcation of ideal eating habits in children, an effect which lasts into adulthood.

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**Conflict of Interest**

The authors declared there is no conflict of interest.

**Author contributions**

YM measured the leftover of meals. KT and YO observed eating behavior. MT analyzed Bayesian network. RH, TT, and RBS planned the study. TT wrote the first draft with RH. DWW advised RH. HSB drew figures. All authors reviewed and commented on subsequent drafts of the manuscript.

**Identification of the Corresponding Author**

Rie Horiuchi, 6-46 Ibebiraki-cho, Nishinomiya city, Hyogo prefecture 663-8558, Japan.

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**References**


*Corresponding Author: Rie Horiuchi, Department of Food Sciences and Nutrition, Faculty of Human Environmental Sciences, Mukogawa Women’s University, 6-46 Ikebiraki-cho, Nishinomiya city, Hyogo prefecture 663-8558 Japan, Tel: 81-079-845-3769; Fax: 81-079-845-3769, E-mail: mhor949@mukogawa-u.ac.jp

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