Measuring Plate Waste: Validity and Inter-Rater Reliability of the Quarter-Waste Method

Katherine M. Getts

A thesis

submitted in partial fulfillment of the

requirements for the degree of

Master of Public Health

University of Washington

2015

Committee:

Donna B. Johnson

Emilee Quinn

Program Authorized to Offer Degree:

Public Health – Nutritional Sciences

Abstract

Background Measuring food waste in school cafeterias is an important tool to evaluate the effectiveness of school nutrition policies aiming to increase consumption of healthier meals. Visual assessment methods are frequently applied in plate waste studies because they are more convenient than weighing; the visual quarter-waste method has become one of the most commonly used in studies of school meal consumption, but little is known about its accuracy.

Objective The aims of this study were to determine whether the visual quarter-waste method is valid and reliable in a school cafeteria setting when compared to weighing plate waste.

Methods Researchers both weighed and visually assessed plate waste from 748 trays in nine middle schools and high schools. In addition, two researchers independently assessed 59 of these trays using the quarter-waste method. The data were analyzed using the weighted Kappa coefficient and interpreted using the scale developed by Landis & Koch.

Results For validity, 45% of foods assessed using the quarter-waste method were in "almost perfect agreement" with the measured weight, 42% of foods visually assessed were in "substantial agreement" with the weight, 10% were in "moderate agreement" and 3% were in "slight agreement". For inter-rater reliability, eight of ten food groups had Kappas in "almost perfect agreement" between the two raters and the other two groups had Kappas in "substantial agreement" between the two raters.

Conclusion These results suggest that the quarter-waste method is a valid and reliable tool for measuring plate waste in a school cafeteria setting.

Table of Contents

List of Tables

Introduction

Policies to improve school nutrition, such as the Healthy Hunger-Free Kids Act of 2010, may result in more students selecting healthy options at breakfast and lunch, including fruits, vegetables and low-fat unflavored milk[1], but it is not always clear whether the students actually consume these foods. Measuring food waste in school cafeterias is an important part of a comprehensive evaluation of the effectiveness of school nutrition policies developed to increase consumption of healthier meals[2].

Weighing food waste from individual plates with a scale is considered the gold standard method[3], but this may be time-intensive, costly and impractical in a busy cafeteria setting[4]. Therefore, indirect forms of measuring plate waste have been developed[5], including aggregate selective plate waste[6], student self-report of consumption[7], visual estimation[7], and, more recently, digital photography[8,9]. Aggregate selective plate waste involves collecting the plate waste of an individual food item from many trays and weighing the mass. Self-report of consumption relies on students' recollections of how much they consumed of each food item. Visual estimation by trained adults assesses the proportion of food wasted in 10%, 25% or 50% increments. Digital photography records images of food waste to be visually assessed at a later point in time.

Of these indirect methods, visual estimation by trained observers is relatively unobtrusive and efficient and safeguards against self-report bias, although it is subject to potential measurement bias – defined as an error in accurately measuring plate waste. The original use of plate waste studies was to evaluate nutrition education programs in schools[10], and visual assessment has since been used to evaluate nutrition interventions in school cafeterias[11,12], monitor menu performance in hospitals[13] and schools[14], to estimate food intake in children[15],

understand characteristics of plate waste in the National School Lunch Program[16], as well as to establish the reliability of other visual assessment methods such as digital photography[17].

The quarter-waste method, first referenced in published research in 1981, is a visual assessment tool in which trained observers rank food waste on a five-point scale – 0% remaining, 2% remaining, 50% remaining, 75% remaining or 100% remaining[7]. Until recently, however, little was known about the validity or the inter-rater reliability of the method. Assessing construct validity - whether a tool actually measures what it contends to measure[18] – is critical to knowing whether the quarter-waste method is a sound method for measuring plate waste. Reliability is the extent to which a tool produces steady, consistent results[19]. For the quarter-waste method it is important that the tool has a high degree of inter-rater reliability, defined as the degree to which different users of the tool give consistent estimates of the same plate waste[19]. The few studies that have assessed the validity of the quarter waste method[7,10,20] have used correlation analyses, which measure association but not necessarily agreement[21] and should be interpreted with caution.

Aims and Hypotheses

The aims of this study are to assess the construct validity of the visual quarter-waste method in comparison to weighing plate waste, and the inter-rater reliability of the visual quarter-waste method. We hypothesize that the visual quarter-waste method is a valid method to measure the amount of plate waste in a school lunch cafeteria setting. We also hypothesize that the visual quarter-waste method has a high level of consensus among raters when used in a school lunch cafeteria setting.

Methods

Data collection

The data were collected by research staff at the University of Washington Center for Public Health Nutrition as part of a larger study evaluating the impact of an intervention implementing low-cost strategies in the school cafeteria on improving students' intake of fruits, vegetables and white milk within the National School Lunch Program. This study's protocols were approved by the University of Washington Institutional Review Board. Data collection took place in May 2014 at nine middle and high schools in the Kent School District in King County, Washington State. Prior to the study, graduate and undergraduate student volunteers received two hours of training in the visual quarter-waste method from the project manager of the study. Training included instruction regarding the tool and protocol as well as time to practice using the protocol with "mock" lunches until the team could accurately assess the food waste compared to test amounts.

Visual assessment method

At each site, the research team reviewed the day's food options before the cafeteria opened in order to familiarize themselves with the size and shape of whole entrees. Some foods, such as whole fruits, vegetable side dishes, and low-fat white and chocolate milk, were the same at all nine schools, while entrees and specialty fruit items varied from school to school. Beverages and most fruits and vegetables were prepackaged with the exception of whole apples and oranges. Cafeteria staff served hot entrees, and one school had an entrée salad bar in operation on the day of data collection. In some cases the team retained whole entrees or side dishes as references and agreed upon measurement standards such as the number of baby carrots in a prepackaged bag. Foods sold outside of the National School Lunch Program, called

competitive foods, were not included in the study, and any competitive foods found on those school lunch trays being assessed were excluded from both visual assessment and weighing.

When students arrived for their lunch period, researchers recruited students in specific sections of the cafeteria to participate in the evaluation study, as described by Quinn et al (forthcoming). After the students purchased their meals, research staff completed a card for each tray that denoted the foods present on the tray and taped it to the bottom of the student's tray. Students were instructed to return their trays with all waste and wrappers to a marked rack in one section of the cafeteria when they were finished eating. These trays were then randomly distributed to members of the research team for visual assessment.

Each food on the tray was visually assessed using the quarter-waste method, rating the amount of food waste as either 0% (none left), 25% remaining, 50% remaining, 75% remaining, or 100% remaining (all left). Foods for which there was no evidence or that were added after the data card was filled out were noted as such. Entrees served with a side dish in the same container, such as chicken fingers and roasted potatoes, were visually assessed as separate foods. Visual assessors poured milk and juice into a measuring cup and measured the remaining fluid to the closest quarter-cup before pouring it back into the carton. A full milk carton is 8 ounces and a full juice carton is 4 ounces; using simple math the visual assessor determined the appropriate category for "percent remaining".

Inter-rater reliability testing was conducted at three schools with smaller student populations and/or fewer lunch periods, which allowed the team to collect additional data. At these schools the team attempted to test ten trays for inter-rater reliability. After one rater assessed a tray she/he stapled the visual assessment card underneath a blank visual assessment

and marked which the foods were present, before passing the tray at random to a second rater for visual assessment. All members of the team were included in inter-rater reliability testing.

Weighing method

Once a researcher had visually assessed each food item on the tray, it was passed to another researcher who weighed the food waste for each individual food on a scale (Edlund E Series E-160 Digital Portion Scale, Burlington, VT) and noted the gram weight in the appropriate row on the data card. All scales were calibrated prior to data collection according to manufacturer directions. Beverages were weighed in their containers. For an entrée served in a cardboard boat that included more than one type of food item, such as chicken nuggets and French fries, each food was weighed separately and staff noted the presence or absence of the container for each weight. Once a tray's food items had been weighed and recorded, they were discarded.

Throughout the data collection period, researchers weighed at least one of each whole and/or uneaten unique entrée item offered in the schools. Researchers also obtained multiple weights for items offered at all schools, such as whole fruit and milk. Multiple weights obtained for the same food/beverage were averaged together to provide a baseline, "uneaten" weight for each food. Foods weighed in containers or packaging were noted as such. Researchers also collected and retained at least one type of container/packaging for all food items, which were then washed, dried and cleaned before being weighed and recorded.

Data entry, cleaning and analysis

Graduate students at the Center for Public Health Nutrition entered the data into a custom University of Washington online survey interface for each school, which were then used to populate a master spreadsheet (Excel, part of Microsoft Office 2013. Redmond, WA: Microsoft

Corporation). Each of the foods was separated into individual spreadsheets and sorted by gram weight in ascending order. Any weights that had no corresponding visual assessment score were excluded from analysis (n=71). An additional three data points were excluded as outliers indicating data collection or entry errors.

For foods served in a boat, container, carton or plastic bag, the packaging weight was subtracted from the recorded weight of the food waste to provide a final weight of the food waste alone. Three apple cores were retained from trays and weighed; these weights were subtracted from the average weight of an uneaten apple. The same process was applied to an orange and its peel. The final weight for each food was divided by the average "uneaten" weight for that food and then multiplied by 100 to calculate a "percent remaining" for each food. These percentages were then sorted into five categories to correspond with the visual assessment scale: 0-12.5% remaining (0% on visual assessment scale), 12.51-37.5% remaining (25% on visual assessment scale), 37.51%-62.5% remaining (50% on visual assessment scale), 62.51%-87.5% remaining (75% on visual assessment scale), and 87.51-100% remaining (100% on visual assessment scale). These bands reflect the distribution of the possible categories that could be assigned by visual assessors.

The data for both validity and inter-rater reliability for each food were analyzed (Stata Statistical Software: Release 13. College Station, TX: StataCorp LP) using the weighted Kappa statistic. The Kappa measures the amount by which the agreement between two raters exceeds that expected by chance. A weighted Kappa assigns less weight to agreement as categories become further apart and is chance-corrected to account for the possibility that both raters could be assigning rankings at random[22]. The Kappa is intended to compare the results of two raters. In

this case one of the ratings is not a rater but an actual weight; the "percent remaining" gram weight was calculated using a full, uneaten weight based on a random sample of trays.

The Kappa statistic has a maximum of 1 when agreement is perfect, 0 when agreement is no better than chance, and negative values when agreement is worse than chance. While no one tool to evaluate Kappa is perfect we utilized the most commonly cited interpretation of Kappa by Landis & Koch (Table 1).

Table 1. Interpretation of the Kappa statistic by Landis & Koch[22]

Kappa	Agreement
< 0	Less than chance agreement
0.01-0.20	Slight agreement
0.21-0.40	Fair agreement
0.41-0.60	Moderate agreement
0.61-0.80	Substantial agreement
0.81-0.99	Almost perfect agreement

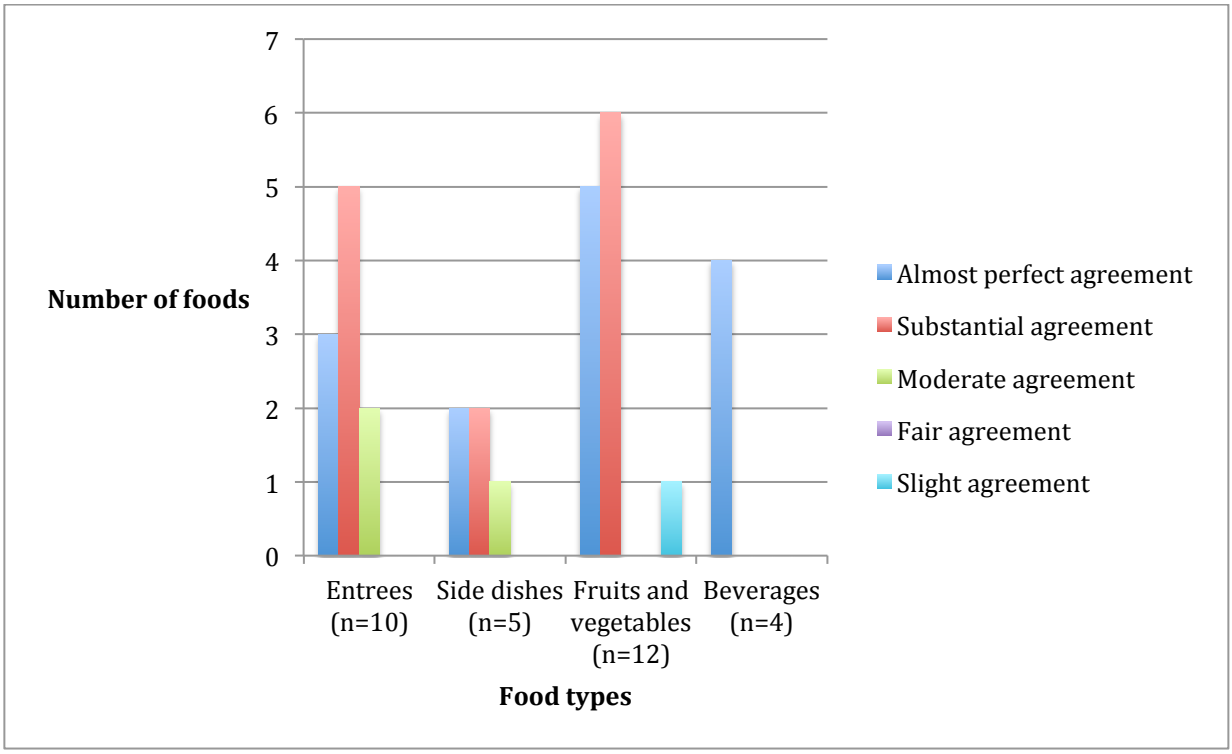
Results

Validity

Overall, fifty-three percent (n=748) of the trays that were visually assessed were weighed. A total of 2,227 individual weights were collected for 41 types of food; including beverages, fruits, vegetables, entrees, and side dishes. Certain items, such as white and chocolate milk, apple and orange juice, apples, oranges, baby carrots and cheese pizza, were served at every school, while other entrees and side dishes varied from school to school. The number of

weights collected for a specific food ranged from a low of one for bean salad to 400 for apple juice. The average number of weights per food was 57 and the median was 21. The validity analysis excludes foods for which there are less than six weights (n=8). The validity analysis produced 31 Kappa statistics, one for each food for which there were at least six weights. Forty-five percent of foods assessed using the quarter-waste method were in "almost perfect agreement" with the actual measured weight, forty-two percent of foods visually assessed were in "substantial agreement" with the actual weight, ten percent were in "moderate agreement" and three percent were in "slight agreement" (Table 2). When organized by type (Table 3) – entrée, side dish, fruits and vegetables, or beverage - all had a majority of visually assessed ratings in "almost perfect" or "substantial" agreement with the actual weight (Figure 1).

Figure 1. Level of agreement for validity with measured weight, by type of food



Inter-rater reliability

For inter-rater reliability two raters rated 59 trays at a total of three schools. 29 foods were rated by two raters at least once; of these 12 appeared on at least six pairs of trays and were included in the analysis. Foods for which there were less than six pairs of ratings were excluded from analysis (n=17). To increase the sample size, foods collected were analyzed in a second way by being grouped into ten categories including "All entrees", "All pizza", "All vegetables", etc. This allowed individual foods with fewer than six pairs of data to be included in the analysis by analyzing like items.

The reliability analysis produced 12 Kappa statistics, one for each food with at least six pairs of ratings from two raters. Nine were in "almost perfect agreement", two were in "substantial agreement" and one was in "moderate agreement". Of the nine foods with Kappas above 0.81 five of them had Kappas of 1.0, indicating almost perfect agreement between the two raters (Table 4). When the 29 foods with at least one pair of ratings were categorized by type of food (entree, side dish, etc) and analyzed, eight of the ten types produced Kappas in "almost perfect agreement" between the two raters and the other two groups (juice, vegetables) produced Kappas in "substantial agreement" between the two raters (Table 5).

Discussion

The high number of Kappas indicating "almost perfect" or "substantial" agreement between the quarter-waste method of visual assessment and weighed amount of the food waste suggests that the quarter-waste method is a valid tool for measuring plate waste in a school cafeteria setting. The considerable cases of "almost perfect" or "substantial" agreement between two raters using the quarter-waste method suggest that it is also a reliable tool. It would be

expected that the Kappa statistics for food types in both the validity and inter-rater reliability analyses might be lower than for individual foods due to combining different items, but they are remarkably strong in both groups.

For validity, some of the highest Kappas were produced by foods that are served in a standardized size or shape, such as hot dogs, pizza and bread rolls. Pre-packaged items such as potato salad, fruit cup, baby carrots, and raisins also performed very well with the quarter-waste method. This is to be expected as a visual assessor is able to accurately assess how much of the food is remaining based on the standard size of the full item. In cafeterias that have non-standardized portion sizes or a significant amount of food items that are "made to order" or "self-serve" it may be difficult for a visual assessor using the quarter-waste method to accurately estimate the amount remaining.

All beverages – chocolate and white milk, and orange and apple juice - had Kappa statistics that indicated "near perfect" agreement between the quarter-waste method rating and the measured weight. One might expect certain foods to be difficult to assess visually due to characteristics related to the food's visual appearance and/or flow when agitated[23], such as non-pureed soups that involve particles suspended in liquid and change shape easily. However, soup (e.g. chicken penne or clam chowder) had a Kappa of 0.91, indicating "nearly perfect agreement" with the recorded weight. This suggests that visual assessment is able to accurately assess amorphous, soupy foods as well as those with firmer, more recognizable shapes.

For validity, the four foods with Kappa statistics below 0.61 (indicating a level of agreement less than "substantial") were rice served with an entrée, Chicken Caesar salad, burgers and side salad. The lower Kappa for rice with entree may be explained by the fact that the rice in

question was served with another item - sweet and sour chicken, with sauce - and was thus difficult to visually isolate and assess. The lower Kappa statistics for the other three foods may highlight a limitation of weighing and a strength of the quarter-waste method: weighing does not distinguish between the primary food item and dressing or condiments. It was observed that students typically consumed salads with a substantial amount of cream-based dressing, much of which was left in the container after the student was finished eating. For a salad that was entirely consumed except for leftover dressing, the actual gram weight of the waste reflected the weight of the dressing, while the visual assessor might note the lack of salad contents and ignore the presence of salad dressing when determining the most appropriate category.

A similar situation was noted with burgers. Hamburgers and cheeseburgers were combined for data analysis because the distinction between these two foods is minimal and they were expected to have similar performance; the larger sample size also increased the strength of the Kappa statistic. When determining a rating for the amount remaining of a hamburger or cheeseburger the visual assessment took into account the fact that some students left part of the bun, cheese or toppings but ate the burger meat. While this could conceivably introduce variability in determining at what point an entrée item such as a burger has been mostly consumed it nonetheless points out the fact that visual assessment is a more nuanced method to assess food items that are not uniform in appearance or which consist of a grouping of discrete pieces of food – bread, meat, cheese, lettuce - that together constitute a "food". Therefore, the low level of agreement for salads may be due to the increased accuracy of the visual assessor compared to the actual weight of the waste and illuminates the fact that in some cases the "gold standard" weight is less accurate than a visual assessment.

The inter-rater reliability data demonstrated a high level of agreement among raters using the quarter-waste method in a school cafeteria setting. The majority of foods that had at least six pairs of ratings had Kappas that were in "almost perfect" or "substantial" agreement, but even when aggregated together with foods that had less than six pairs of ratings and analyzed by type the Kappa values were quite strong. While the sample size of foods used to assess inter-rater reliability was smaller than for validity this data suggests that the quarter-waste method is a reliable tool.

To date, this is the first known study of the validity and inter-rater reliability of the visual quarter-waste method that features a large sample of a variety of foods served at multiple middle- and high-school cafeterias. The strength of the results is especially important considering that data collection occurred in a real-life cafeteria environment with accompanying space, time, and noise limitations. These conditions are representative of those in which the quarter-waste method may be used to assess plate waste and therefore it is significant that even when used in a real-life setting the method is reasonably valid.

Furthermore, our research staff consisting of undergraduate and graduate students received only two hours of training in the quarter-waste method. Cafeteria staff and administrators can utilize the tool without the assistance of research staff or expensive equipment, and are ostensibly already familiar with serving sizes of foods served in the cafeteria. Additionally, in comparison to other plate waste assessment methods the quarter-waste method is not very disruptive to a cafeteria environment. Methods such as digital photography or weighing may slow down the lunch line as data is collected pre-consumption. Weighing large amounts of aggregate waste in garbage bins requires sorting and may include trash from lunches brought from home. Finally, this is the first known study to use the chance-corrected Kappa statistic to

analyze the data, which is well suited to the research question when compared with results of the weighing, the most rigorous measurement tool.

Limitations

Due to the logistics of this study, data for inter-rater reliability was only able to be collected at three of the schools. This limited the sample size for individual foods because only a certain number of lunch items were offered at each school on the day of data collection. Therefore, the results for inter-rater reliability should be interpreted with caution, but preliminary data are supportive of the quarter-waste method as a reliable tool with regards to inter-rater reliability. Further research is needed to corroborate these findings and to assess other types of reliability, such as test-retest.

Obtaining multiple weights for each whole, uneaten entrée item, which were sometimes unique to a school's menu during the data collection period, was not always feasible due to time, logistics and burdening of cafeteria staff. Some of the entrees were pre-made and simply heated on-site, such as pizza, hot dogs, and hamburgers, so we expect weights for these types of foods to vary little. Additionally, previous research has shown that calculating a mean serving size for foods with low variability in serving size does not require many samples to be accurate[24]. For a few entrees that involved on-site assembly of multiple foods, such as the chicken Caesar entrée salad and the sweet and sour chicken bowl, serving size may have been more diverse due to human variability. Therefore, it is possible that the actual "percent remaining" for these entree foods was not exact. However, the "percent remaining" was ultimately assigned to one of five weight bands corresponding to the five possible ratings for the quarter-waste method, so the odds that a food was wrongly assigned to the correct weight band are low.

Beverages were visually assessed by being poured into a measuring cup and determining the amount remaining to the closest quarter-cup. The next best alternative for visual assessment is to pick up the carton and determine by feel approximately how much fluid is remaining. Since the act of pouring fluids into a measuring cup takes negligibly more time than the latter approach and is quite accurate (Kappa > 0.81 for all four beverages) it is a reasonable modification to visual assessment that can be utilized in a real-world school cafeteria setting.

Conclusion

There are a variety of options for choosing a plate waste measurement tool, and while weighing plate waste from every tray on a scale is the gold standard it is not always feasible. This study suggests that the quarter-waste method is a valid and reliable visual assessment tool for plate waste in a school cafeteria compared to weighing, and in certain cases is actually more accurate. These findings are important because they validate results of past studies in which the quarter-waste method was used as a tool to measure plate waste[13,16] and support its use as a visual assessment method in future research.

Table 2. Validity: Level of agreement between the actual amount remaining and the visually assessed amount remaining of all foods. N=number analyzed.

Food	N	Kappa
Hot dog	18	0.96
Dinner roll	50	0.93
Soup	58	0.92
Orange juice	109	0.85
Cheese pizza	107	0.84
Chocolate milk	333	0.83
White milk	114	0.83
Fruit cup	32	0.83
Potato salad	29	0.83
Apple juice	388	0.82
Fruit of the day	16	0.82
Fish taco	19	0.82
Baby carrots	53	0.82
Raisins	9	0.81
Grapes	10	0.80
Canadian bacon & pineapple pizza	37	0.80
Seafood basket	56	0.80
Orange	17	0.80
Applesauce	30	0.79
Apple	61	0.79
Lettuce/tomato/pickle cup	22	0.77
Sub Sandwich	72	0.75
Pepperoni pizza	57	0.74
Corn	12	0.73
Side fries	221	0.66
Chicken tenders	67	0.64
Fries with entrée	108	0.63
Burger	26	0.59
Rice with entrée	12	0.58
Chicken Caesar entrée salad	12	0.56
Side salad	14	0.16

Table 3. Validity: Level of agreement between the actual amount remaining and the visually assessed amount remaining of food by type. N=number analyzed.

Food - Entrees	N	Kappa
Hot dog	18	0.96
Cheese pizza	107	0.84
Fish taco	19	0.82
Canadian bacon & pineapple pizza	37	0.80
Seafood basket	56	0.80
Sub sandwich	72	0.75
Pepperoni pizza	57	0.74
Chicken tenders	67	0.64
Burger	26	0.58
Chicken Caesar entrée salad	12	0.56
Food - Side Items	**N**	**Kappa**
Dinner roll	50	0.93
Soup	58	0.92
Side fries	221	0.66
Fries with entrée	108	0.63
Rice with entrée	12	0.58
Food - Fruits and Vegetables	**N**	**Kappa**
Fruit cup	32	0.83
Potato salad	29	0.83
Fruit of the day	16	0.82
Baby carrots	53	0.82
Raisins	9	0.81
Grapes	10	0.80
Orange	17	0.80
Applesauce	30	0.79
Apple	61	0.79
Lettuce/tomato/pickle cup	22	0.77
Corn	12	0.73
Side salad	14	0.16
Beverages	**N**	**Kappa**
Orange juice	109	0.85
Chocolate milk	333	0.83
White milk	114	0.83
Apple juice	388	0.82

Table 4. Inter-rater reliability: Level of agreement between two raters using visual assessment of amount remaining of all foods with N>5. N=number analyzed.

Food	N	Kappa
White milk	12	1.00
Cheese pizza	11	1.00
Fries w/ entrée	9	1.00
Hot dog	6	1.00
Baby carrots	5	1.00
Sub sandwich	9	0.91
Hawaiian pizza	12	0.89
Chocolate milk	31	0.87
Orange juice	6	0.81
Apple juice	33	0.78
Side fries	13	0.69
Pepperoni pizza	7	0.59

Table 5. Inter-rater reliability: Level of agreement between two raters using visual assessment of amount remaining of all foods, sorted by type. N=number analyzed

Food	N	Kappa
All fruit	9	1.00
All non-pizza entrees	28	0.97
All entrees	58	0.95
All fruits and vegetables	18	0.92
All milk	43	0.90
All pizza	30	0.88
All fries	22	0.87
All beverages	82	0.86
All juice	39	0.80
All vegetables	10	0.62

References

1. Nutrition standards in the National School Lunch and School Breakfast Programs; Final Rule, 7 CFR § § 210 (2012). 7 CFR § § (2012). http://www.gpo.gov/fdsys/pkg/FR-2012-01-26/pdf/2012-1010.pdf.

2. Snyder MP, Story M, Trenkner LL. Reducing fat and sodium in school lunch programs: the LUNCHPOWER! Intervention Study. *J Am Diet Assoc*. 1992;92(9):1087-1091.

3. Wolper C, Heshka S, Heymsfield S. Measuring food intake: an overview. In: Allison D, ed. *Handbook of Assessment Measures for Eating Behaviors and Weight-Related Problems*. Thousand Oaks, CA: Sage Publishing; 1995:215-240.

4. Jansen GR, Harper JM. Consumption and plate waste of menu items served in the National School Lunch Program. *J Am Diet Assoc*. 1978;73(4):395-400.

5. Buzby J, Guthrie J. Plate waste in school nutrition programs: Final report to Congress. March 2002. http://www.ers.usda.gov/media/887982/efan02009.pdf.

6. Comstock EM, Symington LE, Chmielinski HE, McGuire JS. Plate waste in school feeding programs: individual and aggregate measures. December 1979. http://www.dtic.mil/dtic/tr/fulltext/u2/a097819.pdf.

7. Comstock EM, St Pierre RG, Mackiernan YD. Measuring individual plate waste in school lunches. Visual estimation and children's ratings vs. actual weighing of plate waste. *J Am Diet Assoc*. 1981;79(3):290-296.

8. Swanson M. Digital photography as a tool to measure school cafeteria consumption. *J Sch Health*. 2008;78(8):432-437. doi:10.1111/j.1746-1561.2008.00326.x.

9. Williamson DA, Allen HR, Martin PD, Alfonso AJ, Gerald B, Hunt A. Comparison of digital photography to weighed and visual estimation of portion sizes. *J Am Diet Assoc*. 2003;103(9):1139-1145. doi:10.1053/jada.2003.50567.

10. Kirks BA, Wolff HK. A comparison of methods for plate waste determinations. *J Am Diet Assoc*. 1985;85(3):328-331.

11. Hanks AS, Just DR, Wansink B. Smarter lunchrooms can address new school lunchroom guidelines and childhood obesity. *J Pediatr*. 2013;162(4):867-869. doi:10.1016/j.jpeds.2012.12.031.

12. Williams CL, Bollella MC, Strobino BA, et al. "Healthy-start": outcome of an intervention to promote a heart healthy diet in preschool children. *J Am Coll Nutr*. 2002;21(1):62-71.

13. Connors PL, Rozell SB. Using a visual plate waste study to monitor menu performance. *J Am Diet Assoc*. 2004;104(1):94-96. doi:10.1016/j.jada.2003.10.012.

14. Snyder M, Fee R, Lytle L, Hann B. Visually monitoring students' consumption of school lunch entrees. *Sch Foodserv Res Rev*. 1996;20(20):63-68.

15. Dhingra P, Sazawa S, Menon VP, Dhingra U, Black RE. Validation of visual estimation of portion size consumed as a method for estimating food intake by young Indian children. *J Health Popul Nutr*. 2007;25(1):112-115.

16. Reger C, O'Neil C, Nicklas T, Myers L, Berenson G. Plate waste of school lunches served to children in a low socioeconomic elementary school in south Louisiana. *Sch Foodserv Res Rev*. 1996;20:13-19.

17. Parent M, Niezgoda H, Keller HH, Chambers LW, Daly S. Comparison of visual estimation methods for regular and modified textures: real-time vs digital imaging. *J Acad Nutr Diet*. 2012;112(10):1636-1641. doi:10.1016/j.jand.2012.06.367.

18. Golafshani N. Understanding reliability and validity in quantitative research. *Qual Rep*. 2003;8(4):597-607.

19. Phelan C, Wren J. Exploring reliability in academic assessment. https://www.uni.edu/chfasoa/reliabilityandvalidity.htm.

20. Hanks AS, Wansink B, Just DR. Reliability and accuracy of real-time visualization techniques for measuring school cafeteria tray waste: validating the quarter-waste method. *J Acad Nutr Diet*. 2014;114(3):470-474. doi:10.1016/j.jand.2013.08.013.

21. Dubois S. Accuracy of visual estimates of plate waste in the determination of food consumption. *J Am Diet Assoc*. 1990;90(3):382-387.

22. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977;33(1):159-174.

23. Thompson CH, Head MK, Rodman SM. Factors influencing accuracy in estimating plate waste. *J Am Diet Assoc*. 1987;87(9):1219-1220.

24. Comstock EM, Symington LE. Distributions of serving sizes and plate waste in school lunches. Implications for measurement. *J Am Diet Assoc*. 1982;81(4):413-422.