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Food waste in primary schools: Evidence from peri-urban Viet Nam

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ABSTRACT

Schools are a major source of food waste and an important setting for achieving dietary improvements. Few studies explore the links between food waste and nutrition. This study measured individual plate waste of about 1700 primary school children in peri-urban Viet Nam, adding to evidence on school food waste in low- and middle-income countries. We used survey data to explore whether food waste is associated with personal characteristics such as sex, knowledge and attitudes about nutritious foods. Qualitative interviews and focus groups with teachers, parents, food providers and children helped identify potential causes of food waste. The average student wasted 23% of the food served (approximately 85 g) during lunch, which roughly equates to 15.3 kg of food in a school year. Vegetables were wasted most: children left almost half of their portion unconsumed. Boys wasted less food than girls. Better knowledge and attitudes about fruits and vegetables are associated with less waste of these foods. A large portion was associated with a higher share of wasted food, suggesting the potential trade-off between efforts to cut food waste and efforts to increase consumption of nutritious foods. Students were dissatisfied with the quality of the dishes, especially vegetables were evaluated as undercooked, served too cold and too oily. To reduce food waste, it is critical for schools to prepare food in line with students' preferences. Food waste reduction could be treated as an intermediate step towards ultimate policy goals such as healthier food consumption.

1. Introduction

Food waste is a globally significant issue. It was estimated in 2021 that 17% of total global food production may be wasted, 61% of which comes from households, 26% from food service and 13% from retail (UNEP, 2021). Reducing food loss and food waste by 50% in 2030 is one of the United Nations' Sustainable Development Goals (United Nations, 2015). In addition, there could be a trade-off between decreasing food waste and improving the nutritional status of the poor and vulnerable. A substantial share of the world's population depends at least in part on public food provision, such as school meals and food served in care institutions for the elderly (Drake et al., 2020). In such settings, decreasing portion sizes to avoid food wastage may result in lower overall consumption. The "portion size effect", demonstrating that increasing portion size leads to increased energy intake in both adults and children, has been observed in numerous studies across types of foods and settings (English et al., 2015).

Most studies quantifying the amount of food waste have been prepared in high-income countries (European Commission, 2011; World Wildlife Fund, 2019). However, it is urgent to complement these with studies from low and middle-income countries (LMICs), where problems with food waste are most expected to grow. Many LMICs are undergoing changes in food systems due to rapid urbanisation, expansion of supermarket chains, and changes in diets and lifestyles (FAO, 2015; Thi et al., 2015). It is projected that households' uneaten food has been levelling off in rich countries but are growing rapidly in emerging economies, particularly China and South Asia. These areas are likely to play a key role in determining global food waste at mid-century (Lopez Barrera & Hertel, 2021; UNEP, 2021). Nevertheless, there is insufficient data on the extent of the problems in LMICs (UNEP, 2021), with a particular lack of micro-studies that capture detailed information at each stage of the value chain (Delgado et al., 2021).

Schools are important entry points for tackling the complex relationship between food waste and nutrition for at least three reasons. First, school meals and school feeding programmes worldwide are an important source of nutrition and diet improvements for children (WFP, 2013). Second, schools are an effective setting for educating young consumers and influencing future habits regarding healthy eating

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(Micha et al., 2018) and sustainability (Derqui et al., 2018). Third, several studies in high-income countries have indicated that school canteens are a major source of FW (Cordingley et al., 2011; Derqui et al., 2018; World Wildlife Fund, 2019; Falasconi et al., 2015; Kaur et al., 2021). Although similar problems have been suggested by the limited evidence available from China (Liu et al., 2016, p. 1288) and Malaysia (Kasavan et al., 2021), food waste in schools in LMICs has hardly been studied. Food waste behaviour has been found to be influenced by a mix of both internal factors (such as attitudes, knowledge, habits and resources) and external factors (such as social norms and environmental contexts) (Abe & Akamatsu, 2015; Roodhuyzen et al., 2017). Across contexts, the most frequently leftover foods in schools are nutritious foods such as milk and vegetables (Blondin et al., 2015; Byker et al., 2014; Silvennoinen et al., 2015; Smith & Cunningham-Sabo, 2014). While increasing portion size can be an effective way to increase consumption of nutritious foods (Miller et al., 2015), this could lead to even more food waste.

Despite the potential trade-off between food waste reduction and nutrition goals, few studies have explored this link. To our knowledge, most studies have looked separately at efforts to decrease food waste and efforts to increase healthy food intake. When they were looked at together, the focus has been the nutritional aspect of food consumption, with food waste merely serving to assess nutrient loss (Kaur et al., 2021). Cohen et al. (2014) found that increasing portion size for vegetables resulted in more cups of vegetables consumed. The dearth of research that looks at both issues concurrently is troubling, given the need to look at trade-offs within the food system (Béné et al., 2019). Exceptions include two studies that assessed the impact of new USDA nutrition standards in the National School Lunch and Breakfast Programmes and did not lead to increased food waste among the elementary school children studied. Schwartz et al. (2015) found similar results in middle schools, where new school meal regulations that increased fruit consumption did not increase total plate waste.

Viet Nam provides a good context to explore the issue of food waste. Viet Nam is an LMIC in Southeast Asia whose population is going through a nutrition transition characterised by higher purchasing power for food and increased consumption of protein-rich and ultra-processed foods that are high in fats, sugar and salt (Raneri et al., 2019). Besides the significant amount of food loss at earlier stages of the food value chains (CEL Consulting, 2018), Viet Nam is estimated to be the second-largest producer of food waste in the region, behind China. In a survey covering 4000 households in eight Asia-Pacific countries, 87% of Vietnamese households admitted that they waste two plates of food per week on average (Vu, 2019). An estimated 95% of Viet Nam's primary schools serve lunches (Le et al., 2021). Even in big cities like Hanoi and Ho Chi Minh City, school meals are usually prepared by kitchen staff without sufficient knowledge of nutrition and suffer from a limited variety of dishes on offer (S. D. T. Le Nguyen, 2012; Le et al., 2021), which is considered to lead to food waste (Thuan et al., 2019). Yet, no study to date has either quantified the extent of food waste in Viet Namese schools or explained its causes.

This paper serves a dual objective: to assess the level of food waste in primary schools in peri-urban Viet Nam, and to discuss potential causes and solutions to reduce this food waste. We posed the following research questions (RQ):

- How much food is wasted during a school meal? (RQ1)
- What type of food is wasted the most by the end-users – school children? (RQ2)
- Is plate waste by school children associated with personal characteristics, such as sex, nutrition knowledge and attitudes? (RQ3)
- Would plate waste decrease with smaller portions? (RQ4)
- What are the potential causes of food waste in school? (RQ5)

We contribute to the evidence base on food waste in three ways. First, we add to the limited pool of evidence on the issue of food waste in schools in LMICs. In comparing the situation in Viet Nam with those in previous international studies, we can understand the extent of the problem and contribute to identifying research gaps. We also identify which types of foods are being wasted most, helping to establish priorities for interventions intended to reduce food waste. Second, we explain the intention-attitude-behaviour gap that may act as a barrier to the success of interventions designed to prevent food waste (Kaur et al., 2021). Both qualitative and quantitative methods were used to explore the potential causes of food waste by children in primary schools. From our results, we can identify points of leverage to reduce food waste and suggest promising interventions. Third, we provide essential information on the potential trade-offs and/or synergies between efforts to minimise food waste and improve nutritional quality of school meals. These contributions are importantgiven the dearth of research that investigates both issues concurrently.

2. Methods

2.1. Plate waste assessment

Measurement of food waste is complicated, as various definitions and measurements exist (Bellemare et al., 2017). In educational settings, food waste can be divided into 'pre-consumer waste', which is kitchen waste arising at the time of storage, preparation and production, and 'post-consumer waste', which consists of leftovers or plate waste (Kaur et al., 2021). Plate waste is the focus of the present study. The measure chosen for food waste was individually weighed plate waste, which is defined as the quantity of edible food served on a plate but left unconsumed (Chapman et al., 2019; Huang et al., 2017).

2.1.1. Data collection

We measured the plate waste left during lunch by a sample of 1777 children in grades 3–5 (9–12 years old) at 12 primary schools in Dong Anh district, peri-urban Hanoi, Viet Nam in 2019. The collected data were part of a research project to assess the effect of nutrition education on children's consumption of fruits and vegetables (hereafter RCT). The nutrition lessons involved trained teachers delivering nutritional messages to children in 5-min show-and-tell talks right before lunch, for five consecutive weeks. Each week covered a topic, which was presented to children on two different weekdays. The full explanation of the sampling procedure can be found in Nguyen et al. (2021). To summarise, an average of ten children from each of the 197 3rd to 5th grade classes joined the research, either as a control or randomised treatment group. The specific site was selected for growing concerns about child obesity in the context of urbanisation and the nutrition transition (T. Nguyen et al., 2021). The endline data from all children was used in this paper. As previous research has shown that the intervention, which was randomly assigned to half of the children, did not affect food consumption and waste, we ignore it in the remainder of the paper (T. Nguyen et al., 2021). Data collection included a survey among children to assess their knowledge and attitudes about fruit and vegetable consumption, and plate weight measurement to assess the children's vegetable consumption. The questionnaire included questions related to the contents of the treatment lessons, such as the role of different fruits and vegetables of different colors and the recommended consumption amount (Appendix 1). Additionally, we also collected food diaries recording children's home consumption. This part of the dataset did not contain any food waste data and was not used for this paper. Household demographic and income data were taken from the baseline survey interviews with children's parents.

In all the participating schools, the food was prepared outside of schools by a contractor. The dishes were then brought in large containers to the schools, where the contractors' staff would divide them into roughly equal portions served on plates. The plates were then delivered to the classrooms where the children would sit at their desks to eat. Parents were responsible for covering the cost of the school meal,

and public schools in the same district followed similar cost norms. A meal cost 15,000 Viet Namese dong (66 US cents) during the school year 2018/19.

The school lunch menu was typically based on Viet Namese cuisine, with rice as the staple and main source of carbohydrates. Each portion consisted of rice, a vegetable dish, and two protein-based dishes (for example meat, shrimp or tofu). All vegetables served were fried. No boiled vegetables or salads were served. The meal also included a watery soup, consisting of finely chopped green vegetables, water and bouillon, which was served to each classroom in a large container. From the observation of a nutritionist, this soup did not hold much nutritional value as there was very little vegetable in it. In Vietnamese meals, the soup is typically eaten toward the end of the meal and helps children to swallow down the remaining rice and cleanse the palate.

Although the schools also indicated the standard portion sizes in the weekly menus, we made our own measurement of a portion on the day of the school lunch for better accuracy. To estimate the so-called standard portion for each grade, the enumerators were instructed to measure at random, three plates and take the average values of the measurements as the standard portion. We used a kitchen scale to measure the value in grams of the 'dry' dishes: rice, vegetable and protein-based dishes.

When the plates were distributed to the children, the enumerators marked the plates provided to the children with a sticker containing an ID number (according to the code from the sampling list). After the children finished their lunches, the enumerators collected the numbered plates, weighed each meal component separately and recorded the leftover amount. We did not measure the amount of soup wasted because the children could take as much as they wanted. We measured the plate waste for two days, with one day in between, in each school. Table 1 displays the average portion size, by component (dish) measured in grams.

In comparison to the food pyramid published by the National Institute of Nutrition (NIN) for children aged 6–11,[1] the vegetable portion provided only a quarter of the daily recommendation (200–300 g of vegetables). The rice portion provided half of the daily recommendation (400–700 g of rice). The total protein dishes provided an equivalent of almost 2.5 servings (each serving is equivalent to 7 g of protein), around half of the daily recommendation (4–6 servings). Assuming that the lunch meal provides half of the daily food intake, the amount of vegetable offered during lunch was much lower than recommended, while the amounts of protein-based foods and rice were adequate.

2.1.2. Analysis

To quantify food waste, we calculated the amount of plate waste for each dish. The data were also disaggregated by variables that have been found to be related to food waste: child gender (Abe & Akamatsu, 2015; Kaur et al., 2021; Wu et al., 2019) and household income level (Wu et al., 2019). The household income reported by children's parents was categorised into quartiles, with the 1st income quartile representing the 25% least well-off and the 4th income quartile representing the 25% most well-off households. Pairwise t-tests were conducted to determine whether the differences between groups were statistically significant.

As we were also interested in how portion sizes, as an external factor of the school food environment, can influence the relative amount of food waste, we ran the following series of simple linear regressions:

$$y_{ij} = \alpha_0 + \alpha_1 x_{ij} + \varepsilon_{ij} \quad \text{Model 1}$$

where y_{ij} is a vector of the amount consumed, the amount of leftover, and the share of leftover of each dish for child i in school j; x_{ij} is the portion size of the respective dish; and ε_{ij} is the clustered error term for child i in school j. As the children from the same school shared the same menu, clustering at the school level prevented underestimating the variance in the estimators.

To answer exploratory questions on whether personal factors can influence the amount of food waste, we ran the following simple model with OLS regressions, as follows:

$$y_{ij} = \alpha_0 + \alpha_1 Knowledge_{ij} + \alpha_2 Attitude_{ij} + \alpha_3 Frequency_{ij} + \sum_{i=1}^{n} \beta_j X_{ij} + \varepsilon_{ij} \quad \text{Model 2}$$

where y_{ij} is the relative amount of leftover (as a share of the respective portion) for child i in school j. *Knowledge* is the score for knowledge of fruits and vegetables, while *attitude* is the score for attitudes towards consumption of fruits and vegetables. These scores were based on a mean effects index (Kling et al., 2007) where the control group in the RCT takes the mean 0 and standard deviation 1 (T. Nguyen et al., 2021) . *Frequency* represents how many times children ate vegetables in a week as a proxy for consumption habits. X_{ij} variables include socio-demographic characteristics (child gender, child age, child's household income quartile), while ε_{ij} is the clustered error term for child i in school j.

The knowledge and attitude variables were constructed concerning fruit and vegetable consumption (See T. Nguyen et al. (2021) for a detailed description of how the variables were constructed using mean effects indexing) and were expected to directly influence the leftover amount of vegetables. As there can be substitution effects among different dishes, we ran similar regressions for the three food types.

2.2. Determination of causes of food waste in schools

2.2.1. Data

We used the qualitative data collected as part of a scoping study to design the RCT. In this study, two schools in Dong Anh were selected by the Division of Education and Training. Although the researchers provided the authorities with background information on the research, including school selection criteria (schools with more disadvantaged children, with high rates of undernutrition and/or overnutrition), the authorities did not reveal to the researchers how they selected the schools For each school of the two schools, the researchers conducted in-depth interviews (IDIs) with a parent, the school authority and the meal provider, as well as two focus group discussions (FGDs) with 5–8 students each (Table 2).

2.2.2. Analysis

The FGD and IDI transcripts were treated as secondary texts to be analysed for this study on school food waste, and the following step-by-step approach was employed:

Table 1
Mean, standard deviation, range of weight (g) and number of plates measured.

Dish	Mean	SD	Min	Max	N
Rice	229.1	23.7	177.5	280.5	1720
Vegetable dish	49.9	8.7	34.0	76.0	1720
Protein dish 1	48.6	8.5	30.5	65.5	1720
Protein dish 2	45.0	10.5	24.5	80.5	1720
Total protein dishes	93.6	14.7	67.5	146.0	1720

Table 2
Number of FGDs and IDIs carried out.

School	FGD - Children	IDI – School's Authority	IDI – Parents' Representative	IDI – Meal Provider
A	2	1	1	1
B	2	1	1	1

[1] http://chuyentrang.viendinhduong.vn/FileUpload/Documents/TL%20truyen%20thong/TDD%20HL%20cho%20tre%206-11%20tuoi.pdf.

Step 1: Document scanning to discern exchanges that involve the theme of leftover/wasting food. This step involved identifying excerpts that contained the keywords 'leftover'; 'not finished'; 'waste'; 'throw away' etc. This process can be seen as 'a way of tagging data that are relevant to a particular point', or 'indexing' as described by Elliott (2018).

Step 2: At this stage the identified excerpts were read through line by line for coding. To construct as many codes as possible, a number of coding strategies based on the work of Miles et al. (2014) were employed, such as in vivo coding, process coding, emotion coding, and so on.

Step 3: The codes were carefully read and connected to each other to construct broader themes relating to the students' leftover/wasting food behaviour. Repetition of phrases and codes was also searched for to determine important themes. After that, the transcripts were closely read for another round to recode and expand upon the chosen themes of 'the children's dissatisfaction with school food', 'large portion', and 'food hygiene'.

Step 4: Narrating took place during this step, in which short analytical memos were written based on each code and then organised based on the themes as the basic draft for the write-up of the findings. This step was based on Miles et al.'s 4th and 5th analytical moves in qualitative data analysis (Miles et al., 2014, p. 10).

3. Results

3.1. Plate waste amount

Answering RQ1, considerable amounts of food offered were not eaten by the students. In absolute amounts, students wasted on average of 85 g (SD = 72) of food during lunch. As shown in Table 3, rice was the least wasted of the main dishes. On average, students left 15% of their rice portion on the plate. From our observation, towards the end of their meal, children often mixed watery soup with the rice left on their plate to 'swallow down' the rice more easily. On the one hand, this soggy rice may have seemed to children like a larger portion than it was. On the other hand, there is a concern for measurement: some leftover rice got wet from the soup and became heavier when weighed. Thus 15% may be an overestimation of the actual amount wasted.

Regarding RQ2, vegetables were wasted the most: the children left almost half of their portion unconsumed, on average. The most 'popular' and most often consumed vegetable appeared to be water spinach (Table 4), which was served in 7 out of 12 schools. Regarding RQ2, vegetables.

On average, about a quarter of the amount of protein-based foods was wasted, although this figure varied noticeably with the type of foods offered (Table 5). For example, pork and fish were likely to be wasted least.

3.2. Factors influencing food waste

3.2.1. Personal characteristics and food waste

In this section, we present the answers to RQ3. Differences in the amount of food waste were detected for some sub-groups. In our sample, boys wasted less food than girls, and the differences were statistically significant for rice and protein-based foods. Boys wasted 4% less rice (p-value = 0.0002) and 3% less protein-based food (p-value = 0.0089) than girls. On average, children from the poorest income quartile wasted less food than children from higher-income households, but the differences were not statistically significant.

The results of the regression using Model 2 show the association between children's personal characteristics and food waste. As

Table 3
Plate waste as share of a standard portion, by dish.

Dish	Mean	Std. Dev.	Min	Max	N
Rice dish	0.15	0.21	0.00	0.91	1720
Vegetable dish	0.49	0.38	0.00	1.00	1720
Protein dishes	0.27	0.25	0.00	1.00	1720

Table 4
Wasted vegetable as share of average portion size, by dish type.

Name of dish	Mean	Std. Dev.	Min	Max	N
Wax gourd	0.64	0.34	0	1	71
Cabbage	0.60	0.34	0	1	277
Bean sprouts (and carrots)	0.40	0.40	0	1	79
Potatoes (with tomatoes)	0.43	0.37	0	1	312
Chinese cabbage	0.60	0.34	0	1	196
Water spinach (with garlic)	0.39	0.38	0	1	514
Chayote (and carrots)	0.52	0.38	0	1	271

Table 5
Wasted protein-based as share of average portion size, by dish type.

sow	Mean	Std. Dev.	Min	Max	N
First protein dish					
Beef	0.41	0.26	0.00	1.00	229
Fish	0.18	0.26	0.00	1.00	222
Chicken	0.28	0.27	0.00	1.00	386
Pork	0.18	0.25	0.00	0.99	676
Eggs	0.42	0.36	0.00	1.00	128
Shrimps	0.32	0.26	0.00	1.00	79
Second protein dish					
Chicken	0.52	0.31	0.00	1.00	71
Peanuts	0.30	0.35	0.00	1.00	903
Pork	0.21	0.29	0.00	1.00	228
Eggs	0.29	0.30	0.00	1.00	518

Table 6
Results of OLS regressions of leftover shares on child characteristics.

Variables	(1)	(2)	(3)
	leftover share vegetable	leftover share rice	leftover share protein
Knowledge score	−0.024**	−0.013**	−0.013**
	(0.010)	(0.007)	(0.006)
Attitude score	−0.031***	0.001	−0.006
	(0.010)	(0.006)	(0.006)
Vegetable consumption frequency	−0.001		
	(0.002)		
Age of child	−0.019	−0.014	−0.001
	(0.022)	(0.013)	(0.008)
Male child	−0.074***	−0.042***	−0.048***
	(0.018)	(0.013)	(0.009)
Household income quartile = 2	−0.013	0.007	0.010
	(0.026)	(0.015)	(0.015)
Household income quartile = 3	−0.005	0.001	0.010
	(0.037)	(0.014)	(0.017)
Household income quartile = 4	0.028	0.019	0.006
	(0.028)	(0.015)	(0.013)
Vegetable portion size	−0.003		
	(0.003)		
Rice portion size		−0.001	
		(0.000)	
Protein portion size			−0.001
			(0.001)
Constant	1.050***	0.589***	0.414***
	(0.224)	(0.282)	(0.184)
Observations	1367	1367	1367
R-squared	0.183	0.156	0.199

Clustered robust standard errors in brackets. The model also includes school dummies (not shown).
***p < 0.01, **p < 0.05, *p < 0.1.

displayed in Table 6, having more knowledge about a healthier diet was associated with less vegetable, rice and protein waste. A better attitude towards eating fruits and vegetables was associated with less vegetable waste but was not associated with waste of rice and protein dishes. As the descriptive results showed, boys wasted less food than girls.

3.2.2. Food waste and food portion size

We had a positive answer for RQ4. One reason for lunch food waste mentioned during the FGDs was the amount of food served to the children. Some children found the roughly standardised portion to be too big for them. However, reducing the portion size to combat food waste possibly comes at the cost of less intake of nutritious foods, as our data show that when the portions were bigger, the children ate more but also wasted more. Table 7 displays the relation between the portion size and the amount of food consumed and wasted. Coefficients of 0.25 and 0.75 for vegetables mean that increasing the vegetable portion by 100 g was associated with a 25-g increase in the amount of vegetable consumed, but also 75 g of vegetables wasted. For rice and protein dishes, just half of the larger portion was consumed. As portion size increased, the relative amount of waste (leftover share) also increased for all three dish types. Vice versa, if portion size decreased, while waste decreased, food intake also decreased.

3.2.3. School food environment and food waste

Finally, in answering RQ5, we found potential causes of food waste in school to be students' dissatisfaction with the taste of the dishes and food providers' limited capacity to improve the quality of foods served at school.

Transcripts of the FGDs with children showed that children reported not finishing the lunch portions served at school. The majority of the children participating in the FGDs complained that the food, especially the vegetables, were often cold, not sufficiently cooked, and too oily for their taste. They found it really difficult to finish their meals. On average, the children were estimated to consume only about 125 g of fruits and vegetables per day, of which 25 g of vegetables came from lunch meals. The children in all four FGDs in Dong Anh reported that vegetables, eggs and rice were the three items that were left over the most in every meal because these dishes were often the least well prepared. They considered rice the least favorite dish. The children also noted the repetition of some dishes such as fried eggs, which bored them.

During the interviews, the food providers explained that they were aware of the tool to support schools in planning diverse, nutritious and healthy meals introduced by the Ministry of Training and Education and NIN.[2] However, they indicated that many of the options presented did not suit their context. For example, serving boiled vegetables to children was not practical because that would require the serving of accompanying fish or soy sauces or other condiments for each child, which is difficult to manage since the younger age groups cannot properly serve themselves yet. In Vietnamese meals, boiled vegetables are always served with a dipping sauce as they are considered tasteless on their own. Salads were also difficult for the provider to prepare because serving raw vegetables requires higher levels of hygiene. The tap water in Viet Nam is not drinkable without being boiled first; thus, it would be risky for the provider to use tap water to wash vegetables for salad. The school representatives and food providers also explained/stated that the lunch menu for children could not be as diverse as a menu devised for adults or older children because primary school children's food requirements are very particular and restrictive. In the in depth interviews, both food providers and school representatives indicated that the meat served should be lean, chicken and fish had to be the boneless fillet parts, not many spices could be used, and spring onions or herbs should be sparingly used to suit the taste of the majority of the children.

Both providers and schools considered costs to be a barrier to better school meals. During the individual interviews, they expressed reluctance to suggest increasing the meal price to improve school food's nutritional content and palatability because they feared the parents would not believe their motives and might think that the school was trying to make more profit from the children's meals. Meanwhile, some parents consider the lunch meals as inferior to home meals and do not seem to expect better quality as 'school meals in rural districts are just to cover the necessary intake [of rice, meat and vegetables]', to 'fill children up to get through the school day' and 'just to prevent hunger, not for taste or nutrition' (Interviews with parents in Dong Anh, 2019).

One rather unexpected finding from the qualitative data analysis is the potential effect of bad food hygiene experience on children's consumption of school food. Children in both FGDs reported bad experience with school food hygiene: Someone reported having mild food poisoning after eating school lunch "After one school lunch my classmate and I had a bad stomachache" (Focus group discussion with children in Dong Anh, 2019), which had put them off eating school food ever since. One child reported "I once saw a worm in the fried morning glory dish, after that I avoided eating vegetables at schools" (Focus group discusison with children in Dong Anh, 2019) and started eating less after the incident because she was 'feeling haunted' by the image. When confronted with the comment that school food hygiene has been reported in the media as a serious issue in Viet Nam, the school food providers, nevertheless, stated that they had done their best to ensure food safety and abide by requirements and standards.

Table 7
Amount of food consumed and amount and share wasted as a function of portion size, based on individual regressions for each dish type (without controls).

Variables	(1)	(2)	(3)
	Consumed amount	Leftover amount	Leftover share
Vegetables	0.25	0.75***	0.005*
	(0.15)	(0.15)	(0.003)
Rice	0.54***	0.47***	0.001***
	(0.051)	(0.051)	(0.000)
Protein	0.57***	0.43***	0.001***
	(0.040)	(0.040)	(0.000)

Clustered robust standard errors in brackets.
***p < 0.01, **p < 0.05, *p < 0.1.

4. Discussion

Students wasted on average 23% of total food served (85 g per day). This was comparable to the average amount (21% of total food served) recorded in schools in Beijing, China (Liu et al., 2016, p. 1288). The method used by Liu et al. (2016), p. 1288 to measure plate waste was similar to our method. The amount we calculated could be translated into over 15.3 kg of food waste per student in a school year, which is lower than the figure reported by a study in the US at 19.4 kg (42.8 pounds) (World Wildlife Fund, 2019). The US study used aggregate plate waste data, which usually produces an underestimation compared with individually weighed plate waste data (Chapman et al., 2019). Additionally, this study does not make clear how yearly food waste was calculated from (per meal) audit food weight.

Vegetable dishes were wasted the most, with half of the portion unconsumed. This finding is similar to those from school-based studies in other countries, in which the greatest amount of food waste came from vegetables, fruits and salads (Blondin et al., 2015; Byker et al., 2014; Silvennoinen et al., 2015; Smith & Cunningham-Sabo, 2014). Studies in the USA have revealed that students wasted 40% and 30%, respectively, of the fruits and vegetables they were served (Templeton et al., 2005; Byker et al., 2014). We also found that boys wasted less food

[2] The tool includes 120 menus and 360 unique dishes. See https://buaanhocduong.com.vn/About/Index/6.

than girls in our sample, with findings for staple foods similar to those of Wu et al. (2019).

Despite the waste, the food provider had no incentive to cut down the plate size as they followed a standard meal composition and preparing less would make the meals look 'meagre' in parents' eyes. In addition, simply decreasing portion sizes would have negative side effects for vegetables, as this would also reduce vegetable consumption. This finding echoes Boschini et al.'s (2020) study, which found that the serving size significantly affected the amount of a diner's leftovers, but went further to show that reducing the serving size by a certain percentage can lead to an even greater reduction in consumption. As children are currently not eating sufficient amounts of vegetables, schools must confront the trade-off between reducing plate waste and making sure children eat enough vegetables.

Education programmes can sensitise school children about waste (Antón-Peset et al., 2021; Phan Hoang & Kato, 2016; Prescott et al., 2019) and nutrition (T. Nguyen et al., 2021). This fits with a growing need for schools to integrate health and environmental approaches in the school context to nurture healthier and more environmentally aware young people (Proctor et al., 2020). However, programs that increase knowledge do not necessarily lead to a change in attituted and behaviour. In our research schools, nutrition lessons helped to increase the children's knowledge, but did not succeed in changing their attitude, nor did they increase consumption or lower the amount of food waste (T. Nguyen et al., 2021). A more holistic program of food systems education that integrates sustainability and food may have better results (Prescott et al., 2019). In addition, rather than just providing information, researchers can test targeted content utilising behavioural science concepts. Examples are invoking social emotions (Jagau & Vyrastekova, 2017), setting social norms (Kallbekken & Sælen, 2013), using nudges like smaller plates (Kallbekken & Sælen, 2013), and experiential learning (Ahmed et al., 2018; Langellotto & Gupta, 2012). More evidence (e.g., field experiments) are needed to test the efficacy of such interventions.

Other strategies may be needed to complement nutrition training. The school food environment is a promising entry point as it significantly influences children's food options, especially in terms of availability and desirability of different types of food. In our case, the school food providers were not able to provide a wide range of dishes and varied cooking methods due to budget constraints and safety concerns. As a result, the food offered to children was not appetising enough to get them to finish their meals. This finding is consistent with some previous studies, for example, Martins et al.'s (2020) study on factors influencing food waste at lunch by fourth-grade school children in Portugal. The study highlights the effect of children disliking food on food waste behaviour. In particular, their study shows that satisfaction with sensory characteristics of the food was associated with low plate waste values for both the main dish and soup. Indeed, disliking food has been shown by various studies to be the most common issue affecting children's eating behaviour during school lunches and subsequent plate waste (Bustamente et al., 2018; Cohen et al., 2013; Moore et al., 2010; Serebrennikov et al., 2020; cited in Martins et al., 2020).

To reduce plate waste, it is critical for schools and food suppliers to ultimately provide food that is not only nutrient dense but also in line with students' preferences, both in terms of palatability and cooking methods. For example, introducing salads has been suggested in the National School Campaign programme, but this is not yet feasible for the research area due to food safety constraints and problems with the sourcing of good-quality vegetables. Other solutions have also been endorsed in previous studies as reviewed by Kaur et al. (2021): improvement of taste and quality, hiring well-trained cooks, menu revision and using locally grown and in-season foods. The local contexts, nevertheless, will impose several constraints on such solutions. Implementing the necessary changes would not only require attention from schools and food providers, but would also demand changes in local regulations and the support of parents. Clear and continuous communication among kitchen managers, kitchen staff, students and school authorities can boost the success of food waste reduction efforts (Prescott et al., 2019; Zhao et al., 2019). However, such efforts face numerous barriers (Kaur et al., 2021), and it is important to understand the private costs and benefits of such actions (Cattaneo et al., 2021). In our context, the headmasters and food providers we interviewed both thought that a better quality meal for the children would require a larger financial contribution from the parents, but the parents were not willing to pay more for a meal that they feel is only meant to prevent hunger. The cost of a high-quality meal can be a constraint, and a tool to propose alternative lower-cost options is needed (Fernandes et al., 2016). The current meal planning tool introduced by Viet Nam's Ministry of Training and Education does not provide such lower-cost alternatives and is not suitable for more disadvantaged schools.

Our study highlights the potential trade-off between reducing food waste and improving nutrition. It has been proposed that food loss and waste reduction should be treated as an intermediate measure, while interventions should be designed and targeted to further ultimate goals of policy interest (e.g. food security, reducing GHG emissions, etc.) (Cattaneo et al., 2021). As such, school-based nutrition interventions should view reduction of food waste as a stepping-stone towards the ultimate aim of increased consumption of healthier food. A school-based approach to healthy eating may result in increased consumption of nutrient-dense food while at the same time reducing food waste (Dudley et al., 2015). However, our data show that the simple intervention of increasing portion size to boost the consumption of nutritious foods will likely lead to more food waste. Similar findings are reported for pre-schoolers: increasing portion size leads to higher consumption but also higher food losses (Diktas et al., 2021; Spill et al., 2010). Conversely, limiting food waste by flexible food portioning (e.g. half-portions) (Derqui et al., 2020; Lagorio et al., 2018) can reduce consumption of healthier foods such as vegetables, as children are likely to eat even less of them when served a smaller portion. This trade-off between food waste and nutrition goals has been discussed in the context of obesity (Ellison & Prescott, 2021). While obesity and food waste are both positively related to portion size, underconsumption of nutritious foods and food waste are both exacerbated by a lack of quality meals, as our findings show. Improving the quality of school meals, therefore, remains a critical aspect of tackling both food waste and undernutrition, next to solutions to help students learn to like foods such as vegetables, for example experiential learning, sensory food education and lessons on healthy eating as discussed above.

The study has several limitations. First, this paper does not address pre-consumer and post-consumer waste handling. Examples of pre-consumer waste include not re-using surplus food or preparing too much (Kaur et al., 2021). Post-consumer handling examples include recovering food for other productive purposes. In Viet Nam, leftover food is commonly used for animal feed (Tuan et al., 2018). Interviews with the schools confirm that the food waste is usually left for the maintenance workers to take and recycle as animal feed or compost. According to the definition by Bellemare et al. (2017) that 'as long as food does not end up in a landfill, it is not wasted', we are overestimating food waste if such productive use of leftover food is not taken into account. Second, we used a simple characterisation of food groups by weight. When food waste is converted into energy (kcal), macro- and micronutrients, more insights may emerge. For example, if most of the foods wasted come from added fats and oils and added sugars and sweeteners, trying to recover them can lead to unintended negative public health consequences (Ellison & Prescott, 2021). Third, the way food waste is measured in this study differs from the studies that have been conducted in other countries, leading to incompatible comparisons and limited external validity. So far, a large diversity of methods have been used (Kaur et al., 2021), the introduction of a standard method would be a step forward to help comparative studies draw definite conclusions. Additionally, the measurement was performed over two days only, making the results more susceptible to bias due to the specific

foods served on those two days. Although the menus throughout the week were designed to be comparable in terms of nutritional values (Interviews with food providers in Dong Anh, 2018) and we covered much of the variety in menus by having 12 schools, we recommend that future studies should include an even greater variety of dishes in the measurement. Fourth, because we used observational data, we cannot establish causality between food waste and some of the possible explanations discussed in the paper. Several factors that may help explain food waste (e.g., attitudes toward sustainability and knowledge about food waste) were not covered in the original data collection plan. Future targeted studies can address these limitations and include an explicit reference to theory, which has frequently been missing in literature on food waste reduction interventions (Reynolds et al., 2019). Finally, the sample for the qualitative component of the study was small, covering only two schools in different locations, one located in the town centre, and the other on the outskirts of the district. Although we obtained similar insights from both schools, caution is required when generalising the findings to different settings.

5. Conclusion

This study measured individual plate waste and used survey data and qualitative interviews to identify causes of food waste and potential related factors in primary schools in peri-urban Viet Nam. Students wasted more than 20% of the food served, of which vegetables were wasted the most, with almost half of the portion unconsumed. A larger portion size was associated with a higher share of wasted food but also with higher consumption, suggesting aa potential trade-off between reducing food waste and increasing consumption of nutritious food. Food waste reduction should therefore be treated as an intermediate step towards achieving policies' ultimate goals, such as healthier food intake. Underconsumption of nutritious foods and food waste are both exacerbated by a lack of quality meals. To solve this issue, it appears critical to improve the quality of school meals.

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Author contributions

Trang Nguyen: Conceptualization, Methodology, Formal analysis, Investigation, Writing - Original Draft, Writing - Review & Editing. **Marrit van den Berg**: Conceptualization, Methodology, Writing - Original Draft, Writing - Review & Editing, Supervision, Funding acquisition. **Minh Nguyen**: Data curation, Formal analysis, Investigation, Writing – Original Draft, Project administration.

Institutional Review Board statement

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of the National Institute of Nutrition in Viet Nam.

Informed consent statement

Informed consent was obtained from all subjects involved in the study.

Declaration of competing interest

The authors declare no conflicts of interest.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2023.106485.

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