FRUIT AND VEGETABLE WASTE FROM SCHOOL LUNCHES:

A SYSTEMATIC REVIEW AND META-ANALYSIS

A Thesis

by

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ABSTRACT

This work used the systematic review and meta-analysis techniques to assess fruit and vegetable (F&V) plate waste from school lunches, to determine whether there is a difference in F&V waste pre- and post- implementation of the new school meal standards, and to identify factors associated with plate waste. It followed the Cochrane Collaboration Guidelines, USDA's Nutrition Evidence Library (NEL) Bias Assessment Tool, and USDA NEL Conclusion Statement Evaluation Criteria. Meta-analysis of percentage selection and effect size of percentage plate waste was performed in STATA. Twenty-three studies were included in the systematic review and twenty-one in the meta-analysis.

The estimated mean percentage of students that selected fruits and vegetables were 60% (95% CI: 46%-75%), and 48% (95% CI: 31%-65%), respectively. The percentage of students who selected fruits increased significantly after the implementation of the new standards. This increase was consistent across all the studies and ranged from 5% to 24%. Fruit waste was estimated to be 34.7% (95% CI: 31.0%-38.6%) and vegetables waste was 44.5% (95% CI: 34.7%-54.5%). The estimated mean percentage fruits waste was 35.7% pre- and 39.5% post-implementation, and for vegetables was 45.5% pre- and 50.5% post-implementation, with no significant difference between them. Child related factors such as age, gender, and ethnicity/race were not statistically significant to explain the aggregate waste across studies. Mandatory/optional selection of F&V had no effect on plate waste. Only few studies on plate waste explored the relationship between variables such as preferences or attitudes,

preparation methods, availability of competitive food, time devoted to eating, and F&V waste, we could not establish any other relation beyond the descriptions provided in the original studies.

The low percentage of F&V selection and the high mean percentage waste are worrisome outcomes in the NSLP. The change in standards has had a positive effect in increasing the number students selecting fruits. We could not draw any conclusions on the change in percentage of students selecting vegetables. The mean percentage waste of F&V after the implementation of the HHFKA 2010 has not been significantly higher than before implementation of new standards. Acceptance and consumption of dark green vegetables appears to be one of the challenging aspects of the new regulation, and this type of vegetables could be a focus of future research.

DEDICATION

To my husband, who left everything behind to accompany me to pursue this dream.

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CHAPTER I

INTRODUCTION

Frequent Fruit and Vegetable (F&V) consumption is one of the effective ways to help provide diverse and nutritious diets to individuals and help reduce risk of diseases such as cardiovascular disease, hypertension, diabetes, cancer, obesity, depression and osteoporosis (WHO 2003, Boeing et al. 2012, Lui et al. 2016, Wang et al. 2014, Fulton et al. 2016). Since most Americans do not consume enough F&V, the Dietary Guidelines for Americans - DGA (2010, 2015-2020) recommended increasing daily intakes and variety of F&V consumed, especially dark-green, red, and orange vegetables, and beans and peas. This recommendation based on scientific evidence, as well as, some previous legislative developments led to an important new U.S federal legislation, the Healthy Hunger Free Kids Act (HHFKA-2010). According to the USDA, HHFKA-2010 gave the "opportunity to make real reforms to the school lunch and breakfast programs by improving the critical nutrition and hunger safety net for millions of children".[1]

The public concern for the high-caloric diet consumed by most of children and adolescents as well as the increasing rates of obesity in this population group has enabled the identification of scenarios and interventions to improve diets and promote physical activity. School meals are considered the ideal settings to implement the DGA recommendation since children consume at least one of their main daily meals at school and spend the majority of their weekdays in school.

[1] https://www.fns.usda.gov/school-meals/healthy-hunger-free-kids-act.

The National School Lunch Program (NSLP) is the largest federally assisted meal program operating in schools and childcare institutions, and one of the most popular welfare programs in the U.S. In 2015, 30.5 million school children[2] participated in the NSLP, which represented about 61% of the school children in the U.S.[3], and 72.6% of the participants received their meal for free or at a reduced price. This program was created to provide nutritious and balanced food to children by improving availability, accessibility, and quality of meals, in recognition of the relationship between food and good nutrition and the capacity of children to develop and learn.[4]

Existing studies on the effect of the NSLP on the dietary quality of school-age children have found mixed results. Using data from the School Nutrition Dietary Assessment III (SNDA-III, 2005), Condon, Crepinsek, and Fox (2009) found that NSLP participants were more likely to consume milk and F&V, and less likely to consume desserts, snacks and other beverages compared to non-participants. Using the NHANES data from 1999 to 2006 Campbell et al. (2011) found that NSLP participants do not consume higher-quality diet, but rather consume a higher quantity of food than not participants. Ishdorj, Crepinsek, and Jensen (2013) determined that NSLP participants consumed more F&V in the school, but this increase may substitute consumption out-of-school. Although there is no consensus regarding whether or not the NSPL provides a better diet for participants than for nonparticipants, in general, it is widely accepted that

[2] https://www.fns.usda.gov/sites/default/files/pd/slsummar.pdf [Accessed January 2017].

[3] According to the National Center for Education Statistics, in 2015 a projection of 50,268,100 students would be enrolled in public schools. https://nces.ed.gov/programs/digest/d15/tables/dt15_203.20.asp. [Accessed January 2017].

[4]U.S. Child Nutrition Act of 1966. Consulted in https://www.fns.usda.gov/nslp/history_6. [Accessed December 2016].

NSLP has made it possible for students from low-income households to access nutritious foods they could not afford otherwise. Overall, the program has made important contributions to improve students' food security across the U.S.

In addition to accomplishing the NSLP nutritional goals, implementing a cost-effective program and reducing waste are also program goals. Plate waste is, of course, an undesired outcome and a main concern for policy-makers, school administrators, cafeteria managers, parents and the public. Plate waste threatens to derail attaining the objectives of the NSLP, and it is an unacceptable misuse of resources at the highest value-added level of the production chain.

In 2002, the House of Representatives Committee on Appropriations requested that the USDA's Economic Research Service (ERS) evaluate of plate waste in school meal programs. In response to this request, ERS prepared an extensive review of the existing published and unpublished studies and officially reported a waste of 12% of the calories served. They cited Devaney et al. (1995), a study that used nationally representative data from the School Nutrition Dietary Assessment (SNDA-1, 1991-92). The official report included some important findings on nutritional benefits of school meals and strategies for reducing plate waste, but the authors claimed that more research was needed in many aspects of policy implementation (Buzby and Guthrie 2002). Byker Shanks, Banna, and Serrano (2017) conducted a systematic review of methods used to measure food waste from school lunches. They concluded that diverse food waste data collection methods was used and that a comprehensive evaluation of food waste is challenging due to the wide variety of methods and reporting metrics used by the researchers.

DGA (2010) was enforced through the HHFKA-2010 and incorporated into the NSLP standards starting in fall of 2012. Besides the authority granted to USDA to improve the quality of the meals, the HHFKA-2010 has been seen as remarkable progress in expanding the students' access to the program and an opportunity to improve program operations. However, the school meal "trilemma" involving nutrition, participation, and costs, continues unabated in spite of a larger share of funding and the experience of the program operation (Ralston et al. 2008). Even though scientists celebrated the focus on improving nutrition, plate waste has drawn considerable attention after the policy change, since the new regulation comprises, among other improvements, some increases in quantity and variety of F&V, which are usually the most wasted components of the meal. Along with the change in the regulation, some concerns arose about a possible increase in waste and/or drop in the participation rate; these issues have been studied in the recent published literature.

The revision in school meals following the HHFKA-2010 is especially important due to the mandatory specifications on servings and portion sizes of foods served at schools during breakfast and lunch. This represents an improvement in quality of diet but also could lead to increased waste of the healthier lunches, which are expected to be more expensive (Newman 2012). Although a number of studies evaluated the effect of new school meal standards on students' food consumption and nutrient intake, most of the studies were local and regional in nature and were not representative enough to provide any conclusive findings. Regarding the quality of meals, Johnson et al. (2016) conducted a rigorous and extensive longitudinal study, although not nationally representative, that provided evidence of the significant improvement in the nutritional quality of foods related to the policy change using two outcomes: mean adequacy ratio (58.7 before and 75.6 after) and mean energy density (1.65 before and 1.44 after), with no difference in student participation.

Regarding the effect on waste, the current research will add to the existing literature by using the systematic review and meta-analysis techniques to (1) assess F&V plate waste from school lunches, (2) determine whether there is a difference in F&V waste pre- and post- implementation of the new NSLP standards, and (3) identify factors associated to waste.

CHAPTER II

METHODOLOGY

In February 2017, a systematic literature search was conducted following the Cochrane Collaboration guidelines in Ovid (Medline, CAB, AGRIS) and Ebsco (Agricola, ERIC, CINAHL) for concepts "fruit/vegetable" AND "food service/lunch program" AND "children" AND "nutrition surveys" AND "plate waste" AND "food waste" AND "nutrient intake". Publications since 1990 were included in the search. Studies were screened to meet the following eligibility criteria: (1) peer-reviewed publications, (2) reported fruit or vegetable waste, (3) reported fruit or vegetable consumption that can be converted to waste through arithmetic calculations, (4) within the U.S. National School Lunch Program operations, (5) observational study design (ecological designs, cross sectional, case-control, case-crossover, retrospective, and prospective cohorts), (6) not intervention studies, (7) not methodology validation studies, (8) written in English. Appendix A shows the searching protocol and its results.

The following information was extracted from each study: identification (study ID number, authors, publication date, data collection date); study design (sample size, method of data collection, duration, days of data collection, number of observations); population characteristics (grades); school characteristics (type of school, optional or mandatory selection of fruits and vegetables); outcomes (selection, consumption or waste of fruits, vegetables, or fruits and vegetables combined); and study's conclusions.

Waste was defined as the proportion of food served to students during the school lunch that was uneaten. Most studies reported waste as percent of total serving or consumption as percent of total servings. In cases where waste was not reported, its percentage was calculated by subtracting percentage consumed from 100. Some studies reported the total amount of food served, and consumption or waste in absolute measures (cups or servings), so percent wasted was calculated based on the information provided. When overall estimation of consumption or waste was not explicitly reported in the study, it was calculated using a weighted average.

The quality appraisal of the selected studies was conducted following the USDA's Nutrition Evidence Library (NEL) Bias Assessment Tool supported by the 2015 Dietary Guidelines Advisory Committee (DGAC)[5]. The tool provided 12 criteria for observational studies, and risk of bias scores between 0 and 24 points were assigned to each study. Scores closer to zero meant a lower risk of bias. Risk of bias scores were converted to a quality index by subtracting the assigned score from 24 and calculating the proportion. A higher quality index meant a lower risk of bias. Appendix B shows the quality appraisal of selected studies.

Meta-analysis was used to analyze the data on F&V selection and waste in schools. For selection data, the STATA command METAPROP (Nyaga, Arbyn, and Aerts, 2014) was used in the analysis. For waste data, the Effect Size (ES) was calculated for each study as a function of the proportion of waste, using the approximation method with the *arcsine* transformation as reported by Thyberg, Tonjes

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[5] Available at https://www.cnpp.usda.gov/sites/default/files/usda_nutrition_evidence_flbrary/2015DGAC-SR-Methods.pdf

and Gurevitch (2015) and the STATA command METAN. Due to heterogeneity among studies included, the random-effect meta-analysis was used for all analyses and it was performed in STATA 14.2® (Palmer and Sterne J.A.C. (Eds) 2016). Appendices C and D show data transformation and STATA commands used for analysis.

This study was exempt from institutional review board approval since there was no interaction with human subjects.

CHAPTER III

RESULTS

3.1 Study selection and data extraction

As shown in the Prisma Flow Diagram in Figure 1, 604 records were retrieved during the primary search and 458 titles and abstracts of unique records were screened for meeting inclusion criteria using the free web application Rayyan® (Ouzzani et al. 2016)[6]. Of those, 89 were selected for full-text assessment for eligibility criteria using the online bibliographic management program Refworks®. A total of 27 papers pertaining to 23 studies were included in this review.

[6] http://rayyan.qcri.org

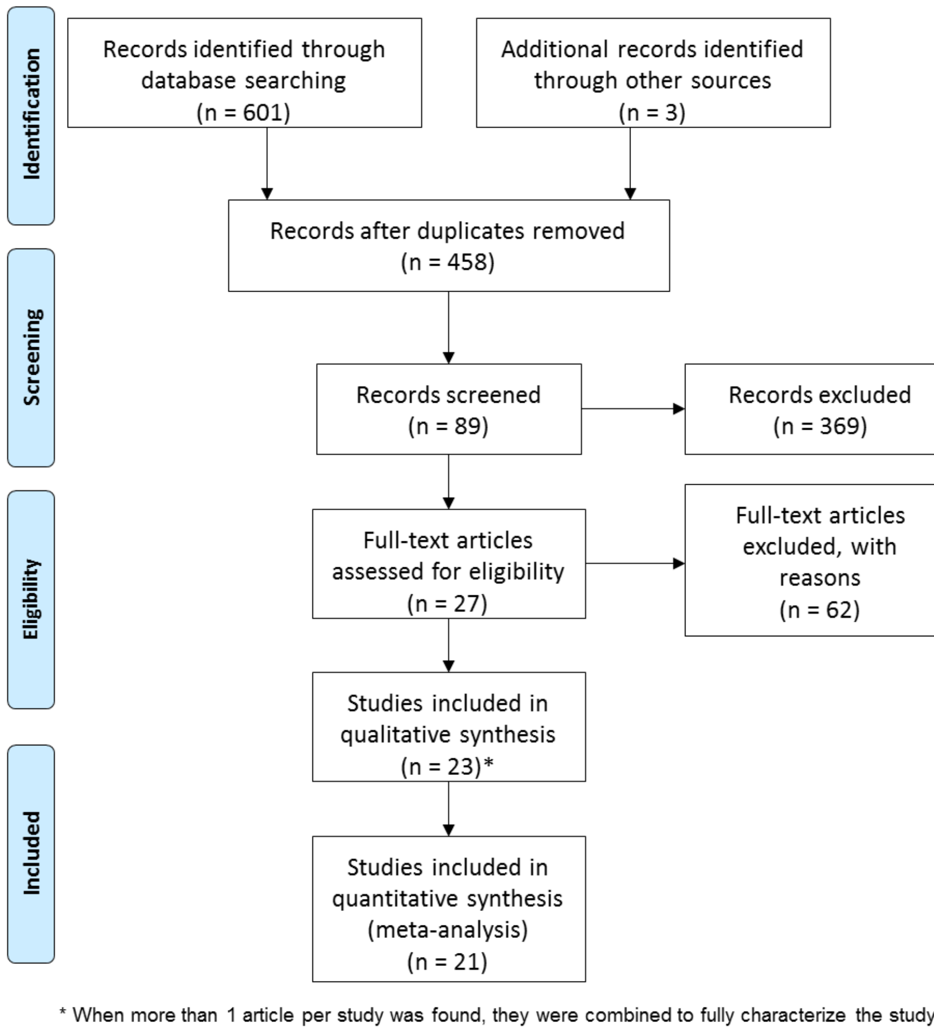

Figure 1. Literature search and meta-analysis selection process for retrieving peer-reviewed publications

Although intervention studies were excluded by design from this review, an exception was made for Cullen et al. (2015) since the intervention goal was to investigate the changes in food selection and consumption as a result of a partial implementation of the new NSLP standards, initiated in 2011. Similarly, the baseline in study 1 and 2 reported in Just and Price (2013) met the criteria, although the publication reported the results of an intervention study.

3.2 Studies on F&V selection and waste

This systematic review included 23 studies conducted in the West, South, and Northeast regions of the U.S. (See Appendix E). No peer-reviewed studies on F&V plate waste from school lunches in the Midwestern region were found. Most studies were focused on youngest school-age children. There is little research on F&V consumption and plate waste patterns of high school students. Ten studies were conducted in elementary schools, four in middle schools, seven in elementary and middle schools setting, one in high school, and one study included grades 1 through 12.

Studies varied widely in their sample sizes starting from 237 students to 8,430 students, and from 340 to 48,533 plate observations. Eleven studies out of 23 were carried out before the implementation of the new NSLP standards, five were conducted after, and seven studies quantified the effect of the changes in the NSLP standards by monitoring consumption/waste before and after the change. Researchers used all the acknowledged methods for plate waste. Nine studies collected data using the weighing method, six used the visual estimation method, seven used digital photography, and one used food records (Table 1).

Table 1. Studies of F&V waste and consumption in NSLP school lunches

Study	State/Region	N students	School audience	HHFKA-2010 (1)	Method of data collection
Adams et al. (2005)	California	294	1st-5th	Before	Weighing
Adams et al. (2016)	Arizona	533	6th-8th	After	Weighing
Amin et al. (2015)	Northeastern U.S.	NR (498 plates before, 944 plates after)	3th-5th	Before & after	Weighing
Baxter and Thompson (2002)	Georgia	237	4th	Before	Visual quarter
Bontrager Yoder, Foecke and Schoeller (2015)	Wisconsin	1877	3th-5th	Before & after	Digital photography
Byker et al. (2014)	A rural county in the southwest region of the U.S.	NR (304 plates)	Pre-K-K	After	Weighing
Capps Jr. et al. (2016); Ishdorj et al. (2015); Ishdorj, Capps Jr. and Murano (2016)	Texas	8,430 (144 obs before, 305 obs after)	K-5th	Before & after	Weighing
Cashman et al. (2010)	Washington	2,285 (5,420 plates)	2nd-5th	Before	Weighing
Cohen et al. (2014, 2016)	Massachusetts	1,030 1,001	3rd-8th	Before & after	Weighing
Connors and Bednar (2015)	Texas	1,418 plates	7th	Before	Digital photography
Cullen and Zakeri (2004)	Texas	594	Cohort 1: 4th grade transitioning to middle school. Cohort 2: middle school in both years	Before	Food records
Cullen et al. (2015)**	Texas	1,149 elementary and 427 middle school students	Elementary and middle schools	Before & after	Visual quarter
Gase et al. (2014)	California	2228	Middle school	After	Visual quarter
Goggans, Lambert, and Chang (2011)	Mississippi	876	4th-5th	Before	Weighing
Haas, Cunningham-Sabo, and Auld (2014)	Colorado	317	9th-12th	Before	Digital photography
Handforth et al. (2016)	Pennsylvania	693	1st-12th	After	Digital photography
Just, Lund and Price (2012); Just and Price (2013) Study 2-Baseline.	Utah	NR over 48,533 child-day observations, 41,374 child-day observations	Elementary school children	Before & after	Visual half
Marlette, Templeton, and Panemangalore (2005)	Kentucky	743	6th	Before	Digital photography
Martin et al. (2010)	Louisiana	2049	4th-6th	Before	Digital photography
Niaki et al. (2017)	Texas	573	K-5th	After	Visual quarter

Table 1. Continued

Study	State/Region	N students	School audience	HHFKA-2010 (1)	Method of data collection
Reger et al. (1996)	Louisiana	248	3rd-6th	Before	Visual quarter
Schwartz et al. (2015)	Connecticut	1340	K-8th	Before & after	Weighing
Smith and Cunningham-Sabo (2013)	Colorado	899	1st-8th	Before	Digital photography

(1) Whether the study was performed before or after the Healthy Hunger-Free Kids Act (2010) implementation in Fall 2012
Studies in bold reported consumption.
** Intervention study

Two main outcomes were identified in this review. The first one was selection, measured as the proportion of students selecting F&V. Selection of F&V occurred due to the application of the Offer *vs.* Serve provision, which is mandatory for high schools and elective for elementary and middle schools, or due to the presence of salad bars as an internal policy in the school or school district. Offer *vs.* Served provision was established to reduce waste and give the students the opportunity to choose the foods they want to eat (U.S. Department of Agriculture, 2015). Table 2 shows the percentage of students selecting F&V when the school allowed them choosing to place the items on their tray or not, for each study. The second outcome was percentage waste of F&V (Table 2). Studies in bold reported only consumption. For those studies, plate waste values were calculated as explained in the methodology section.

Table 2. Percentage of selection and waste reported in or calculated from selected studies

Study	Selection of F&V			Waste of F&V			Q index (3)
	% students selecting fruit (1)	% students selecting vegetables (1)	% students selecting F&V combined (1)	Mean % Fruit Waste (2)	Mean % Vegetable Waste (2)	Mean % combined F&V Waste (2)	
Adams et al. (2005)	Students attending schools with salad bars took an average of 112+/-70 g F&V compared to 104+/-86 g taken by students at non-salad bar schools			NR	NR	54.7	0.9167
Adams et al. (2016)	98.6% when salad bar was inside the serving line, and 22.6% when it was outside the serving line			NR	NR	44.9	0.8333
Amin et al. (2015)	Around 18%* before, around 29%* after	Around 24%* before, around 32%* after	Around 42%* before, around 36%* after	NR	NR	41.2	0.8333
Baxter and Thompson (2002)	F&V were served by default			51.0	56.0	NR	0.7917
Bontrager Yoder, Foecke and Schoeller (2015)	F&V were served by default			26.8	22.9	27.0	0.6667
Byker et al. (2014)	F&V were served by default			33.0	51.4	NR	0.9583
Capps Jr. et al. (2016); Ishdorj et al. (2015); Ishdorj, Capps Jr. and Murano (2016)	F&V were served by default			NR	52.3	NR	0.9583
Cashman et al. (2010)	F&V were served by default			Around 50%*	Around 40%*	NR	0.7917
Cohen et al. (2014, 2016)	52.7% before, 75.7% after	68.5% before, 68.6% after	NR	42.0 36.2	67.0 55.9	NR	0.9167
Connors and Bednar (2015)	70.4	86.5	NR	54.4% of the students discarded none, 18.8% half, and 26.8% all	61.3% of the students discarded none, 23.9% half, and 14.8% all	NR	0.7917
Cullen and Zakeri (2004)	F&V were served by default			Transitioning from elementary to middle school: consumed servings decreased 33%	Transitioning from elementary to middle school: consumed servings decreased 42%	NR	0.7917
Cullen et al. (2015)**	43.2% before, 52.9% after	49.1% before, 59.9% after	NR	31.5	47.7	NR	1.0000
Gase et al. (2014)	45.5	36.6	NR	77.4% of the students discarded some, and 22.6% all	68.7% of the students discarded some, and 31.4% all	NR	1.0000
Goggans, Lambert, and Chang (2011)	65.0	55.8	NR	41.4	48.5	40.2	0.7500

Table 2. Continued

Study	Selection of F&V			Waste of F&V			Q index (3)
	% students selecting fruit (1)	% students selecting vegetables (1)	% students selecting F&V combined (1)	Mean % Fruit Waste (2)	Mean % Vegetable Waste (2)	Mean % combined F&V Waste (2)	
Handforth et al. (2016)	58.2	20.9	20.9	Median portions consumed: canned 100%, whole 20%, cut fresh 100%	Median portions consumed: potato 90%, cooked vegetable 50%, raw vegetable 60%	NR	0.6250
Just, Lund and Price (2012); Just and Price (2013) Study 2-Baseline.	NR	NR	NR	38.7	58.8	NR	1.0000
Marlette, Templeton, and Panemangalore (2005)	21.7	40.3	NR	41.4	29.9	NR	0.8333
Martin et al. (2010)	NR	NR	NR	NR	NR	37.1	1.0000
Niaki et al. (2017)	F&V were served by default			32.3	34.4	NR	0.8750
Reger et al. (1996)	93.9	41.5	NR	24.0	52.0	NR	0.9583
Schwartz et al. (2015)	53.7% before, 68.6% after	68.4% before, 57.3% after	NR	31.6	52.5	NR	0.9167
Smith and Cunningham-Sabo (2013)	53.7	41.3	NR	38.8	32.6	NR	1.0000

(1) selection reported as % students selecting item unless another measure is specified
(2) waste reported as % unless another measure is specified * Results reported in graphs ** Intervention study
(3) Between 0 and 1, being 0 more risk of bias and 1 less risk of bias
Studies in bold reported consumption, then some arithmetic calculations were made as explained in methodology section

The internal validity of each study was assessed using the NEL Bias Assessment Tool (BAT). The risk of selection, performance, detection and attrition biases that were jointly considered in the score were later converted to a quality index ranging from 0 to 1, with 1 being of the highest quality due to the less risk of bias. As shown in Table 2, eleven studies were assigned a quality index above 0.90, nine studies graded between 0.75 and 0.90, and only three studies graded between 0.60 and 0.74. It is important to be aware that the risk score is not only dependent on the quality of the study but also on the detail of reporting. Therefore, some studies could obtain a low quality score due to the lack of detail in the reporting.

3.3 Meta-analysis

Meta-analysis of selection data pooled the reported proportions to compute exact binomial and score test-based confidence intervals, by using METAPROP command (Nyaga, Arbyn, and Aerts, 2014). Meta-analysis of waste data was performed using the *arcsin* transformation (Thyberg, Tonjes, and Gurevitz 2015) and METAN command in STATA.

Meta-analysis of the proportion of students selecting F&V

Results of a continuous random effects model reported in Figure 2 show that the pooled percentage of students selecting fruits was 60% (95% CI: 46%-75%), and for vegetables was 48% (95% CI: 31%-65%). Heterogeneity was quantified using the I-squared measure. Significant intra-group heterogeneity was observed, which was calculated to be

99.70% for fruits and 99.79% for vegetables (p=0.00 in both cases). However, the test for heterogeneity among subgroups shows insignificant inter-group heterogeneity (p=0.27), which allows us to pool the data from all the studies into one data sample. Overall, 54% (95% CI: 43%-65%) of the students place fruits or vegetables on their tray when selection is allowed. These results show how challenging trying to influence better-eating habits can be.

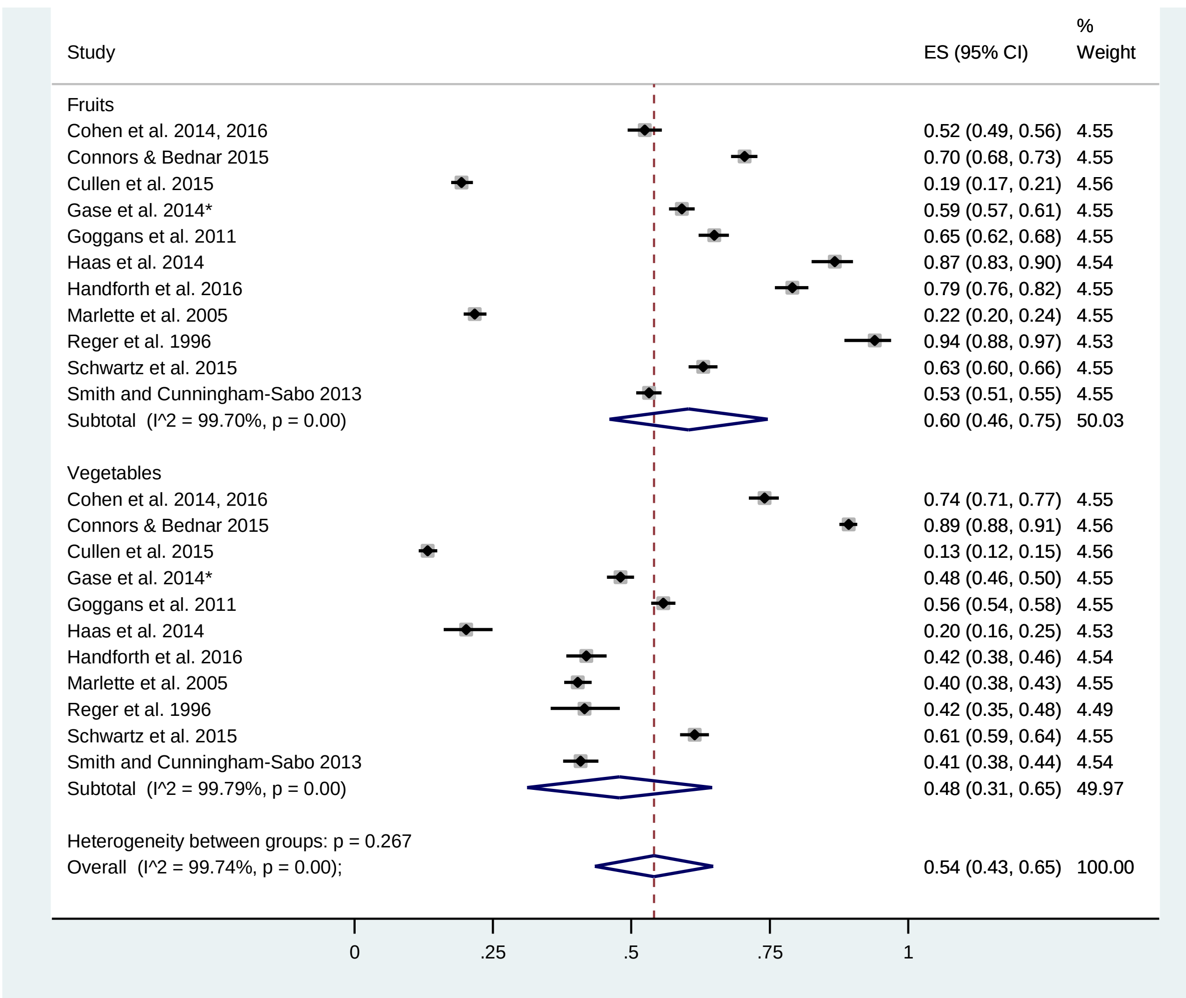

Figure 2. Forest plot of proportion of students selecting F&V

Forest plot in Figure 2 shows some outliers that can be used to explore some explanations to variability. With respect to fruit waste outliers, two studies reported a considerably lower percentage (Cullen et al. 2015, Marlette et al. 2005) and three studies reported a below average percentage (Haas et al. 2014, Handforth et al. 2016, Reger et al 1996). Regarding vegetable waste outliers, two studies reported a noticeably lower percentage (Cullen et al. 2015, Haas et al. 2014) and other two a higher percentage (Cohen et al. 2014, 2016; Connors and Bednar, 2015). These outliers can partially be explained by methodological differences among studies. First of all, four out of seven studies conducted using digital photograph belong to the outliers' group, implying that this method could be under and overestimating the outcome. Second, Haas, Cunninghan-Sabo, and Auld (2014) is the only published study on plate waste from high schools only, which reports a lower selection of vegetables and a higher selection of fruits by students. Third, Cullen et al. (2015) showed a lower selection for both F&V possibly related to the fact that they conducted a study on partial implementation of new NSLP standards. Finally, Reger et al. (1996) conducted the study with the smallest sample size.

Quantification of selection before and after changes in regulation showed that selection of fruits increased significantly after the implementation of the new meal standards. This increase was consistent across all the studies whereas selection of vegetables had conflicting results. With respect to fruits, Amin et al. (2015) found an increase from around 18% to around 29%, Cohen et al. (2014) found an increase from 52.7% to 75.7%, and Cullen et al. (2015) estimated an expected increase from 51% to 56% for elementary school children and from 21% to 45% for middle school students selecting fruits. Schwartz et al. (2015) found that the percent of students selecting fruits increased from 53.7% in 2012 (before the change) to 70.6% in 2013 a year after the change, but decreased to 66.0% in 2014. With respect to vegetables, Amin et al. (2015) found a non-significant increase; Cohen et al. (2014) found that there was no change in selection; and, Schwartz et al. (2015) found that the decrease in selection in the first year was statistically significant, but not significant in the second year after change. Finally, the simulation of NSLP standard change carried out by Cullen et al. (2015) showed that students would select significantly more vegetables under the new regulation.

Meta-analysis of F&V waste

Eighteen studies were included in meta-analysis of F&V plate waste. Results from the continuous random effects model, using *arcsine* transformation to calculate Effect Size (ES) and stabilize the variance are shown in Figure 3. From the overall ES estimated, the percentage of fruit waste was calculated to be 34.7% (95% CI: 31.0%-38.6%), and percentage of vegetable waste was 44.5% (95% CI: 34.7%-54.5%). When combined F&V waste was reported, we found that pooled percentage waste was consistently estimated in between those values, with a mean of 40.5% (95% CI: 33.8%-47.5%). Significant intra-group heterogeneity was observed, which was calculated to be 97.6% for fruits and 99.7% for vegetables ($p=0.00$ in both cases). Overlapping intervals showed that across studies these results do not support particular findings in Baxter and Thompson (2002) and Gase et al. (2014), that fruits are wasted significantly less than vegetables. By the contrary, these results support findings in Bontrager Yoder et al.

(2015), and Byker et al. (2014) which did not show a statistically significant difference in waste between groups. This study estimated an overall percentage of F&V waste of 39.6% (95% CI: 34.7%-44.5%).

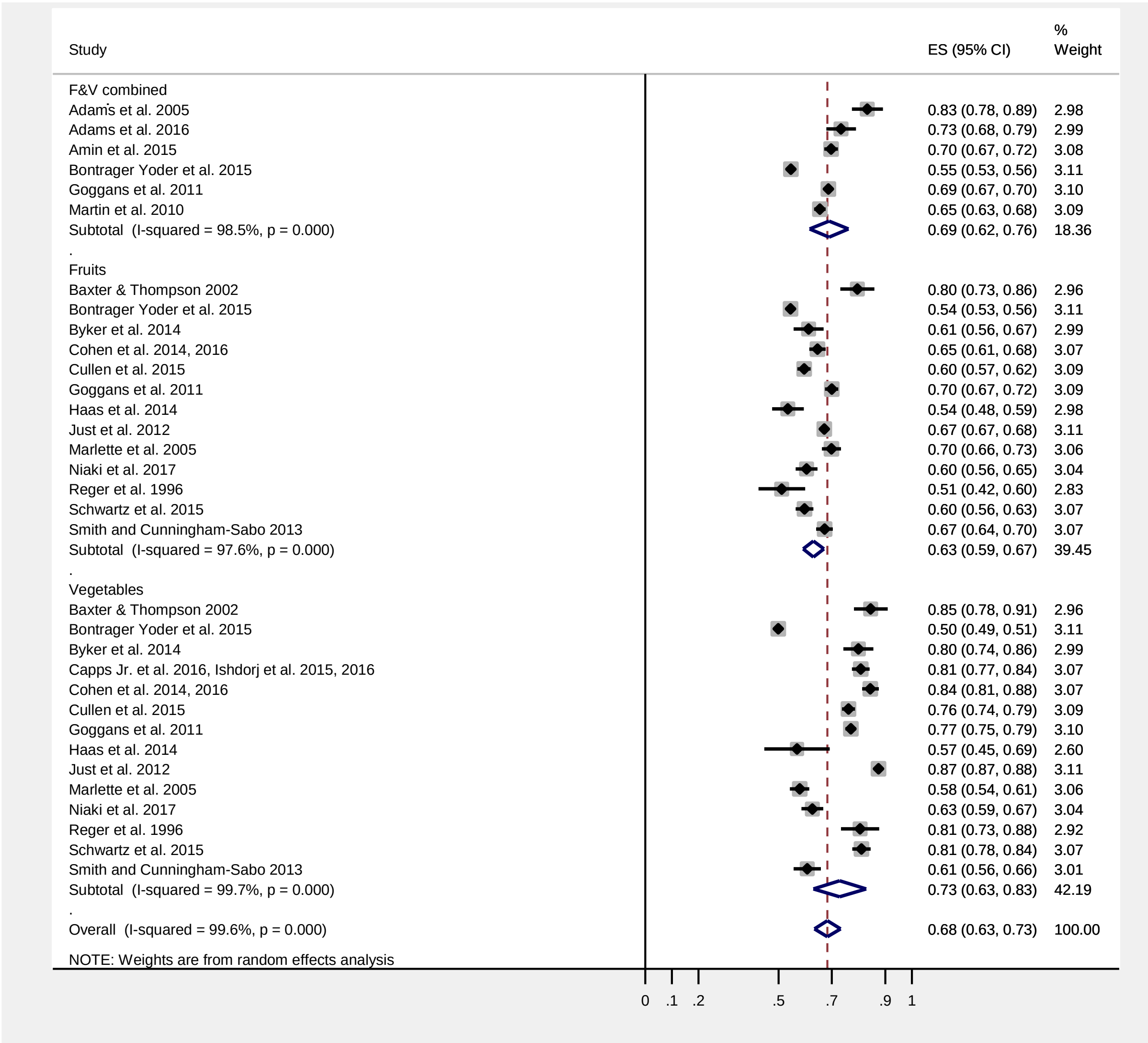

Figure 3. Forest plot of F&V waste ES

Seven studies quantified the change in consumption/waste due to the change in regulation and reported conflicting results. In one hand, evidence of a significantly increased mean waste post-implementation was found by Amin et al. (2015) for F&V combined, Capps Jr. et al. (2016) for vegetables, and Just and Price (2013) for fruits or vegetables. On the other hand, three studies reported consistent positive changes in selection and consumption and its implication in waste. Cohen et al. (2014) and Schwartz et al. (2015) found a significant increase in mean percentage consumed of vegetables and no change in fruit consumption. According to their analysis, since selection of fruits increased and consumption remained unchanged; and selection of vegetables remained unchanged but consumption increased, both studies concluded that waste did not increase. Cullen et al. (2015) in their intervention study to partially implement the new standards found that elementary school students selected and consumed more vegetables whereas intermediate school students had an increased selection and consumption of both fruits and vegetables; however, F&V waste was greater due to an increase in quantity of food selected. Finally, Bontrager Yoder et al. (2015) reported that change in waste was not significant for fruits ($p=0.87$) and for vegetables ($p=0.35$) for the population being studied (elementary schools participating in *Farm to School Program*).

When all studies were pooled for meta-analysis and the effect size was calculated using the *arcsine* transformation, we did not find any difference either in fruit or vegetable waste for results obtained pre- and post-implementation. From results in Figure 4, mean % waste of fruit was estimated to be 35.7% pre-implementation (95% CI: 30.0%-40.5%) and 39.5% post-implementation (95% CI: 23.0%-56.4%); and from results in Figure 5, mean % waste of vegetables was estimated in 45.5% before (95% CI:

37.6%-53.5%), and 50.5% after the change (95% CI: 33.8%-67.1%). In both food groups, variation of effect size and waste was greater after the change. I-squared measure of heterogeneity showed the variation in ES was attributable to significant intra-group heterogeneity (more than 97.6% for both groups and the two periods of time). Meta-analysis of the effect size of the seven pre- and post-implementation studies could not be performed due to missing information of standard deviation or p-value for some of them.

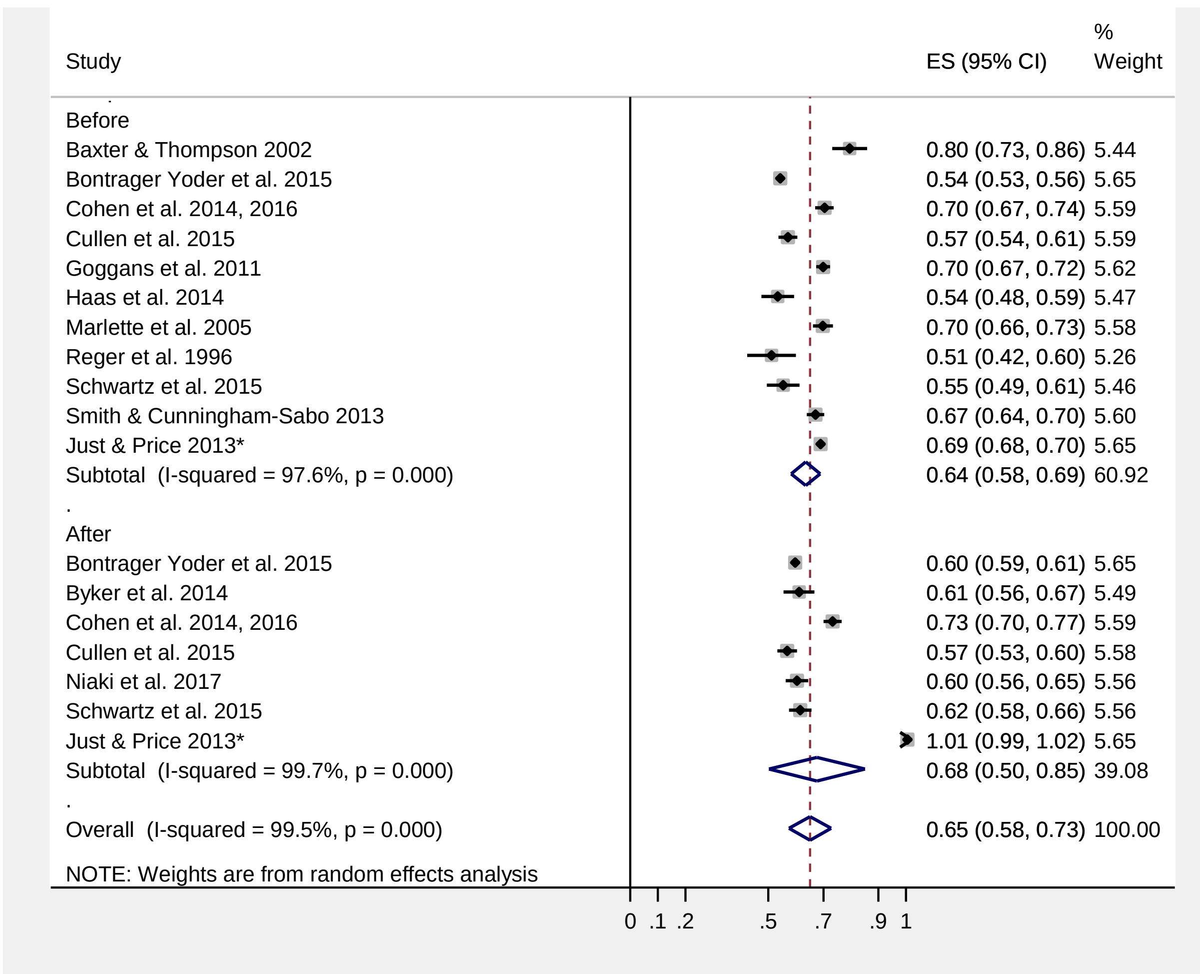

Figure 4. Forest plot of fruit mean waste effect size, pre- and post-implementation of HHFKA-2010

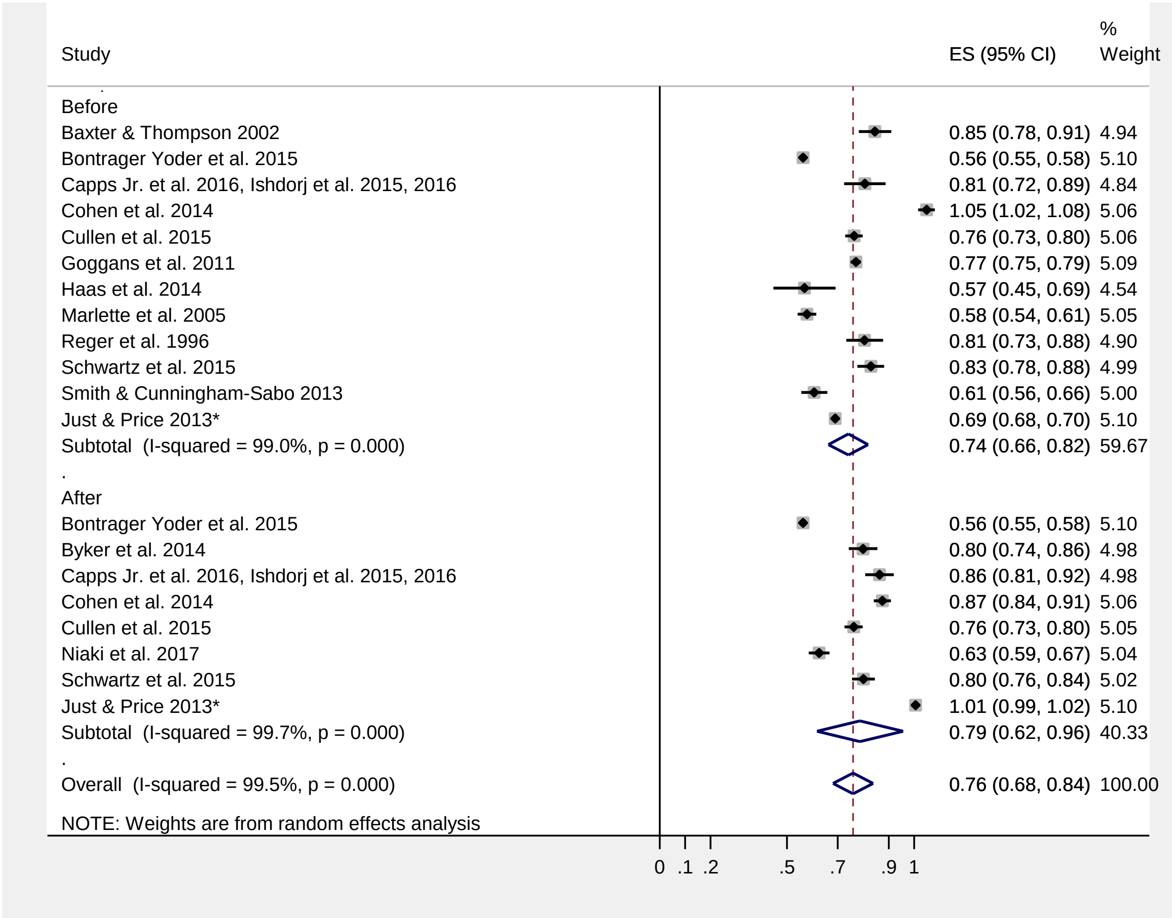

Figure 5. Forest plot of vegetable mean waste effect size, pre- and post-implementation of HHFKA-2010

Finally, five linear models were estimated using meta-regression analysis to establish the consequence of having the opportunity to choose whether or not to place fruits and vegetables on the tray on the Effect Size (ES) of waste, when controlling for type of food (fruit or vegetable) and two possible sources of heterogeneity: method of data collection and category of school. Visual and photography methods were compared to the weighing method. Middle, high and the mixes of elementary and middle school students were compared to the elementary school students. Dummy variables for the category of schools were considered as the better proxy available for age since most studies report overall outcomes for grouped courses. Two approximations for mandatory selection of fruits and vegetables were used. The first one was a dummy variable taking value 0 for studies were placing fruits and vegetables are not required for all study groups, and value 1 when selection was mandatory for at least one study group. The second one was the proportion of students in the study having the opportunity to voluntarily place fruit and/or vegetables on their tray. Results are shown in Table 3.

Table 3. Meta-regression analysis of F&V waste ES

	Model 1	Model 2	Model 3	Model 4	Model 5
Dependent variable	ES	ES	ES	ES	ES
Number of observations	27	27	27	27	27
Independent variables					
Constant	0.6006*** (0.0309)	0.6674*** (0.0356)	0.6827*** (0.0406)	0.6656*** (0.0557)	0.6820*** (0.0427)
Vegetable (0=fruit, 1=vegetable)	0.0965** (0.0379)	0.0972** (0.0388)	0.0941** (0.0356)	0.0937** (0.0364)	0.0942** (0.0365)
Mandatory (0=selection allowed, 1=mandatory to place F/V in the tray)	0.0776* (0.0385)			0.0232 (0.0504)	
Optional (proportion of students having the option whether to place F/V in the tray or not)		-0.0739 (0.0443)			0.0055 (0.0674)
Visual method (1=visual, 0=otherwise)			-0.0172 (0.0423)	-0.0181 (0.0432)	-0.0169 (0.0436)
Photograph method (1=photog, 0=otherwise)			-0.1467** (0.0546)	-0.1344** (0.0618)	-0.1486** (0.0612)
EUM (1=elementary and middle school students, 0=otherwise)			-0.0063 (0.0387)	0.0040 (0.0456)	-0.0091 (0.0518)
Middle (1=middle school students only, 0=otherwise)			0.0554 (0.0809)	0.0604 (0.0834)	0.0526 (0.0896)
High (1=high school students only, 0=otherwise)			-0.0269 (0.0865)	-0.0220 (0.0888)	-0.0299 (0.0947)
Regression tests					
REML estimate of between-study variance tau2	0.0091	0.0096	0.0079	0.0083	0.0084
% residual variation due to heterogeneity I2_res	0.9885	0.9915	0.9856	0.9859	0.9863
Joint test for all covariates F test	5.56**	4.75**	3.29**	2.74**	2.68**

Reporting coefficient and SD in parenthesis. * Significance level at 10%, ** Significance level at 5%, *** Significance level 1%

The constant is highly significant in all models, meaning that the default level of waste is an important component to explain the reported results in literature. This default waste was estimated to be between 32% and 40% for fruits, consistent with the results reported in Figure 3. Vegetables had a significantly increased effect size (between 0.094 and 0.097) meaning that default percentage waste of vegetables is significantly higher than percentage waste of fruits and around of 0.9%. Since this significantly a little higher waste of vegetables found from meta-regression analysis is very small, this result is not inconsistent with the previous one in Figure 3.

The variable of interest for this analysis, mandatory/optional selection of fruits and vegetables, was significant at 10% only in the first model when we did not control for method of data collection and category of school. For all other estimated models, it was not significant. These results do not support the general idea that the Offer *vs.* Served provision and other school policies that allow voluntary selection of F&V reduce mean percentage waste, and the findings in Goggans, Lambert, and Chang (2011); Just and Price (2013); and Amin et al. (2015). A possible explanation for this counter-intuitive result could be that reported factors like preferences, variety, restriction of competitive foods, and time devoted to eating are more related to waste than this kind of policy. This result seems to be consistent with an official policy analysis report from USDA-ERS. Newman (2013) compared the absolute mean consumption of F&V (cups) in schools in 2005 that already met the 2012 weekly and daily standards for F&V *vs*. schools that did not meet the new standards requirements, using nationally representative data from SNDA-III. Regression analysis results showed that Offer *vs.* Serve availability did not have any significant effect on the amount of fruit or vegetables consumed. From all her results, she found evidence supporting the hypothesis that "once a student is willing to eat some of a vegetable, he or she is willing to eat more, if it is generally offered". This gives us an insight on consumption (and possibly waste) could be more related to preferences, variety or familiarity, among other factors.

We could not find evidence of the effect of age since variable of school type was not significant in any of the estimated models. It could be due to the wide range in each category which masks the small marginal effect of each grade on ES if exists. Finally, this analysis found that there is a significantly less waste reported when using the digital photography method than when using the weighing method, but in a small magnitude ranging from 1.8% to 2.2%.

3.4 Factors related to F&V selection and waste

Child-related factors, such as age, gender, race/ethnicity, and preferences were used in most of the selected studies. Age/grade and gender were the most discussed explanatory variables for plate waste. However, studies on the relation between these factors and waste reported conflicting results.

Ten studies reported any type of relation between grade and consumption/waste. Three studies conducted in elementary schools found that younger children wasted significantly more F&V than older children (Cashman et al. 2010, Just and Price 2013, Niaki et al. 2017). One study, also in elementary schools, showed that older students wasted more F&V than the younger children (Reger et al. 1996), and two studies reported inconclusive results (Bontrager Yoder et al. 2015, Capps Jr. et al. 2016).

Adams et al. (2016) and Haas et al. (2014) who studied middle and high school students found no significant differences in waste related to grade. For two studies, in a wider range of grades, the pattern of waste by grade was not clear. Smith and Cunningham-Sabo (2013) found that younger children wasted more F&V in elementary schools, but waste of fruits by grade is not significant in middle schools, and waste of vegetables was non-conclusive in middle schools. Handforth et al. (2016) found that high school students wasted less fruit than middle and elementary school students, but difference in waste was not significant for vegetables. Meta-regression results showed a no significant relationship between ES of waste and grade (Table 3).

Eight studies reported a relationship between gender and consumption/waste of F&V. Two studies, one for middle school and other for grades one through twelve, did not find any significant differences in waste with respect to gender (Adams et al. 2016; Handforth et al. 2016). Gase et al. (2014) found that middle school girls wasted significantly less F&V than boys. In contrast, four studies found that boys wasted less compared to girls (Reger 1996, Cashman et al. 2010, Just and Price 2013, Smith and Cunningham-Sabo 2013). Finally, Haas et al. (2014) found mixed results for high school students, girls waste significantly more fruits than boys, but waste was not significantly different for vegetables.

The discussion is still open on race/ethnicity as possible factors related to F&V selection, consumption, and waste due to familiarity with specific type of food. Two studies conducted in middle schools found no differences in F&V selection and consumption with respect to race (Gase et al. 2014, Adams et al. 2016) whereas one study in elementary schools showed that Caucasian students wasted significantly less F&V than Hispanic students.

Preferences and attitudes were less considered factors among selected studies. Baxter and Thompson (2002) found that preferences for F&V among elementary school children were significantly related to students' consumption, and Haas et al. (2014) found that high school students prefer good taste over nutritional content, being "dislike the taste of food" the main reason for throwing the food away.

Based on the literature, food/food service-related factors can play an important role on F&V selection, consumption, and waste. Most notable and compelling results show that variety of items offered (Adams 2005, Just et al. 2012), preparation methods (Marlette et al. 2005, Bontrager Yoder et al. 2015, Handforth et al. 2016), presentation and subgroup of food (Bontrager Yoder et al. 2015, Handforth et al. 2016), entrée/vegetable pairings (Ishdorj et al. 2015), and location of the salad bar (Adams 2005, Bontrager Yoder et al. 2015, Adams et al. 2016) can significantly affect children's decisions in the lunchroom. In general, a greater number of items offered can increase the probability of F&V selection and consumption, with no effect on mean waste. Cooked vegetables and whole fruits were wasted the most. Potato products were likely to compete with other vegetable options since they had the highest acceptance rate among the vegetable options in majority of the studies selected. Pairing entrée/vegetable has an important effect in overall plate waste. Ishdorj et al. (2015) found that pairing the most popular entrées with the most popular vegetables yielded a lower plate waste, whereas pairing the most popular entrées with the less popular vegetables results in very high waste of vegetables. The authors also found that most of the pairings with the least overall plate waste involved white potato products. Lastly, salad bars inside the serving line were more likely to increase consumption and reduce waste.

Besides the mandatory/optional selection of F&V, which was included as one of the controls in meta-analysis, some of the most important school-related factors, associated with consumption/waste discussed in the literature, were the availability of competitive foods (Cullen and Zakeri 2004, Marlette et al. 2005), and time devoted to eating (Cohen et al. 2016). Both studies on access to competitive food (snacks, sweetened beverages, sweets) found that consumption of school provided meals declined and waste increased for students exposed to competitive foods. The study on the effect of lunchtime on waste found that consumption of vegetables was significantly lower when time allocated to eat lunch was reduced from at least 25 minutes (reference time) to 20-24 minutes, and significantly lower vegetable consumption was reported when time allocated for eating lunch was reduced to less than 20 minutes.

Finally, Free and Reduced Price (FRP) rate was considered as one of the explanatory variable in evaluating consumption and waste. Three studies reported results on the effects of this variable on waste. Just and Price (2013) found that FRP price rate had a significant effect on the probability of eating one serving of fruits or vegetables, but no significant effect on servings wasted. Adams et al. (2016) found no significant effect of FRP rate on consumption; and Capps Jr. et al. (2016) did not have conclusive results.

CHAPTER IV

DISCUSSION

"How much food children waste during school meals?" is an important question that has remained unanswered for almost fifteen years. The present study contributes to compile, review and synthesize the results of peer-reviewed publications on F&V waste in the NSLP since 1990 to estimate an overall amount of waste, and partially answer to this query. In our better understanding, this is the first meta-analysis on this topic.

Widely accepted methodological guidelines for search, documenting, assessment and reporting were used for this systematic review and meta-analysis. It was possible to identify two outcomes directly related to the question in this study: (1) percentage of students selecting fruits or vegetables, and (2) mean percentage waste of fruits or vegetables (or both), and fulfill an analysis with moderate to strong conclusions.

Using the USDA Nutrition Evidence Library Conclusion Statement Evaluation Criteria[7], a standard of judgment for the strength of the body of evidence in systematic reviews, we found that most criteria can be graded as moderate or strong. We found several good quality studies carried out by independent researchers that analyzed a large number of trays, grading moderate to strong on the criteria of quantity. Although the dispersion of the outcomes and effect sizes, quantitative findings across studies are consistent when they are properly categorized and assessed using meta-regression, grading strongly in criteria of consistency. However, when the analysis focused on the factors that could explain waste, findings across studies are diverse, i.e., a factor like

[7] https://www.cnpp.usda.gov/sites/default/files/usda_nutrition_evidence_flbrary/2015DGAC-SR-Methods.pdf

grade/age is significant for some studies, not significant for others, or inconclusive. This situation makes conclusions on factors related to waste very limited. Since outcomes relate directly to the question in this review, the grade for criteria of impact is strong. Generalizability to the U.S. population of interest is restricted since the Midwest region is not represented among the included studies, grading limited to moderate. Risk of bias, the last criteria, was considered moderate because only a few studies had some minor methodological concerns. Given de aforementioned grading scores, the results of this systematic review and overall estimations in meta-analysis can be considered moderate to strong (see Appendix F).

The overall estimate of percentage of students selecting fruits was 60% (95% CI: 46%-75%), and selecting vegetables was 48% (95% CI: 31%-65%). These results are different from USDA's report on F&V consumption by school lunch participants (Newman 2013)[8]. From the report, an estimation of 44% of students selecting fruits can be done. Estimation of vegetable selection falls within a wide range depending on the type of vegetables, from 6% of the students selecting dark green vegetables[9] to 70% for other vegetables[10]. Although the official report is a good reference, the methodologies are not completely comparable. Whereas the outcome in the studies included in meta-analysis was determined by the evaluator using a quantitative method and during more than one school day, the outcome of interest from the SNDA-III was collected by a 24-

[8] That study used a subsample of 287 schools from the nationally representative SNDA-III dataset.
[9] Include bok choy, broccoli, collard greens, dark green leafy lettuce, kale, romaine lettuce, and spinach (Newman 2013).
[10] Include artichokes, asparagus, avocado, bean sprouts, beets, Brussels sprouts, cabbage, cauliflower, celery, cucumbers, eggplant, green beans, green peppers, iceberg lettuce, mushrooms, okra, onions, parsnips, turnips, wax beans, and zucchini (Newman 2013).

hour dietary recall survey of students, which means that self-reporting is determined by the ability to remember what and how much they consumed, and may not be representative of habitual behavior since a single interview was conducted[11]. The key point of this comparison is that both the official report and this study found a low (and unsatisfactory) level F&V selection that challenge food service personnel. Fortunately, pooled evidence shows that implementation of NSLP new standards had encouraging results on fruit selection. The percentage of students selecting fruits increased significantly after new standards consistently across all the studies in a range from 5% to 24%. The increase in selection observed in this analysis was due to the increase in variety and not due to the mandatory selection of fruit or vegetables under OVS. Just, Lund, and Price (2012) have discussed that the increased variety of items might increase the fraction of children eating at least one serving because of increased chances of finding one appealing item or due to the "sensory-specific satiety" phenomenon. We do not know whether the inconclusive results for vegetable selection could be due to a possible substitution of vegetables with fruits.

The overall fruit waste was estimated in 34.7% (95% CI: 31.0%-38.6%) and vegetables waste in 44.5% (95% CI: 34.7%-54.5%). A wasting level close to one-third of fruits and around one-half of the vegetables served is a disappointing and unacceptable outcome of the program that is being addressed through increasing variety in the menus and several intervention projects. In this study, we could not find statistical evidence that supports anecdotal evidence of an increased F&V waste after new NSLP

[11] USDA. 2007. School Nutrition Dietary Assessment Study—III. Volume III: Sampling and Data Collection. Report No. CN-07-SNDA-III.

standards. Mean percentage fruits waste was estimated 35.7% pre- and 39.5% post-implementation, and mean percentage waste estimated in 45.5% pre- and 50.5% post-implementation, with no significant difference between them. These findings are aligned with those in Newman (2013). She found that students who attended schools that in 2005 already met one or some of the 2012 daily standards ate more vegetables for all types of vegetables, excepting dark green vegetables, than students who attended schools that did not meet the new standards.

In summary, estimations on consumption and waste of F&V give us a worrisome picture. Overall, mean % selection is low (this study and Newman's), mean consumption is low (Newman's) and waste is high (this study). When compared HHFKA-2010 pre- and post-implementation periods, the change in policy seems to provide promising results: selection increased (this study and Newman's), consumption increased (Newman's) and waste not increased (this study). However, these results must be considered with caution since there are important differences when analyzing waste between subgroups of vegetables, especially for dark green vegetables. According to Newman (2013), the share of students who ate dark green vegetables are larger in schools that did not meet 2012 daily standards than in schools that met the new standards, but the amount consumed was greater for those who attended schools that did meet 2012 daily standards. Additionally, a preliminary ANOVA of data from selected studies for this review showed that dark green vegetables are wasted more compared to starchy vegetables. These results suggest that factors like preferences, appealing and tasting might be playing an important role in selection and consumption of vegetables.

Contrary to the motivation of OVS provision and results in Goggans, Lambert, and Chang (2011), meta-regression analysis showed that mandatory/optional selection of F&V was no effect on waste. This result is consistent with Newman (2013) who found that Offer *vs.* Serve availability did not have any significant effect on the amount of fruit or vegetables consumed. The relation between voluntary selection, consumption or waste, and the salad bar use is still inconclusive in the literature. A review of the effectiveness of school salad bars did not found evidence that supports any possible relationship between those factors and claimed some efforts to produce more and better-quality research on salad bars (Adams, Bruening and Ohri-Vachaspati 2015).

Meta-regression analysis provided evidence that the ES of F&V waste is significantly less when using the digital photography method than when using the weighing method. However, when calculated as % waste, the underestimation by the digital photography method is only around 1.8% to 2.2%. Since these results were obtained from regular diet trays, and for standardized unpackaged food, they are consistent with some publications that found a good degree of reliability and accuracy of the digital photography method (Williamson et al. 2003; Hanks, Wansink, and Just 2014; Navarro et al. 2014; Taylor, Yon, and Johnson 2014).

Finally, we could not find evidence supporting links between traditionally accepted factors such as age and gender, and waste. Meta-regression results showed a non-significant relationship between ES of waste and grade. Since not all of the studies reported waste by gender, we could not incorporate this variable in the analysis. Similarly, only a few studies on plate waste explored the relationship between preferences or attitudes and F&V waste, then we could not establish any other relation beyond the description in the original study. Simultaneously, food service-related factors (such as preparation methods, availability of competitive food, and time devoted to eating) seem to have an important role on school food waste. Unfortunately, we could not incorporate these factors in the quantitative analysis.

This study has some limitations. First, PW analysis was focused on F&V. Although this priority is justified since researchers and policy-makers have targeted F&V for several reasons, an overall estimation of plate waste is more appropriate when analyzing implications on nutrition, cost and cafeteria operations.

Second, this study is limited to observational studies whose main objective was quantification and excluded intervention studies. Several intervention studies detail a baseline that might be included to increase the body of evidence and strength this analysis. Additionally, our results from comparison waste before and after HHFKA-2010 implementation through the new NSLP standards were obtained from the pooled set of studies and not exclusively from the seven studies that evaluated effect pre- and post- implementation. Meta-analysis of these seven studies could not be performed due to missing information of standard deviation or p-value in some of them. Improving quality of reporting can contribute to drawing some general conclusions by better usage of meta-analysis techniques.

Third, discussion of factors associated with PW waste is limited to selected studies, and as we discussed previously, the wide variety of findings across studies makes the conclusions very limited.

CHAPTER V

CONCLUSION AND IMPLICATIONS

A low percentage of F&V selection and a high mean percentage waste are worrisome outcomes that defy to school food service directors and scientists to find best ways to improve eating behaviors. Although this issue is being addressed by the new NSPL requirements for reimbursable meals[12] and the increased variety that schools must offer, monitoring the quality of items served, menu options, menu cycle, time spent in line, and preparation methods could be an important way to improve the relationship between acceptance and cafeteria operations.

Minimizing plate waste and improving nutrient intake through school interventions has been a topic of intensive research as evidenced by the growing body of literature. Identifying, implementing and evaluating cost-effective single and multicomponent interventions to improve F&V consumption can contribute to maximizing the ratio between nutrition and costs, and it is a promising research area for policy improvement. Further research on the effects of preferences, pairing entrée-vegetable, time allowed for eating lunch, tailoring portion sizes to age of students, restriction of alternative foods (or making them more healthful) on waste will be useful to understand children's decisions and behaviors in the cafeteria. Acceptance and consumption of dark green appears to be one of the challenging aspects of the new regulation, and this type of vegetables could be a focus of future interventions.

[12] Under OVS, students must be allowed to decline components, except for the required ½ cup serving of fruit and/or vegetable. https://www.fns.usda.gov/sites/default/files/cn/SP41_2015a.pdf

We found gaps in the literature for both the geographic regions the studies were conducted and type of schools. Existing F&V waste studies were mostly focused on elementary schools and there is limited information in regards to plate waste in middle and high schools. Collection of consumption and waste data at the school level is very costly. Future plate waste studies with more standardized data collection and reporting methods will allow the aggregation of these studies to the nationally representative level. Lastly, since operational costs are the main concern for policy executers, it could be useful to document also the production waste (food prepared and left over after service). Only one study reported production waste (Gase et al. 2014) and by improving the understanding of waste in the cafeteria, researchers can inform and propose better solution for food service directors and policy-makers.

The change in NSLP standards has had a positive effect in increasing the number students selecting fruits. We could not draw any conclusions on the change in percentage of students selecting vegetables. Further research is needed on a possible substitution between F&V under the new OVS provision requirements. The positive effects of the new regulation on improving school nutrition programs have been welcomed by several stakeholders (Hager and Turner 2016, Thiagarajah et al. 2015), which pave the way for proposing, executing and evaluating alternatives to continue meeting target nutritional goals at lower costs.

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APPENDIX A

DOCUMENTATION OF SEARCHING PROTOCOL AND RESULTS

The following searching protocol was performed and documented by Associate Professor Margaret Foster, Systematic Reviews Coordinator, at Texas A&M University Library.

Table A-1. Summary of retrieved articles

Databases	retrieved	dups	Newly added
Medline	356	9	347
CAB	64	27	37
AGRIS	31	1	30
Agricola	18	10	8
ERIC	14	1	13
CINAHL	118	98	20
Totals	601	146	455

Medline OVID
Feb 21 2017, 356 articles retrieved moved to Rayyan, 347 new articles

1. exp "vegetables"/ or vegetable*.ti,ab. or exp "fruit"/ or fruit*.ti,ab.
2. exp "Food Services"/ or (food adj1 service*).ti,ab. or (lunch* adj2 program*).ti,ab.
3. exp "Nutrition Surveys"/ or exp "Feeding Behavior"/ or exp "Food Preferences"/ or exp Eating/ or exp "Energy Intake"/ or waste*.ti,ab. or ((diet* or nutrition*) adj1 survey*).ti,ab. or ((food or feed*) adj1 (behav* or preference*)).ti,ab.
4. exp child/ or exp adolescent/ or exp "Schools"/ or (child* or adolescen* or teen* or kindergarten* or schoolchild*).ti,ab. or (grades 1 or grades 2 or grades 3 or grades 4 or grades 5 or grades 6 or grades 7 or grades 8 or grades 9 or grades 10 or grades 11 or grades 12).ti,ab. or (grade* adj1 (1st or 2nd or 3rd or 4th or 5th or 6th or 7th or 8th or 9th or 10th or 11th or 12th or first or second or third or fourth or fifth or sixth or seventh or eighth or ninth or tenth or eleventh or twelfth)).ti,ab.

5. and/1-4
6. limit 5 to (english language and yr="1990 -Current")

CAB Abstracts (OVID)
Feb 21 2017, 64 articles retrieved, removed duplicates, moved 37 new articles to Rayyan

1. exp vegetables/ or vegetable*.ti,ab. or "vegetables".sh. or exp fruit/ or fruit*.ti,ab. or "fruits".sh.
2. "school lunches".sh. or (food adj1 service*).ti,ab. or (lunch* adj2 program*).ti,ab. or school food service.sh. or exp school lunches/ or exp school food service/
3. exp nutrition surveys/ or feeding behaviour.sh. or exp food preferences/ or exp eating/ or exp energy intake/ or waste*.ti,ab. or ((diet* or nutrition*) adj1 survey*).ti,ab. or ((food or feed*) adj1 (behav* or preference*)).ti,ab.
4. ("school children" or "children").sh. or (child* or adolescen* or teen* or kindergarten* or schoolchild*).ti,ab. or (grades 1 or grades 2 or grades 3 or grades 4 or grades 5 or grades 6 or grades 7 or grades 8 or grades 9 or grades 10 or grades 11 or grades 12).ti,ab. or (grade* adj1 (1st or 2nd or 3rd or 4th or 5th or 6th or 7th or 8th or 9th or 10th or 11th or 12th or first or second or third or fourth or fifth or sixth or seventh or eighth or ninth or tenth or eleventh or twelfth)).ti,ab. or exp schools/ or exp high schools/ or exp elementary schools/ or exp nursery schools/ or exp public schools/
5. and/1-4
6. limit 5 to (english language and yr="1990 -Current")

AGRIS (OVID)
Feb 21, 2017, 31 articles retrieved, removed ups, moved 30 new articles to Rayyan

1. (child* or adolescen* or teen* or kindergarten* or schoolchild* or (grades 1 or grades 2 or grades 3 or grades 4 or grades 5 or grades 6 or grades 7 or grades 8 or grades 9 or grades 10 or grades 11 or grades 12) or (grade* adj1 (1st or 2nd or 3rd or 4th or 5th or 6th or 7th or 8th or 9th or 10th or 11th or 12th or first or second or third or fourth or fifth or sixth or seventh or eighth or ninth or tenth or eleventh or twelfth))).ti,ab. or exp SCHOOL CHILDREN/ or "elementary students".ie. or "elementary schools".ie.
2. "vegetable consumption".ie. or exp FRUITS/ or exp VEGETABLES/ or (vegetable* or fruit*).ti,ab. or (school adj1 lunch*).ti,ab.
3. ((food adj1 service*) or (lunch* adj2 program*)).ti,ab. or "National School Lunch Program".ie. or exp FOOD SERVICE/
4. exp NUTRITION SURVEYS/ or "plate waste".ie. or (waste* or ((diet* or nutrition*) adj1 survey*) or ((food or feed*) adj1 (behav* or preference*))).ti,ab. or exp NUTRIENT INTAKE/ or exp FEEDING PREFERENCES/
5. and/1-4
6. limit 5 to (english language and yr="1990 -Current")

Agricola (Ebsco)

18 retrieved, 8 uploaded to Rayyan
(((ZU "fruits") or (ZU "fruits (food)")) or ((ZU "vegetables")) OR TI (vegetable* or fruit*) OR AB (vegetable* or fruit*)) AND ((((((ZU "school children") or (ZU "school children (6 to 11 years)") or (ZU "school children (6-11 years)") or (ZU "school children (6-12)") or (ZU "school children 6 11 years") or (ZU "school children 6-11 years")) or ((ZU "elementary schools"))) or ((ZU "middle schools"))) or ((ZU "high schools"))) OR (OR TI ((child* or adolescen* or teen* or kindergarten* or schoolchild* or (grades 1 or grades 2 or grades 3 or grades 4 or grades 5 or grades 6 or grades 7 or grades 8 or grades 9 or grades 10 or grades 11 or grades 12) or (grade* n1 (1st or 2nd or 3rd or 4th or 5th or 6th or 7th or 8th or 9th or 10th or 11th or 12th or first or second or third or fourth or fifth or sixth or seventh or eighth or ninth or tenth or eleventh or twelfth)))) OR AB ((child* or adolescen* or teen* or kindergarten* or schoolchild* or (grades 1 or grades 2 or grades 3 or grades 4 or grades 5 or grades 6 or grades 7 or grades 8 or grades 9 or grades 10 or grades 11 or grades 12) or (grade* n1 (1st or 2nd or 3rd or 4th or 5th or 6th or 7th or 8th or 9th or 10th or 11th or 12th or first or second or third or fourth or fifth or sixth or seventh or eighth or ninth or tenth or eleventh or twelfth)))))) AND (((ZU "school lunch") or (ZU "school lunch program") or (ZU "school lunch program (u.s.)") or (ZU "school lunch programs") or (ZU "school lunches") or (ZU "school lunchrooms, cafeterias, etc")) OR (TI ((school n1 lunch*) or ((food n1 service*) or (lunch* n2 program*))) OR AB ((school n1 lunch*) or ((food n1 service*) or (lunch* n2 program*))))) AND (((((ZU "food preferences")) or ((ZU "nutrition surveys"))) or ((ZU "energy intake"))) OR (TI ((waste* or ((diet* or nutrition*) n1 survey*) or ((food or feed*) n1 (behav* or preference*)))) OR AB ((waste* or ((diet* or nutrition*) n1 survey*) or ((food or feed*) n1 (behav* or preference*))))))

ERIC (Ebsco)
14 retrieved, 13 new articles
(DE "Food Service" OR (TI ((school n1 lunch*) or ((food n1 service*) or (lunch* n2 program*))) OR AB ((school n1 lunch*) or ((food n1 service*) or (lunch* n2 program*)))) AND (TI ((waste* or ((diet* or nutrition*) n1 survey*) or ((food or feed*) n1 (behav* or preference*)))) OR AB ((waste* or ((diet* or nutrition*) n1 survey*) or ((food or feed*) n1 (behav* or preference*)))) AND (TI (vegetable* or fruit*) OR AB (vegetable* or fruit*)) AND (TI ((child* or adolescen* or teen* or kindergarten* or schoolchild* or (grades 1 or grades 2 or grades 3 or grades 4 or grades 5 or grades 6 or grades 7 or grades 8 or grades 9 or grades 10 or grades 11 or grades 12) or (grade* n1 (1st or 2nd or 3rd or 4th or 5th or 6th or 7th or 8th or 9th or 10th or 11th or 12th or first or second or third or fourth or fifth or sixth or seventh or eighth or ninth or tenth or eleventh or twelfth)))) OR AB ((child* or adolescen* or teen* or kindergarten* or schoolchild* or (grades 1 or grades 2 or grades 3 or grades 4 or grades 5 or grades 6 or grades 7 or grades 8 or grades 9 or grades 10 or grades 11 or grades 12) or (grade* n1 (1st or 2nd or 3rd or 4th or 5th or 6th or 7th or 8th or 9th or 10th or 11th or 12th or first or second or third or fourth or fifth or sixth or seventh or eighth or ninth or tenth or eleventh or twelfth))))

CINAHL (Ebsco)

118 retrieved, 20 new articles
((MH "Vegetables+") OR (MH "Fruit+")) OR TI (vegetable* or fruit*) OR AB (vegetable* or fruit*) AND ((MH "Schools, Middle") OR (MH "Students, High School") OR (MH "Schools, Secondary") OR (MH "Schools, Elementary")) OR TI ((child* or adolescen* or teen* or kindergarten* or schoolchild* or (grades 1 or grades 2 or grades 3 or grades 4 or grades 5 or grades 6 or grades 7 or grades 8 or grades 9 or grades 10 or grades 11 or grades 12) or (grade* n1 (1st or 2nd or 3rd or 4th or 5th or 6th or 7th or 8th or 9th or 10th or 11th or 12th or first or second or third or fourth or fifth or sixth or seventh or eighth or ninth or tenth or eleventh or twelfth)))) OR AB ((child* or adolescen* or teen* or kindergarten* or schoolchild* or (grades 1 or grades 2 or grades 3 or grades 4 or grades 5 or grades 6 or grades 7 or grades 8 or grades 9 or grades 10 or grades 11 or grades 12) or (grade* n1 (1st or 2nd or 3rd or 4th or 5th or 6th or 7th or 8th or 9th or 10th or 11th or 12th or first or second or third or fourth or fifth or sixth or seventh or eighth or ninth or tenth or eleventh or twelfth)))) AND (MH "Food Services+") OR TI ((school n1 lunch*) or ((food n1 service*) or (lunch* n2 program*))) OR AB ((school n1 lunch*) or ((food n1 service*) or (lunch* n2 program*))) AND ((MH "Food Preferences") OR (MH "Eating") OR (MH "Eating Behavior")) OR TI ((waste* or ((diet* or nutrition*) n1 survey*) or ((food or feed*) n1 (behav* or preference*)))) OR AB ((waste* or ((diet* or nutrition*) n1 survey*) or ((food or feed*) n1 (behav* or preference*)))).

APPENDIX B

QUALITY APPRAISAL OF SELECTED STUDIES

Following the USDA's Nutrition Evidence Library (NEL) Bias Assessment Tool, for observational studies the following questions apply.

Criteria	Risk of bias question	Type of bias
1	Were the inclusion/exclusion criteria similar across study groups?	Selection bias
2	Was the strategy for recruiting or allocating participants similar across study groups?	Selection bias
3	Was distribution of health status, demographics, and other critical confounding factors similar across study groups at baseline? If not, does the analysis control for baseline differences between groups?	Selection bias
4	Did the investigators account for important variations in the execution of the study from the proposed protocol or research plan?	Performance bias
5	Was adherence to the study protocols similar across study groups?	Performance bias
6	Did the investigators account for the impact of unintended/ unplanned concurrent interventions or exposures that were differentially experienced by study groups and might bias results?	Performance bias
7	Were outcome assessors blinded to the intervention or exposure status of participants?	Detection bias
8	Were valid and reliable measures used consistently across all study groups to assess inclusion/exclusion criteria, interventions/exposures, outcomes, participant health benefits and harms, and confounding?	Detection bias
9	Was the length of follow-up similar across study groups?	Attrition bias
10	In cases of high or differential loss to follow-up, was the impact assessed (e.g., through sensitivity analysis or other adjustment method)?	Attrition bias
11	Were other sources of bias taken into account in the design and/or analysis of the study (e.g., through matching, stratification, interaction terms, multivariate analysis, or other statistical adjustment such as instrumental variables)?	Attrition, detection, performance and selection bias
12	Were the statistical methods used to assess the primary outcomes adequate?	Detection bias

Source: U.S. Department of Agriculture. Center for Nutrition Policy and Promotion. 2015.

Each "Yes" response receives 0 points, each "Cannot Determine" response receives 1 point, each "No" response receives 2 points, and each "N/A" response receives 0 points.

Table B-1. Quality appraisal of selected studies

Article	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	Criteria 8	Criteria 9	Criteria 10	Criteria 11	Criteria 12	Risk of bias	Quality index
Adams et al. 2005	1	0	1	0	0	0	0	0	0	0	0	0	2	0.9166667
Adams et al. 2016	1	0	1	0	0	0	0	0	0	2	0	0	4	0.8333333
Amin et al. 2015	0	0	0	0	0	1	0	0	0	2	1	0	4	0.8333333
Baxter and Thompson 2002	1	0	1	1	1	0	0	0	1	0	0	0	5	0.7916667
Brontager Yoder et al. 2015	1	1	1	0	1	2	0	0	1	1	0	0	8	0.6666667
Byker et al. 2014	1	0	0	0	0	0	0	0	0	0	0	0	1	0.9583333
Capps Jr. et al. 2016	1	0	0	0	0	0	0	0	2	0	0	0	3	0.875
Cashman et al. 2010	1	1	0	1	1	1	0	0	0	0	0	0	5	0.7916667
Cohen et al. 2014	0	0	1	0	0	0	0	0	0	1	0	0	2	0.9166667
Cohen et al. 2016	0	1	0	0	0	0	0	0	0	1	0	0	2	0.9166667
Connors and Bednar, 2015	0	0	1	0	0	0	0	0	0	0	2	2	5	0.7916667
Cullen et al. 2004	0	0	1	1	1	0	0	0	0	2	0	0	5	0.7916667
Cullen et al. 2015	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Gase et al. 2014	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Goggans et al. 2011	0	0	1	1	1	0	0	0	0	0	1	2	6	0.75
Haas et al. 2014	0	0	1	1	1	1	0	0	0	1	2	2	9	0.625
Handforth et al. 2016	0	0	2	1	1	2	0	0	0	0	1	2	9	0.625
Ishdorj et al 2015	1	0	0	0	0	0	0	0	0	0	0	0	1	0.9583333
Ishdorj et al. 2016	1	0	0	0	0	0	0	0	0	0	0	0	1	0.9583333
Just and Price 2013. Study 1-Baseline	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Just and Price 2013. Study 2-baseline	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Just et al. 2012	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Marlette et al. 2005	0	0	0	0	1	0	0	0	2	1	0	0	4	0.8333333

Table B-1. Continued

Article	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	Criteria 8	Criteria 9	Criteria 10	Criteria 11	Criteria 12	Risk of bias	Quality index
Martin et al. 2010	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Niaki et al. 2017	0	0	0	1	0	0	2	0	0	0	0	0	3	0.875
Reger et al. 1996	0	0	0	0	0	0	0	0	0	1	0	0	1	0.9583333
Schwartz et al. 2015	0	0	0	0	0	0	0	0	0	2	0	0	2	0.9166667
Smith and Cunningham-Sabo 2013	0	0	0	0	0	0	0	0	0	0	0	0	0	1

APPENDIX C

DATA TRANSFORMATION

Effect size estimation for proportion of fruit and vegetable waste under *arcsin* transformation

P_w= Amount wasted/Amount served **(1a)**

Or

P_w= 1 - Amount consumed/Amount served **(1b)**

Or

P_w= 1- proportion consumed **(1c)**

Where P_w = overall proportion of fruit or vegetable waste per study

When more than one estimation was reported in the study, weighted average was calculated.

E_{sn} = arcsine ($\sqrt{(P_w)}$) (2)

Variance E_{sn} = 1 /4n (3)

Inverse Variance Weight = 4n (4)

Where,

E*sn* = effect size under arcsin transformation

n = total number of samples per study

Source: Thyberg, Tonjes, and Gurevitch 2015.

APPENDIX D

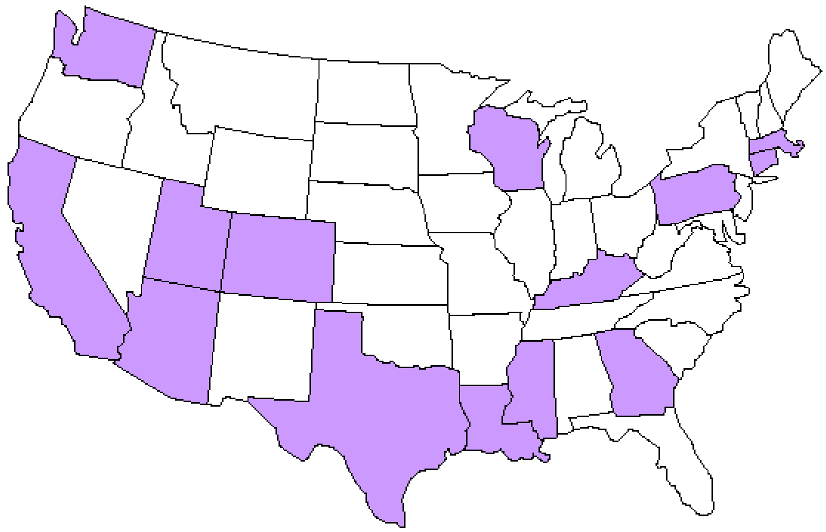
STATA COMMANDS

After importing data in STATA, the following commands were executed.

Figure 2	metaprop n N, random by(Type) lcols(Study) xlabel(0,0.25,0.5,0.75,1) texts(100)
Figure 3	metan ES SD, by(Type) random lcols(Study Meth) xlabel(0.1,0.2,0.5,0.7,0.9,1)
Figure 4	metan ES SD, by(HHFKA2010) random lcols(Study) xlabel(0.1,0.2,0.5,0.7,0.9,1) texts(140)
Figure 5	metan ES SD, by(HHFKA2010) random lcols(Study) xlabel(0.1,0.2,0.5,0.7,0.9,1) texts(140)
Table 3	metareg ES Veggie Mandatory, wsse(SD) metareg ES Veggie Optional, wsse(SD) metareg ES Veggie Visual Photog EUM Middle High, wsse(SD) metareg ES Veggie Visual Photog Mandatory EUM Middle High, wsse(SD) metareg ES Veggie Visual Photog Optional EUM Middle High, wsse(SD)

APPENDIX E

LOCATION OF F&V STUDIES



Two studies carried out in a rural county in the southwest region of the U.S. (Byker et al. 2014) and the Northeastern U.S. (Amin et al. 2015) could not be located on the graph.

Figure E-1. Graphic representation of the location of selected studies

APPENDIX F

CONCLUSION STATEMENT EVALUATION CRITERIA

Table F-1. USDA Nutrition Evidence Library Conclusion Statement Evaluation Criteria

Elements	Grade I: Strong	Grade II: Moderate	Grade III: Limited	Grade IV: Grade Not Assignable*	Rationale
Risk of bias (as determined using the NEL Bias Assessment Tool)	Studies of strong design free from design flaws, bias, and execution problems	Studies of strong design with minor methodological concerns OR only studies of weaker study design for question	Studies of weak design for answering the question OR inconclusive findings due to design flaws, bias, or execution problems	Serious design flaws, bias, or execution problems across the body of evidence	
Quantity • Number of studies • Number of subjects in studies	Several good quality studies Large number of subjects studied Studies have sufficiently large sample size for adequate statistical power	Several studies by independent investigators Doubts about adequacy of sample size to avoid Type I and Type II error	Limited number of studies Low number of subjects studied and/or inadequate sample size within studies	Available studies do not directly answer the question OR no studies available	
Consistency of findings across studies	Findings generally consistent in direction and size of effect or degree of association, and statistical significance with very minor exceptions	Some inconsistency in results across studies in direction and size of effect, degree of association, or statistical significance	Unexplained inconsistency among results from different studies	Independent variables and/or outcomes are too disparate to synthesize OR single small study unconfirmed by other studies	
Impact • Directness of studied outcomes • Magnitude of effect	Studied outcome relates directly to the question Size of effect is clinically meaningful	Some study outcomes relate to the question indirectly Some doubt about the clinical significance of the effect	Most studied outcomes relate to the question indirectly Size of effect is small or lacks clinical significance	Studied outcomes relate to the question indirectly Size of effect cannot be determined	
Generalizability to the U.S. population of interest	Studied population, intervention and outcomes are free from serious doubts about generalizability	Minor doubts about generalizability	Serious doubts about generalizability due to narrow or different study population, intervention or outcomes studied	Highly unlikely that the studied population, intervention AND/OR outcomes are generalizable to the population of interest	

*Standard conclusion statement is used to communicate that there is either insufficient evidence or no evidence available to answer the question.

Source: U.S. Department of Agriculture. Center for Nutrition Policy and Promotion. 2015.