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Strategies to reduce plate waste in primary schools – experimental evaluation

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Abstract

Objective: To determine and compare the effect of two interventions in reducing the plate waste of school lunches.
Design: A between-group analysis was conducted among children from three primary schools: (i) a group receiving intervention A, designed for children and focusing on nutrition education and food waste; (ii) a group receiving intervention B, intended for teachers and focusing on the causes and consequences of food waste; and (iii) a control group with no intervention. For each child, physical weighing of individual meals and leftovers was performed on three non-consecutive weeks at baseline (T0), 1 week (T1, short term) and 3 months (T2, medium term) following the intervention. Plate waste was recorded for a total of 1742 lunches during 14 d over eight different menus.
Setting: Portuguese public primary schools in the city of Porto.
Subjects: All fourth-grade children (*n* 212) attending the three preselected schools.
Results: After intervention A focusing on nutrition education designed for children, a decrease in soup waste was observed compared with the control group. The effect was greater at T1 (−11·9 (SE 2·8) %; $P<0·001$) than at T2 (−5·8 (SE 4·4) %; $P=0·103$). The plate waste of identical main dishes decreased strongly at T1 (−33·9 (SE 4·8) %; $P<0·001$). However, this effect was not found at T2 (−13·7 (SE 3·2) %; $P<0·001$). After intervention B involving teachers, plate waste decreased at T2 (−5·5 (SE 1·9) % for soup; −5·4 (SE 2·4) % for identical main dishes).
Conclusions: Nutrition education designed for children was more effective in the short than the medium term. Thus, this kind of intervention was not effective in reducing food waste in the medium term. In contrast, an intervention focusing on teachers revealed better results in the medium term than in the short term.

Keywords
Children
Food waste
Lunch
Nutrition education
Teachers

Meals offered at school canteens are generally nutritionally adequate and consistent with dietary guidelines[1,2]. The school lunch plays an important role in the diet of school-children and may provide several benefits in terms of children's health, well-being, academic achievement and the reduction of risk factors for some chronic diseases in later life[3]. The school setting provides a valuable opportunity to influence health through policy measures, education on healthy eating habits and food provision. As part of a whole-school approach, the meals provided at lunchtime can reinforce messages on the importance of a healthy varied diet and promote a willingness to try foods that are not familiar[4]. However, simply planning and providing adequate nutritious food may be ineffective if this is not fully consumed[5].

Researchers have reported high plate waste values at school canteens[6–9]. In Portugal, studies developed in this setting found waste values higher than 30 %[10,11] and significantly higher than the acceptable limit of 10 %[12]. Excessive plate waste may indicate that children are not fully benefiting from the nutrients offered by school meals and may be an indicator that meals are not adapted to children's appetite or preferences[13].

Reductions in plate waste can lower costs and ensure that school meals meet nutritional objectives[14]. Many factors can influence food rejection at school lunch, including anxiety about eating, lack of appetite, peer pressure, familiarity with foods, appearance and taste of foods, attention on free time to socialize and insufficient time to eat. Other potential factors include portions' inadequacy to children's nutritional needs, unsuitability to food preferences and the availability of competitive foods from other more appealing sources than the school lunch[6]. The research on school-based interventions in school canteens is vast. In spite of assessing food behaviour changes by school lunch plate waste

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determination[15–18], these interventions aimed to promote healthy eating habits among children, namely increasing fruit and vegetable consumption at the school canteen, but were not focused on plate waste reduction in itself [17–21].

Most of the different strategies proposed to reduce plate waste at school canteens have acted on the determinants. The main strategies have focused on nutrition education, adequacy of food provision at school, adjustment of the portion sizes to children's nutritional needs, meal time adequacy, improvement of the canteen environment and also the foods' sensory characteristics[4,6,13,22–25]. Nevertheless, the effectiveness of the majority of these strategies was not evaluated.

Some evidence has suggested that nutrition education may reduce plate waste, particularly when the education is strongly linked to foods served at the school canteen[13]. Additionally, it has been suggested that schools can reduce 40–60 % of waste by implementing policies that reduce the amount of uneaten food[26].

Children's nutrition education and the role of teachers as models have been also investigated as possible strategies to influence children's behaviour in the school setting, having a positive effect on children's consumption[27]. There is a lack of research on the food waste behaviours of children, as well as on monitoring the effect of interventions aimed at food waste reduction. The published studies focusing on interventions on plate waste reduction failed to evaluate their effectiveness in the medium or long term, limiting their results to a short-term evaluation[6,23–25]. Moreover, in the majority of these studies the reduction of plate waste at school lunch was accomplished only by observational methods[6,24], which is less accurate than physical measurement.

The aim of the present study was to determine and compare the effect of two different interventions, related to nutrition education of children and teaching staff, in reducing lunch plate waste in the short and medium term.

Methods

Design and participants

The city of Porto, Portugal, was chosen for the present study following ease of access criteria. In a first stage, from the fifty-one public primary schools of the municipality, twenty-one were randomly selected following a multistage cluster sampling.

For the present study, data collection involved all fourth-grade children attending three public primary schools from the municipality of Porto that were chosen according to preliminary plate waste data, corresponding to the three out of twenty-one schools previously evaluated that presented the highest average plate waste[28].

The selected primary schools were involved after registering our trial at the Portuguese Ministry of Education (institutional board) and after obtaining informed written consents from the Municipality and the School Councils. Since our study did not directly involve children, ethics committee consent was not necessary. Nevertheless, written consents for the study were also obtained from children's parents. Children whose consents were not granted and children with a special diet or presenting food allergies were excluded from the study. Children, teachers and all assessors involved in the data collection were blinded to the study objective and expected effects.

The flow of participants during the study is presented on Fig. 1. All 212 fourth-grade children were eligible but only those having lunch at the school canteen were involved. A between-group analysis was conducted among the three groups of children participating in the study's planned interventions: (i) one designed for children (*n* 28), intervention A (children); (ii) another intended for teachers (*n* 58), intervention B (teachers); and (iii) a control group randomly selected (*n* 65) who did

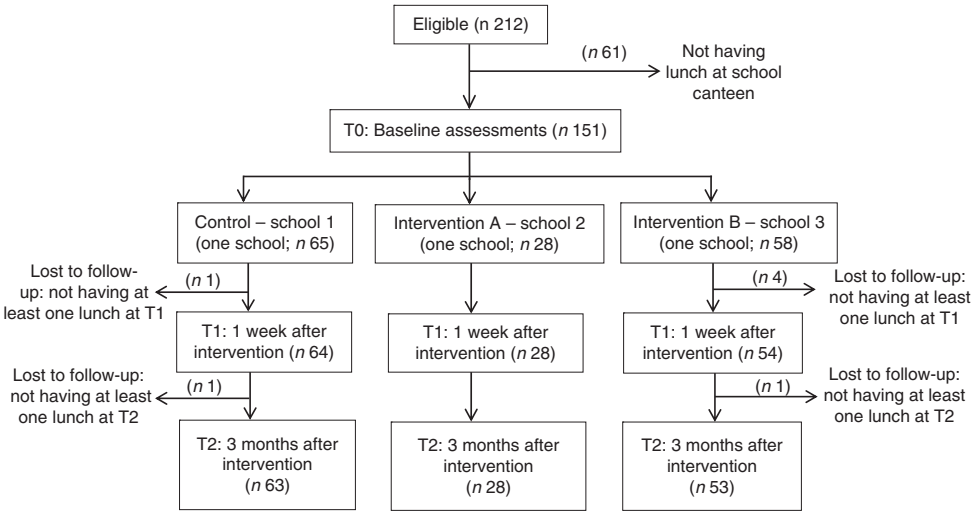

Fig. 1 Flow of participants through each stage of the study; fourth-grade children from Porto primary schools, Portugal

not receive any intervention. The schools were selected for each intervention on a random basis. For evaluation of the impact of the interventions on plate waste reduction at school lunch, plate waste was assessed at baseline, 1 week before the intervention (T0); 1 week after the intervention (T1, short term); and 3 months after the intervention (T2, medium term). Seven children were excluded as they did not have lunch at school at least one day of T1 or T2, impairing comparisons between different moments of plate waste assessment. The final sample at 3-month follow-up included 144 children.

Intervention

Intervention A (children) was designed for children and was performed during 3 d (a total of 6 h) by implementing nutrition education sessions in classrooms developed always by the main researcher. The sessions were performed by an oral presentation and included the following topics: basic concepts of nutrition, food and health; explaining the main concepts expressed by the Portuguese food guide; the relevance of breakfast and snacking; nutritional benefits of school lunch; and social, economic and nutritional consequences of the food waste. During the sessions, together with the oral presentation, different activities were conducted. Children were invited to point out on a colourful paper the reasons for rejecting school lunch and also to identify the most frequently wasted foods. Children were also involved in planning of a school week menu that could help to reduce food waste. Finally, posters were elaborated by children to display at the school canteen with messages related to food waste reduction. All children and teachers participated in the activities proposed. Furthermore, a 'No Plate Waste Day' was implemented and children who did not waste food at school lunch were rewarded with a gold star sticker.

Intervention B (teachers) took place at another school, where five teachers and the school coordinator participated in a 1 h debate session about the causes and consequences of food waste. This session was also performed by the main researcher. Waste data from previous research was presented, showing that this school belongs to the group with higher waste values. The teachers were warned about their important role in the development of children's eating habits and also about the importance of their presence during mealtime in order to promote waste reduction. Whenever possible, teachers were requested to be present during school lunchtime and also to play an active role encouraging children to eat their lunch. Moreover, a flyer about the importance of food waste reduction and also strategies to achieve this goal was distributed to the teachers.

It was expected that both the intervention focusing on nutrition education and the intervention focusing on school lunch monitoring by teachers would lead to plate waste reduction at school lunch.

A third school was taken as a control where no intervention occurred.

Meal environment

All schools were leased to the same catering company. The daily menus were the same in all the Municipality's schools and were developed following the official guidelines for school meals. No other menu choices were available apart from the main menu. In Portugal, the school lunch includes: (i) a vegetable soup that may or may not contain pulses or whole vegetables; (ii) a main dish that has a main protein source (fish or meat), a main carbohydrate source (rice, pasta or potato) and a component of vegetables; and (iii) fresh fruit. Tap water is the only beverage available for lunch. The meals served were composed by either mixed or non-mixed dishes. Mixed dishes are those that present the main protein source in small fractions mixed with other ingredients (e.g. 'Pasta with codfish', 'Rice tomato with shredded chicken'). Non-mixed dishes have the main protein source separate from the carbohydrate source (e.g. 'Hamburger with pasta', 'Hake fillets with rice').

At each canteen, the dishes arrived ready from 'kitchen to kids', the canteen staff being responsible for serving and distributing meals to the children, collecting the plates and washing dishes after the meals. At each school, there was equipment to ensure control of the meal temperature. Moreover, the meal temperature was measured to guarantee the temperature standardization and meal safety. All children had an hour for lunch. During the data collection the canteen staff were informed that the research team members would be responsible for distributing plated dishes and for collecting the leftovers at end of the meal for weighing procedures. During lunchtime, children usually seat at rectangular tables with friends. Each canteen accommodates approximately fifteen classes simultaneously, each one with about fifteen to twenty students. Adult supervision during lunch was provided by school staff and sometimes by class teachers.

During the study development, no changes were implemented on school practices relating to canteens, namely school lunchtime, menus available and school staff daily attending at the canteen, in order to avoid interference with food consumption.

Data collection

Data collection was performed by ten trained researchers, including the main researcher, guided by a manual developed as a reference tool to standardize all collection procedures.

For each child, weighing of individual meals and leftovers was performed on three non-consecutive weeks, between February and May 2013: for five days at baseline (T0), for five days at 1 week after the intervention (T1) and for four days at 3 months after the intervention (T2), since

in the last period of data collection one of the days was a public bank holiday. The plate waste was recorded for a total of 1742 lunches during 14 d and over eight different menus.

The same procedure was employed in both the intervention and control schools at each study phase and measures were recorded across consecutive days in each school and at the same time.

The effect of the interventions was evaluated by measuring plate waste of the soup and the main dish. The school canteens had a 12-week menu cycle allowing data collection at times T0 and T2 when the same menu was offered in order to avoid menu differences influencing plate waste. However, in T1 only two main dishes were identical to T0 and T2. These dishes have been identified in our study as 'identical main dishes'.

The plate waste at lunch was assessed using the weighing method[29]. Aggregated waste across food items was collected for each child when mixed dishes were served, while individual plate waste was collected for non-mixed dishes. Servings and leftovers of each edible food item were weighed by using a digital scale accurate to the nearest gram (SECA® model 851, Germany).

Stickers with unique codes were placed under each plate for identification purposes. At each school, a maximum of two researchers were responsible for weighing meals after plating, while another two distributed meals to children according to the number codes previously assigned.

All plates were weighed empty and after plating, and serving size was determined by the weight difference. At the end of the meal, plates were collected, non-edible items were removed, plates were weighed and the amount of food waste was determined by the weight difference. Percentage of plate waste was calculated as the ratio of edible food discarded per edible food served to children[9].

The research team monitored the children during the lunch period to ensure that children did not throw away any uneaten food.

Sociodemographic data (children's age, sex and socio-economic status, i.e. students on free- or reduced-price school lunches) were obtained from school administration.

Data analysis

Means and standard errors were used to provide an indication of average daily plate waste and initial serving at school lunch. Mean/SE in grams is used for meals' initial servings and mean/SE in percentage is presented for plate waste since it better represents the magnitude of plate waste. Statistical analyses were performed separately for soup, all main dishes and only the two identical main dishes.

Mann–Whitney *U* and Kruskall–Wallis tests were used to compare variables grouped by intervention and control groups. A 0·05 level of significance was considered.

The effect of the interventions was evaluated based on changes in plate waste between baseline (T0), 1 week after the intervention (T1) and 3 months after the intervention (T2), comparing intervention with control schools. Generalized linear models were used to test these differences, taking into account the nested nature of the data. The different scores for plate waste were used as the dependent variable, and adjustment was made for children's social support group and mean initial servings during T0, T1 and T2 in order to maximize precision and minimize differences observed for children's social support and initial servings. The differences in plate waste (%) between baseline and 1 week and/or 3 months post-intervention among intervention and control groups were included as dependent variables. Children's social support group, mean initial servings during T0 and mean initial servings during T1 were included as other variables in the generalized linear models.

The statistical software package IBM SPSS Statistics version 21·0 was used for data analysis.

Results

Table 1 shows the sociodemographic characteristics of the participants in the control and intervention groups.

Overall food waste at baseline was 34·8 (SE 2·0) % for soup and 43·2 (SE 1·6) % for main dish, with significant differences between intervention groups. Table 2 displays school lunch plate waste for soup and main dish in the intervention and control groups. The mean plate waste varied between 34·4 % and 63·5 % for the main dish and between 19·0 % and 52·6 % for soup (Table 2).

After implementation of intervention A (children), a decrease in soup waste was observed in comparison to the control group. Furthermore, the effect was greater at T1 (−11·9 (SE 2·8) %) than at T2 (−5·8 (SE 4·4) %). The plate waste of identical main dishes decreased strongly at T1 (−33·9 (SE 4·8) %); however, this effect was not found at T2 (−13·7 (SE 3·2) %; Tables 3 and 4).

Table 1 Sociodemographic characteristics of control and intervention groups; fourth-grade children from Porto primary schools, Portugal

	Control (*n* 64)		Intervention A (*n* 28)		Intervention B (*n* 55)	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	9·2	0·5	9·4	0·5	9·2	0·4
	n	%	*n*	%	*n*	%
Sex						
Boys	33	51·6	14	50·0	31	56·4
Girls	31	48·4	14	50·0	24	43·6
Social support						
Free school lunch	29	45·3	14	50·0	8	14·5
Partial financial support	7	10·9	6	21·4	8	14·5
No financial support	28	43·8	8	28·6	39	70·9

Table 2 Mean initial serving and mean plate waste in intervention and control schools; fourth-grade children from Porto primary schools, Portugal

	T0 (baseline)							T1 (1 week post-intervention)							T2 (3 months post-intervention)						
	Control		Intervention A		Intervention B			Control		Intervention A		Intervention B			Control		Intervention A		Intervention B		
	Mean	SE	Mean	SE	Mean	SE	*P*	Mean	SE	Mean	SE	Mean	SE	*P*	Mean	SE	Mean	SE	Mean	SE	*P*
Initial serving (g)																					
Soup	184·5[a]	0·9	197·8[b]	1·8	174·7[c]	1·3	<0·001	192·4[a]	1·2	197·7[b]	2·2	162·3[c]	1·2	<0·001	211·9[a]	0·7	209·8[b]	3·5	149·9[c]	1·2	<0·001
Main dish	217·0[a]	1·8	210·5[b]	2·5	154·5[c]	2·3	<0·001	253·2[a]	2·2	183·7[b]	2·1	141·4[c]	1·9	<0·001	265·6[a]	1·9	179·4[b]	2·4	138·2[c]	2·4	<0·001
Main dish (only the two identical menus)	215·2[a]	3·1	204·8[b]	3·3	138·8[c]	3·0	<0·001	223·8[a]	2·8	157·2[b]	1·8	121·1[c]	2·9	<0·001	280·2[a]	2·1	182·4[b]	3·3	140·2[c]	2·8	<0·001
Mean plate waste (%)																					
Soup	34·4[a]	2·7	52·6[b]	5·0	26·2[c]	3·1	<0·001	39·8[a]	2·9	40·9[a]	5·2	19·0[b]	2·1	<0·001	36·3[a]	2·9	46·8[b]	4·3	20·3[c]	2·2	<0·001
Main dish	39·8[a]	2·4	63·5[b]	2·9	36·8[a]	1·9	<0·001	50·3[a]	2·3	50·5[a]	3·2	39·2[b]	2·3	0·003	53·0[a]	1·9	64·1[b]	2·5	34·4[c]	2·2	<0·001
Main dish (only the two identical menus)	46·2[a]	2·8	76·6[b]	3·1	38·6[c]	2·4	<0·001	51·2[a]	2·7	42·7[a,b]	4·1	40·5[b]	2·9	<0·001	59·7[a]	2·4	78·3[b]	2·5	43·3[c]	2·7	<0·001

P values from the non-parametric Kruskal–Wallis test at a 95 % CI.
[a,b,c]Mean values within a row with unlike superscript letters at each time point were significantly different (non-parametric Mann–Whitney test) at a 95 % CI.

Table 3 Differences in plate waste (%) between baseline (T0) and 1 week post-intervention (T1) among intervention and control groups; fourth-grade children from Porto primary schools, Portugal

	Control		Intervention A		Intervention B			Intervention A *v.* control			Intervention B *v.* control		
	Mean*	SE	Mean*	SE	Mean*	SE	*P*	Adjusted difference†	95 % CI	*P*	Adjusted difference†	95 % CI	*P*
Soup	5·1[a]	2·0	−11·9[b]	2·8	−6·8[b]	1·6	<0·001	−16·1	−23·7, −8·5	<0·001	−14·0	−24·1, −3·8	0·007
	n 63		*n* 28		*n* 54								
Main dish	10·5[a]	2·2	−13·0[c]	3·0	3·0[b]	1·6	<0·001	−28·2	−41·1, 15·3	<0·001	−15·1	−35·3, 5·2	0·145
	n 64		*n* 28		*n* 54								
Main dish (only the two identical)	5·0[a]	2·4	−33·9[b]	4·8	3·7[a]	2·6	<0·001	−39·2	−55·3, −23·0	<0·001	−7·2	−37·1, 22·7	0·639
	n 61		*n* 28		*n* 48								

P values from the non-parametric Kruskal–Wallis test at a 95 % CI.
[a,b,c]Mean values within a row were significantly different (non-parametric Mann–Whitney test) at a 95 % CI.
*Unadjusted mean.
†Differences were adjusted for children's social support group; mean initial servings during T0 and mean initial servings during T1.

Table 4 Differences in plate waste (%) between baseline (T0) and 3 months post-intervention (T2) among intervention and control groups; fourth-grade children from Porto primary schools, Portugal

	Control		Intervention A		Intervention B			Intervention A *v.* control			Intervention B *v.* control		
	Mean*	SE	Mean*	SE	Mean*	SE	*P*	Adjusted difference†	95 % CI	*P*	Adjusted difference†	95 % CI	*P*
Soup	1·6	2·4	−5·8	4·4	−5·5	1·9	0·103	−5·0	−14·0, 4·1	0·281	−17·7	−36·3, 1·0	0·063
	n 63		*n* 28		*n* 53								
Main dish	13·1[a]	2·5	0·6[b]	2·7	−2·2[b]	1·8	< 0·001	−0·9	−17·2, 15·3	0·912	3·8	−20·8, 28·5	0·762
	n 63		*n* 28		*n* 53								
Main dish (only the two identical)	8·8[a]	3·2	−13·7[b]	3·2	−5·4[c]	2·4	< 0·001	−40·6	−66·6, −14·6	0·002	−40·8	−79·0, −2·6	0·036
	n 61		*n* 26		*n* 51								

P values from the non-parametric Kruskal–Wallis test at a 95 % CI.
[a,b,c]Mean values within a row were significantly different (non-parametric Mann–Whitney test) at a 95 % CI.
*Unadjusted mean.
†Differences were adjusted for children's social support group; mean initial servings during T0 and mean initial servings during T2.

Intervention B (teachers) did not have a significant effect in reducing plate waste at 1 week post-intervention compared with the control group. At T1 it was observed that soup waste decreased (–6·8 (SE 1·6) %) and the waste of identical main dishes increased (3·7 (SE 2·6) %). At T2, a positive effect of the intervention was observed since plate waste decreased slightly (–5·5 (SE 1·9) % for soup and –5·4 (SE 2·4) % for identical main dishes; Tables 3 and 4).

In generalized linear models there was a greater significant reduction in plate waste for main dish, identical main dishes and soup at T1 in the group receiving intervention A (children) compared with the control group. With intervention A (children), a higher reduction in plate waste than in the control group was also observed for identical main dishes at T2. When results for intervention B (teachers) were analysed, a greater reduction in plate waste than in the control group was observed for identical main dishes at T2 and for soup at T1 (Tables 3 and 4).

Discussion

In the present study the effect of interventions on plate waste was analysed, hypothesizing that intervention would result in a reduction of plate waste. The study results demonstrated that the nutrition intervention designed for children was more effective at reducing plate waste than the intervention focusing on teachers.

The food waste reduction decreased between the short and the medium term in the group of children who received nutrition education focusing on food waste. This fact could be an indicator that continuous interventions are needed for plate waste reduction over time.

Our results also showed high values of plate waste, considering the acceptable limit of 10 % proposed by the Brazilian Federal Council of Nutritionists for food services[(12)]. These recommendations were considered since no reference values are known for the Portuguese reality. In all study periods, the plate waste of main dish was higher than 34 % and soup waste was higher than 19 %. These results are far above those found by other authors in primary-school canteens, which varied between 10 % and 45 % according to the food item evaluated[(8–10)], and are extremely worrying since the nutritional benefits of food are being wasted.

In the published scientific literature, different strategies are found aiming to achieve plate waste reduction at primary schools[(4,6,13,22–25,30,31)]. However, effective results of these interventions are scarce. Furthermore, the majority of studies developed in school canteens are focused on fruit and vegetable consumption and not on plate waste reduction[(15,27,30)]. For this reason, our results will only be compared with those focusing on food waste.

Our results were in line with results obtained by Engstrom and Carlsson-Kanyamain in Swedish primary schools (children aged 6 to 10 years) that implemented a

strategy of 'Zero waste lunch' to reduce food waste. These researchers suggested that encouraging friendly competitions between classes to achieve reduction in waste could be a successful strategy; they observed a decrease in plate waste of 35 % when involving students in weighing waste and posting the results on the canteen wall[25]. These results were better than the ones obtained in our study.

Other researchers demonstrated that nutrient intake at lunch in Korean schools was significantly higher in groups receiving nutrition education related to food waste than in the control group[31], which was in line with our results. The school intervention developed by these authors was similar to ours and included tasting foods, education by a class teacher about the environmental consequences of food waste and a 'No plate waste day' organized by the school[31].

Another successful strategy applied in a Swedish school canteen consisted of daily evaluation of plate waste by students. This intervention had better values than those obtained in our study, exhibiting a reduction of 49 % in food waste[32]. Whitehair *et al.* showed that simple postings about awareness of food waste triggered a significant decrease in waste behaviours[33].

Recent results found by Upton *et al.* showed limited support for both the short- and long-term effectiveness of nutrition education interventions promoting fruit and vegetable consumption in children's school lunch[15]. Other authors observed a positive result of a reward-based intervention in increasing fruit and vegetable consumption at school lunch[30].

Regarding the intervention involving teachers, our results indicated that awareness of teaching staff had a better effect on plate waste reduction in the medium term than in the short term.

Despite comparisons made with other published studies, it is important to note that the majority of interventions that involved teaching staff did not have as the main purpose the evaluation of plate waste at school canteens.

Auld *et al.* evaluated a school-based nutrition education programme in the USA focusing on teaching staff and observed that a reduction in fruit and vegetable waste was associated with more positive teachers' attitudes towards school lunches[16].

Inayama *et al.* evaluated teacher's perspectives associated with health education and the role of school lunch in Japanese primary schools. They observed that for teachers, school lunch was regarded as an opportunity for providing daily supply of nutrients, teaching of table manners, building up nutrition education and developing food preferences through eating lunch together with classmates[34].

Teachers eating together with students is mandatory in Finland[35]. They are supposed to instruct basic table manners and to promote healthy eating habits among children. Additionally, many municipalities have included school meals and their possibilities for cross-subject learning in their curriculum[35]. Moreover, in Sweden, a programme named 'pedagogic meals' was implemented as a result of a government report. This included teachers having lunch together with children. This recommendation appeared to help and encourage children to eat and try new foods served as well as to stimulate teachers to act as a role model and teach children about how to behave in the canteen and discuss food and nutrition during mealtimes. It was also observed that schools with pedagogic lunches hardly had plate waste[21,25]. In Portugal, school practices are quite different. The lunch period is usually a leisure time for teachers and most of them leave the school during this period. Moreover, monitoring children at the school canteen is not an activity of their responsibility. The lack of effect verified at short term in the group submitted to the intervention designed for teachers may be due to teachers' low interest in this particular subject. According to other authors, the efficacy of health promotion interventions depends on the adherence and completeness of teaching staff [36]. Furthermore, other researchers have identified the lack of support from school teachers as a barrier to implement or improve existing nutrition policies[37].

It may be possible that during the period of the present study, teachers became more aware about plate waste issues, encouraging their students to school lunch consumption. This fact could explain the results found at 3 months post-intervention.

Teachers are critical school stakeholders and may have an important influence on the consumption of healthy food by children[38]. For instance, in a school-based programme developed in Mississippi, the main objective of which was to increase fruit and vegetable consumption, involving teachers and school staff eating food items and being a role model resulted in a positive effect on children's intake[27].

Reducing plate waste depends on many factors and will require action by school administrators as well as teachers, school lunch managers and other staff.

Successful interventions performed by research teams frequently fail to continue after the research ends, which could explain the lower effect on plate waste found at 3 months after the interventions. In a review of nutrition education programmes, the authors concluded that interventions must use behaviour change strategies and be implemented with sufficient longevity and intensity[39]. Thus, a continuous programme focusing on plate waste reduction may obtain better results.

While the specific findings in the present study are limited to these particular schools, our results can be useful for setting policies concerning plate waste at lunch in primary schools.

In spite of the results found in our study, the high levels of plate waste observed at all phases highlight the need to look for complementary strategies to reduce plate waste at school canteens. Recent research suggests that offering

smaller portion sizes and giving children a choice of varying portion sizes may support better children's intake of food in school lunch settings, resulting in plate waste reduction[22]. Other authors have shown that food waste is significantly lower when recess is scheduled before compared with after lunch, with plate waste reduction ranging from 10 % to 13 %[24]. The influence of the length of the lunch period on food waste has been also explored by other researchers, who discussed that children spend little time eating their lunch and that a longer lunch period leads to a plate waste reduction[37,40].

Inviting students to participate in menu planning and meal preparation, and improvement of sensory characteristics of school meals are other potential strategies suggested in the literature for achieving waste reduction[9,35]. Potential reasons for the high level of plate waste identified in our study could be related to children's preferences and dissatisfaction with the sensory characteristics of school lunch and to a high level of noise that can adversely affect the environment of the canteen and would impact children's lunch consumption.

Several limitations of the present study were identified. Firstly, evaluation was done only at short and medium term. According to other authors it is essential to have measures at least 6 months after the intervention to be able to study retention of behaviour change and to draw conclusions about the effectiveness of an intervention[41]. It is also important to highlight that the schools involved in our study were selected based on a previous study of plate waste evaluation and all fourth-grade children from these schools were involved. Considering the characteristics of schools and students involved, our results could be generalized for this particular municipality and are also important findings to plan strategies to reduce plate waste at schools. Our results showed that both the intervention focusing on children and implementation of nutrition education sessions in classrooms and the intervention focusing on teachers and their presence during mealtime in order to promote waste reduction could be used by other researchers who are investigating plate waste and also looking for ways to reduce food waste at school canteens.

Other limitations arose from the fact that a child with an empty lunch tray did not necessarily mean consumption of all food items served, since there was a possibility of trading food during school lunch among schoolchildren[42]. At T1 it was not possible to evaluate the same menu as T0 and T2 through the whole week since the food service employs a 12-week cycle menu and changes of this could have introduced a bias in our results. However, to reduce this bias, a separate analysis was performed only for those dishes that were identical between the three periods of data collection.

A particular strength of the present study is that the effect of interventions was measured at two different moments by weighing food discarded, which is the most accurate method for measuring plate waste, with both original servings and plate waste being weighed for each participant[9]. Furthermore, all individual servings were weighed and not just a random sample of initial servings, as performed by other authors[14]. Moreover, analysing the same menus in different periods allowed us to obtain information about the outcome of the intervention, excluding the effect associated by the menu type.

Conclusions

In general, nutrition education sessions designed for children were more effective in the short term than the medium term. This kind of intervention was not effective in reducing food waste in the medium term. In contrast, an intervention focusing on teachers showed better results in the medium term of 3 months after the intervention than in the short term of 1 week after the intervention.

Children's eating behaviour at school lunch is extremely complex and influenced by several factors, either inherent to the canteen environment or related to children's food preferences. This can be particularly difficult to change in short-term interventions. Given this complexity, the lack of effect on consumption could be expected. In addition, our results suggested that teachers should be encouraged to have their lunch with their students since they have an important role in modelling food habits in the long term.

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