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Determination of plate waste in primary school lunches by weighing and visual estimation methods: A validation study

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ABSTRACT

The aim of this study was to validate the visual estimation method for aggregated plate waste of main dish at Portuguese primary school canteens. For this purpose plate waste at school lunch was measured for 505 individual servings, using weighing individual servings and plate waste and visual estimation method by a 6-point scale, as developed by Comstock et al. (1981). A high variability of initial serving weights was found with serving sizes ranging from 88.9 to 283.3 g and with a coefficient of variation ranging from 5.5% to 24.7%. Mean plate waste was 27.5% according to the weighing method. There was a significant bias in the conversion of the visual waste estimations to actual waste, being overestimated by an average of 8.0 g (ranging from −12.9 g to 41.4 g). According to Bland and Altman plot, the mean difference between methods was of 8.0 g and the amplitude interval was 102.6 g. The study showed that the visual estimation method is not as accurate as the weighing method in assessing non-selective aggregated plate waste at primary school canteens. Our findings are thus very important on considering plate waste assessment, since the wide variation on initial servings introduces a relevant bias when considering standard portions or a random sample of initial servings. Although, greater convenience, time-saving and the possibility to monitor plate waste of large groups, make the visual estimation method an important method to assess plate waste at school canteens, these results highlighted the need of portions standardization and control of initial servings to allow for its use.

1. Introduction

The number of children attending school canteens has grown over the past years in Europe, as well as in Portugal (Aranceta Bartrina et al., 2008; Bergman and Gordon, 2010; Truninger et al., 2012) and there has been an increasing concern about food waste, especially at school food services (Baik and Lee, 2009; Campos et al., 2011; Engstrom and Carlsson-Kanyama, 2004; Getlinger et al., 1996; Martins et al., 2004).

Plate waste at school lunch has gained importance since food waste data is commonly used to assess effectiveness of menu performance, meals acceptance, dietary intake adequacy, economic impact and efficacy of nutrition educational programmes (Clark and Fox, 2009; Comstock et al., 1981; Connors and Rozell, 2004; Crepinsek et al., 2009; De Keyzer et al., 2012; Graves and Shannon, 1983). In fact, plate waste is considered an indicator of food service operation efficiency (Gomes and Jorge, 2012) as well as an indicator of nutritional adequacy (Cohen et al., 2013; Condon et al., 2009; Nicklas et al., 2012; Ramsay et al., 2013; Upton et al., 2013).

Plate waste in children's school lunches has traditionally been measured using one of the four following methods: the direct weighing method (Adams et al., 2005; Cohen et al., 2013; Jansen and Harper, 1978), and the indirect methods such as visual estimation (Comstock et al., 1981; Connors and Rozell, 2004; Graves and Shannon, 1983), digital photography (Marlette et al., 2005; Nicklas et al., 2012; Williamson et al., 2003), and food consumption recalled by children (Comstock et al., 1981; Paxton et al., 2011).

The most accurate method for measuring plate waste is weighing food items, with both original servings and plate waste being weighed for each subject (Buzky and Guthrie, 2002). In these method, data can be presented in different ways: individual plate waste, aggregated nonselective plate waste and aggregated selective plate waste, depending on data collection particularities. To obtain individual plate waste, school lunch trays are taken from

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the serving line and food items are weighed separately. At the end of the meal, leftovers of each food item are weighed (Buzky and Guthrie, 2002). Ideally, some authors describe the distribution of the initial serving weights (Comstock and Symington, 1982; Dubois, 1990). However, to simplify and speed up data collection, some studies collect a random sample of trays or use a mean weight for a typical serving size instead of weighing each individual serving (Chu et al., 2011; Cohen et al., 2013; Jansen and Harper, 1978; Kirks and Wolff, 1985). Aggregated nonselective plate waste involves weighing together all the food items left on the plate of each child, resulting in global information at student level (Comstock et al., 1981). Alternatively, waste can be measured separately across food items, involving weighing the total amount of each food item for whole plates, known as aggregate selective plate waste (Campos et al., 2011; Jacko et al., 2007).

The main advantage of individual weighed plate waste is that it can provide detailed and accurate information on each child and each food item. However, this is disruptive for food service operations, costly and time consuming, requiring a great deal of space for holding trays and to scrap food until weighing is completed. In addition, it may influence children's intake since this method takes time and delay the delivery of plates to children and is usually impractical for large sample sizes. Moreover, children could leave the school canteen without having lunch (Buzky and Guthrie, 2002; Comstock et al., 1981; Dubois, 1990).

The disadvantages of the weighing method have led to the search for alternatives. The visual estimation method was suggested by different authors as an accurate alternative (Comstock et al., 1981; Dubois, 1990; Gittelsohn et al., 1994; Kirks and Wolff, 1985). According to this method, trained observers classify foods and estimate portion sizes for each food considering standard portions that have been previously weighed, leading to the indication of wasted proportion of the initial serving (e.g.: 0%, 10%, 25%, 50%, 75%, 100%). The main advantages of the visual estimation method are providing detailed information and not affecting food service activities significantly. Moreover, by minimizing handling of soiled trays and requiring less operators than the weighing method, it presents space and time savings (Buzky and Guthrie, 2002; Comstock et al., 1981; Graves and Shannon, 1983).

In general, the visual estimation of individual food items is difficult to obtain when the majority of dishes were mixed dishes in comparison with non-mixed dishes, impairing the individual assessment of each item of the main dish.

Although visual estimation validity at school lunches have been evaluated by other authors (Comstock et al., 1981; Graves and Shannon, 1983; Kirks and Wolff, 1985), they focused individual foods and not the accuracy of visual estimation for aggregated nonselective plate waste. Moreover, their focus was food consumption and not food waste. In addition, it is not clear the level of accuracy obtained by sampling a number of trays, since in case of high variability of initial servings, the mean percentage of plate waste might not reflect real plate waste and therefore it may not be useful (Comstock and Symington, 1982). Studies evaluating the accuracy of visual estimation method identified in published literature reported the use of modifications of the optimal measurement criterion (Andrews and Castellanos, 2003; Castellanos and Andrews, 2002; Comstock et al., 1981; Dhingra et al., 2007; Dubois, 1990; Gittelsohn et al., 1994; Graves and Shannon, 1983; Kandiah et al., 2006; Kirks and Wolff, 1985; Thompson et al., 1987; Williamson et al., 2003). These modifications considered the weights of standardized portions or randomly selected full servings, representing standard serving weights (Castellanos and Andrews, 2002; Comstock et al., 1981; Dubois, 1990; Graves and Shannon, 1983; Kirks and Wolff, 1985) and referred to visual estimation of individual plate waste (Kandiah et al., 2006; Williamson et al., 2003). No data was available to compare the use of individual weights served and the mean weight to obtain the error introduced by randomly selected full servings.

The objective of the present study was to evaluate the validity of the visual estimation method for aggregated nonselective plate waste of main dish at Portuguese primary school canteens, using individual full-serving weights and the mean based weights.

2. Methods

2.1. Ethics

Written consents for this study were obtained from the Portuguese Ministry of Education, the city of Porto municipality, the School's Councils and children parents.

2.2. Sampling

For the present study, the city of Porto, Portugal, was chosen following ease of access criteria. From the 51 public primary schools of this municipality, 21 schools were chosen following a multistage cluster sampling. For each selected school all children attending fourth-grade, aged from 9 to 10 years old, were considered ($n = 784$). Students were eligible to participate in the study if they had lunch at the school canteen on the data collection day. Children under special diets or presenting food allergies and children that had second helpings were excluded from this study. The final sample ($n = 471$) included all children that had information about the two methods under analysis, according to the flow presented on Fig. 1.

2.3. Meal characteristics

All school canteens were leased to the same catering company. Menus were the same throughout the schools and were developed under the guidelines for school meals (Direção Geral de Educação, 2013; Rocha et al., 2013). No menu choices were available, a single option was offered to each child. The school lunch included soup, main dish and fruit. Tap water was the only available beverage. The menu type dish served was either mixed or non-mixed. Mixed dishes are those who 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 separately from the carbohydrate source (e.g. "Hamburger with pasta", "Hake fillets with rice").

At each canteen, staff members from the catering company were responsible for plating, serving and distributing meals, collecting the dishes and washing up.

2.4. Data collection

Field work was performed between 15th of May and 13th of June 2012, in order to obtain a large variety of menus containing mixed and non-mixed dishes, and fish and meat dishes, from a 3-month menu cycle. The same menu was evaluated at least once, at two different schools. Each child and each school were evaluated once during this period.

During data collection, the canteen staff was informed that the research team would be responsible for distributing plated main dish and collecting them at the end of each meal.

Data collection was performed by 14 trained researchers, including the main researcher. A reference protocol was developed as a tool to standardize data collection procedures. Training was designed to ensure that plate waste measurement procedures were as consistent as possible from school to school and all data collectors operated the scales accurately and made accurate visual estimations. Visual estimation was done always by the same 3 researchers.