Food Choice and Sodium Intake in the American Diet

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Abstract

Food consumption has significant impact on sodium intake, with which overconsumption will result in negative healthy impact on individuals. Using National Health and Nutrition Examination Survey (NHANES) 1999-2010 and regression analyses, we examined the effect of consumption of various food groups on the sodium intake of American adults (19 years of age or older) and changes in the impacts of various food consumption on sodium intake over the study period. The impact of respondents' demographics are also considered. Results demonstrate that per calorie consumption of oils, fruits, fruit juices, fruit products, sugars and sweets, deep-yellow vegetables and beverages and water have no significant impact on individuals' sodium intake. Milk and milk products and cakes contain less sodium per calorie, while fish, tomatoes, other types of meat products, dark-green vegetables, crackers and cheese contain higher sodium per calorie. The contribution of almost half of the food groups to individuals' sodium intake remain unchanged over years.

1. Introduction

Excessive sodium consumption is generally accepted to contribute to some diseases such as hypertension (Cassels, 2008), heart disease, stroke, and kidney disease (USDA and HHS 2010). Based on the 2010 Dietary Guidelines for Americans, adults in general should not take more than 2,300 milligrams (mg) sodium per day, and some specific groups of people (51 years of age or older, African American, high blood pressure, diabetes or chronic kidney disease) should restrict sodium intake to less than 1,500 mg per day (USDA and HHS 2010). However, according to data from the National Health and Nutrition Examination Survey (NHANES) from 2003-2008, the mean sodium intake in a 24-hour period for American adults older than 20 years is 3,371 mg. About 99 percent of adults consume more than 1,500 mg per day and 90.7 percent consume more than 2,300 mg per day (Cogswell et al. 2012). A report by the Institute of Medicine (IOM) concludes, "Analysts estimate that population-wide reductions in sodium could prevent more than 100,000 deaths annually" (IOM 2010). To reduce the negative impact of sodium over-intake on public health, the U.S. Food and Drug Administration (FDA) has taken several actions. This includes mandatorily requiring sodium as a nutrient listed on nutrition label, setting standards for the health claim such as "low sodium" or "reduced sodium" on food label, and even planning to limit the amount of sodium in processed food (FDA 2010, Layton, 2010, Jalonick 2014).

As many other nutrients, sodium is not directly consumable as regular food. Its intake is determined by the consumption of different types of food, or individual diet. A good dietary practice and routine exercise will provide an appropriate level of calories, energy, sodium and saturated fat, therefore improving individual health (USDA and HHS, 2010). However, Lin et al. (2013) suggest that a simple reduction of calorie consumption sometimes increases sodium intake. Therefore, instead of relying on personal effort, sodium reduction by governmental regulation on a population base may be more effective (Norat et al. 2008, Temple 2011).

The FDA has considered policies to limit the amount of sodium in process food (FDA 2013). Research seems support the new FDA regulation because limiting the amount of sodium in food does not decrease of individuals' food consumption. Food with relatively lower sodium but with unchanged perceived salt intensity is still acceptable (Adams et al. 1995, Dötsch et al. 2009). The critical questions related to the FDA regulation on reducing sodium content on process food or in the future on an extended range of food are: do some food groups contribute more to individuals' sodium intake in the American diet; are there any trend or patterns in the importance of different food groups to sodium intake over the years? Answering these questions is important for future policy and regulation development as well as for promoting more effective sodium reduction guidelines by focusing on the food groups that contribute the most to sodium intake in the American diet.

Most previous studies on the source of nutrition implemented methods by ranking the percentages or means of nutrition intake from food groups (Batcher and Nichols 1984, Subar et al. 1998a, Subar et al. 1998b, Cotton et al. 2004, Stroehla et al., 2005, Fox et al. 2006, Hoy et al. 2011, O'Neil et al. 2012, Keast et al. 2013, NCI 2013). Although ranking validly presents means sodium source from various foods in people's diet, it does not clearly demonstrate the relationship between individuals' sodium intake and food consumption. A few studies have investigated the effect of food consumption on sodium intake. Fox et al. (2006)

suggest that the main source of sodium for toddlers between 12 months and 24 months is other food group, which includes salad dressings/mayonnaise, gravies/sauces, butter/oil/ margarine/other fat, condiments, chips/other salty snacks, consommé/broth/bouillon, other foods and other beverages. Subar et al. (1998b) report that the main sodium intake source for American adults is also other food groups, which includes alcoholic beverages, coffee, tea, consommé/broth/ bouillon, condiments/other sauces/artificial sweeteners, meal replacements/ protein supplements, potato chip/corn chips/popcorn and other foods. However, since the "other food group" contains a mix of various foods, it is difficult to confirm which food group contributes the most to sodium intake. O'Neil et al. (2012) and Keast et al. (2013) separate salt from other food groups as an ingredient in home-prepared and restaurant-prepared food, and suggest that salt is the primary source of sodium. Using the NHANES 2005-06 data, NCI (2013) reports that the food groups with both the highest mean sodium intake and the highest percentage sodium contribution are basically identical, including yeast breads, chicken and chicken mixed dishes, pizza, pasta and pasta dishes, cold cuts, condiments and Mexican mixed dishes. In addition, Lin et al. (1999) and Lin et al. (1999) look at the change of sodium density (mg/calorie) of food consumed from various dining environments from 1987 to 1995. Meanwhile, Guthrie et al. (2002) look at the change of sodium density (mg/calorie) naturally from food and from processed food, in 1977-78 versus 1994-96. However, these studies do not provide sodium density of various food groups.

In addition, most previous studies on food choice and sodium intake use single-cycle NHANES data, which may not show the changing pattern of sodium intake and the impact of food consumption on sodium intake over years. Taking advantage of the multiple-cycle NHANES data from 1999-00 through 2009-10, the objectives of this study are to examine the food sources of sodium in the Americans' diet; and to determine the trends in sodium intake and the contribution of different food groups to the changes in sodium intake over the study period.

By using regression models with interactions of year dummy variables and other variables, this paper examines the structural change of sodium intake over cycles based on per calorie and gram food consumed. To guide consumers who are interested in reducing sodium by changing their diet, this paper reports the sodium density (mg sodium per calorie and mg sodium per gram) for each food group. In addition, based on the FDA definition this paper also identifies food groups that are high in sodium or low in sodium (FDA 2014b), which would provide critical information to public policy makers and individuals who plan to reduce their sodium intakes.

The following sections of this paper include an introduction to method and data, results and a discussion. The method and data section introduces data source, food classification, and statistical methods. The Results section presents the sample statistics and regression results. The conclusion section summarizes the main finding, limitations of the study and ideas for future research.

2. Methods and Data

2.1 Data Sources

NHANES is a multistage, comprehensive national survey that monitors the health and nutritional status of Americans, and is conducted by Centers for Disease Control and

Prevention (CDC) and the United States Department of Agriculture (USDA). NHANES 1999-2006 and 2007-2010 both sample from all-age civilian noninstitutional American residents on a national base. However, several differences exist between these two NHANES data. First, NHANES 1999-2006 collected a larger sample of individuals for selection, interview and examination from more locations than NHANES 2007-2010, almost twice the size. Second, the oversampling domains are different (see Curtin et al. 2013). Regardless the difference, this study assumes every sample as an individual random sample (Subar et al. 1998a, Subar et al. 1998b).

The six-cycle NHANES data, from year 1999 to year 2010, contain 56,117 respondents. . Respondents are included in this study only if they are "reliable and met the minimum criteria" in the dietary recall status. Respondents whose demographic variables contain responses "Refused", "Don't Know" and "Missing" are deleted. Respondents in the first two cycles, 1999-20 and 2001-02, reported only the one-day dietary intake information, while respondents in the last four cycles reported two-day dietary intake information: both a face-to-face dietary recall interview and a following-up telephone interview are conducted. To be consistent across the six cycles, this study only uses the data from the first day face-to-face interview for higher accuracy of dietary information. In addition, only adult individuals whose are 19 or older are studied. Finally, the number of respondents in each cycle are 3,153, 4,438, 4,315, 4,418, 4,969 and 5,146, respectively. In the analysis, no change is made for continuous variables such as amount of sodium intake and calorie per capita etc. For categorical variables such as race, education, marital status etc., dummy coding is used. For example, four dummy variables are created for race: Mexican American, other Hispanic, non-Hispanic White and non-Hispanic Black, with other races treated as the base group.

2.2 Definition of Food Groups

Most researches uses similar food group classification methods by determining food groups based on the first two digits of the USDA food code, with specific adjustments to create food groups that can be widely accepted by the public in general. In this study, food groups are created based on the first two digit of the USDA food code (USDA 2014). Although different versions of the USDA food coding scheme are slight different, these differences have no significant influence on this study. This is because different versions have made no change to the classification of foods based on the first two digits of food code. Moreover, some versions of food coding scheme may add some new food groups at the level of first three or four digits of food code, but their food codes are exclusive and different from the codes of any other food groups.

Under each of the nine major food group based on the first digit of USDA food code, foods are combined based on the relevance between products to create food groups according to the first two digits of the USDA food code. In order to prevent ambiguity of food group names, brief titles of food groups are used in this study instead of their formal and long titles (Table 1). In total thirty-two food groups are created under the nine major USDA food groups. Two food groups are included in Group 1: *milk and milk products* (combining three first-2-digit food groups: milks and milk drinks; creams and cream substitute; milk desserts, sauces, gravies) and *cheeses*. Seven groups are under the Group 2: *beef, pork, lamb* (lamb, veal, game, other carcass meat), *poultry, sausages* (sausages and lunchmeats, and meat spreads), *fish* and *other types of meat products* (including organ meat products, miscellaneous from mixture meat products). There are no subgroups under Group 3 and Group 4, and they are kept as the major group: *eggs*, and *dry nuts* (dry beans, peas, other legume, nuts, and seeds), respectively. Eight groups are under the Group 5: *yeast breads*, *quick breads*, *cakes* (cakes, cookies, pies, pastries), *crackers* (crackers and salty snacks from grain products), *pancakes* (pancakes, waffles, French toast and others), *pastas* (pastas, cooked cereals, rice), *cereals* (cereals, not cooked), and *other grain products* (including flour and dry mixes; grains mixture, frozen plate meals, soups; and meat substitutes, mainly cereal protein). Three groups are under Group 6: *fruits* (fresh citrus fruits and other fresh fruits), *fruit juices* (including citrus juices, juices for baby and other fruit juices) and *fruit products* (including dried fruits and other fruit products). Five groups are under the Group 7: *potatoes* (white potatoes and Puerto Rican starchy vegetables and their products), *dark-green vegetables* (dark-green vegetables and their products), *deep-yellow vegetables* (deep-yellow vegetables and their products), *tomatoes* (tomatoes and tomatoes mixtures) and *other vegetables* (other vegetables and their products and vegetables mixture products). Three groups are under Group 8: *fats*, *oils*, and *salad dressings.* At last, two groups are under Group 9: *sugars and sweets*, and *beverages and water* (including non-alcoholic beverage, alcoholic beverage and water).

2.3 Statistical Analysis

Based on cleaned data, we conduct a basic statistical analysis using SAS 9.4. The purpose of statistical analysis is to provide information on sample demographics statistics, means sodium intake from food groups, as well as the amount of sodium from per calorie or gram food consumption (sodium density in calorie or in gram).

Table 1. The Food Group Classification for Foods Reported by NHANES 1999-2010 [1]

Milk and milk products	**Grain products**	**Vegetables**
Milk and milk products [2]	Yeast breads [10]	Potatoes [20]
Cheese	Quick breads	Dark-green vegetables
	Cakes [11]	Deep-yellow vegetables
Meat, poultry, fish, and mixtures [3]	Crackers [12]	Tomatoes [21]
Beef	Pancakes [13]	Other vegetables [22]
Pork	Pastas [14]	
Lamb [4]	Cereal [15]	
Poultry	Other grain products [16]	**Fats, oils, and salad dressings**
Sausages [5]		Fats
Fish [6]		Oils
Other types of meat products [7]		Salad dressings
	Fruits	
Eggs [8]	Fruits [17]	**Sugars, sweets, and beverages**
	Fruit juices [18]	Sugars and sweets
Dry nuts [9]	Fruit products [19]	Beverages and water [23]

Note: **1**. All titles are brief version of their official titles, and except *eggs* and *dry nuts*, food groups at first digit of USDA food code (the bold text) only indicate general titles for their subset food groups. **2**. Milk and milk products include milks and milk drinks, creams and cream substitutes and milk desserts, sauces, gravies. **3**. The subset food groups in this group contain relevant meat, and they also contain relevant meat products such soups or sandwiches. **4**. Lamb is short for lamb, veal, game, other carcass meat. **5**. Sausages are short for frankfurters, sausages and lunchmeats and meat spreads, and organ products are not included. **6**. Fish is short for fish and shellfish. **7**. Other types of meat products include meat, not specified (NS) as to type, organ products, miscellaneous meats products in various groups, Pueto Rican soups, Gelatin and gelatin-based meal supplements, and gravies from meat, poultry, fish base. **8**. The food group only contains eggs, which includes eggs, eggs mixtures, eggs substitutes, and frozen plate meals with eggs as major ingredient. **9**. The food group only contains dry nuts, which is short for dry beans, peas, other legumes, nuts, and seeds, and this food group includes legumes, nuts, nut butters, and nut mixtures, seeds and seed mixtures, and carob products. **10**. Yeast breads are short for yeast breads, rolls. **11**. Cakes are short for cakes, cookies, pies, pastries. **12**. Crackers are short for crakers and salty snacks from grain products. **13**. Pancakes are short for pancakes, waffles, French toast, other grain products. **14**. Pastas are short for pastas, cooked cereals, rice. **15**. Cereals are short for cereals, not cooked or NS as to cooked. **16**. Other grain products include grain mixtures, frozen plate meals, soups, and meat substitutes, mainly cereal protein. **17**. Fruits include citrus fruits and other fruits (including fruits excluding berries, berries, mixtures of two or more fruits and mixtures of fruits and non-fruit items). **18**. Fruit juices include citrus fruit juices, and fruit juices and nectars excluding citrus. **19**. Fruit products include dried fruits and fruits and juices baby food. **20**. Potatoes are short for white potatoes and Puerto Rican starchy vegetables. **21**. Tomatoes are short for tomatoes and tomato mixtures. **22**. Other vegetables include other vegetables, vegetables and mixtures mostly vegetables baby food, vegetables with meat, poultry, fish, and mixtures mostly vegetables without meat, poultry, fish. **23**. Beverages and water include nonalcoholic beverages, alcoholic beverages and water, noncarbonated.

Two models are used to determine the impact of food consumption and demographics on sodium intake. The dependent variables for the models are sodium intake amount in mg. Both models include demographics as independent variables. The difference between these two models is that the first model includes calorie intake from different food groups as additional independent variables; the second model includes gram intake from different food groups as additional independent variables. The two models are

(1) $Sodium_i = \alpha_0 + \sum_{k=1}^{13} \beta_k Demo_{ki} + \sum_{j=1}^{32} \gamma_j Calorie_{ji} + \sum_{h=2}^{6} \theta_h Year_{hi} + \sum_{h=2}^{6} \sum_{k=1}^{13} \beta_{hk} Year_{hi} * Demo_{ki} + \sum_{h=2}^{6} \sum_{j=1}^{32} \gamma_{hj} Year_{hi} * Calorie_{ji} + \varepsilon_i,$

(2) $Sodium_i = \alpha_0 + \sum_{k=1}^{13} \beta_k Demo_{ki} + \sum_{j=1}^{32} \gamma_j Gram_{ji} + \sum_{h=2}^{6} \theta_h Year_{hi} + \sum_{h=2}^{6} \sum_{k=1}^{13} \beta_{hk} Year_{hi} * Demo_{ki} + \sum_{h=2}^{6} \sum_{j=1}^{32} \gamma_{hj} Year_{hi} * Gram_{ji} + \epsilon_i,$

where the dependent variable, $Sodium_i$, is the intake amount of sodium in grams per capita per 24 hours; $Year_{hi}$ are dummy variables for cycle h (h=2 to 6), with cycle one as the base; $Calorie_{ji}$ and $Gram_{ji}$ are intake of calorie and gram per capita from food groups j, respectively; $Demo_{ki}$ is demographic variable k, including gender, age, race, education, marital status, income, living alone or not, and ratio of calorie or gram at home to total food calorie or gram. The ratio of calorie (gram) at home is the ratio of calorie (gram) consumption of food prepared at home to individual's total food consumption in calorie or gram. Ratio of calorie and gram at home are used in model (1) and model (2), respectively.

In order to capture the potential structure changes over cycles, both models include interaction between $Year_{hi}$ and other independent variables. The interaction terms between $Year_{hi}$ and $Demo_{ki}$, $Calorie_{ji}$ and $Gram_{ji}$, respectively enable us to compare the coefficients of *Demo, Calorie and Gram* in different cycles to those in the base cycle, therefore to determine whether the marginal effects of $Demo, Calorie$ and $Gram$ change over years.

To correct the heteroscedasticity from cross sectional data at each cycle, we use White's standard error, or the heteroscedasticity-consistent standard errors, to calculate the *p* values. The models are estimated in SAS 9.4 by *PROC REG* with the *WHITE* option.

3. Results

3.1 Sample Statistics

Table 2 presents the coding scheme and statistics of the demographic variables. Results show that the mean age of the respondents of the 6 cycles included in the analysis is about 49. Male accounts for about 48% of the sample and about 53% of the sample have education levels of high school graduated or lower. The non-Hispanic White accounts for about 50% of the respondents followed by non-Hispanic Black and Mexican American. About 54% of the sample is married, with a median household income of $35,000 to $44,999. The mean value of calorie at home per capita is 69%, and the mean value of gram at home is 70%. About 14% of the respondents live alone.

Based on the mean sodium amount per food group per capita per day of respondents in 1999-2010 NHANES survey, results in Table 3 show that *other grain products* generally contribute to the largest amount of individual sodium intake, followed by *fish, beef, sausages, poultry, pork, pancakes, lamb, other types of meat products* and *pastas*. Other grain products include grain mixtures, frozen plate meals, soups, and meat substitutes, mainly cereal protein. Perhaps frozen meal, soup are the main contributors of the high sodium levels of *other grain products*. Meanwhile, *oils, fruit products, fruits, fruit juices, sugars and sweets, fats, beverages and water, deep-yellow vegetables* have lowest means of sodium.

Table 2. The Coding Scheme and Statistic Information for Demographic Variables.

Variable	Coding Scheme	Mean or Percentage
		Mean
Age	Age < 80: range of value;	48.72
	Age >80: 80.	(18.57)
Ratio of calorie at home to total food calorie	Percentage of calorie of food eaten at home.	0.688 (0.326)
Ratio of gram at home to total food gram	Percentage of gram of food eaten at home.	0.699 (0.318)
		Percentage
Gender	1 = male;	48.29%
	0 = female.	51.71%
Education	Base: high school ungraduated or lower.	29.82%
	1 = high school or equivalent graduated;	23.36%
	1= some college of AA;	27.44%
	1= 4-year college graduate or above;	19.39%
Race	Base: other race-including multi-racial.	4.02%
	1 = Mexican American;	19.57%
	1= other Hispanic;	6.20%
	1= non-Hispanic White;	50.41%
	1= non-Hispanic Black;	19.79%
Marital status	1 = married;	54.19%
	0 = not in marriage;	45.81%
Income	1 = $ 0 to $ 4,999;	2.05%
	2 = $ 5,000 to $ 9,999;	5.27%
	3 = $10,000 to $14,999;	8.61%
	4 = $15,000 to $19,999;	8.09%
	5 = $20,000 to $24,999;	8.75%
	6 = $25,000 to $34,999;	13.93%
	7 = $35,000 to $44,999;	10.40%
	8 = $45,000 to $54,999;	9.09%
	9 = $55,000 to $64,999;	6.64%
	10 = $65,000 to $74,999;	5.22%
	11 = $75,000 and Over.	21.94%
Living alone or not	1 = live alone;	14.18%
	0 = live with other people.	85.82%

Note: Values in parenthesis is standard deviation (SD).

Table 3. Mean Intake of Sodium (mg) of Various Food, NHANES 1999-2010

Food Group	N	Mean	SD
Milk and milk products			
Milk and milk products	18,592	164.26	183.11
Cheese	10,125	362.61	417.18
Meat, poultry, fish, and mixtures			
Beef	9,253	736.91	752.00
Pork	5,067	617.77	715.85
Lamb	352	517.44	574.03
Poultry	9,866	666.61	665.01
Sausages	4,237	685.38	727.34
Fish	7,395	849.06	741.69
Other types of meat products	1,613	472.02	578.29
Eggs	6,368	422.66	409.59
Dry nuts	8,361	374.42	546.79
Grain products			
Yeast breads	17,020	402.40	293.60
Quick breads	6,456	412.35	420.32
Cakes	10,457	264.91	278.61
Crackers	8,422	321.92	379.19
Pancakes	1,388	575.79	369.30
Pastas	5,576	439.39	450.02
Cereal	5,628	284.57	215.57
Other grain products	10,090	1,282.02	1079.61
Fruits			
Fruits	11,648	7.66	24.01
Fruit juices	7,171	8.59	10.43
Fruit products	795	3.18	4.61
Vegetables			
Potatoes	10,711	336.41	367.88
Dark-green vegetables	2,773	182.81	259.12
Deep-yellow vegetables	2,898	100.00	161.49
Tomatoes	11,460	209.40	363.46
Other vegetables	15,574	239.75	413.23
Fats, oils, and salad dressings			
Fats	6,755	92.18	106.84
Oils	347	0.11	0.36
Salad dressings	7,702	284.05	359.34
Sugars, sweets, and beverages			
Sugars and sweets	15,626	24.83	53.46
Beverages and water	25,549	92.97	153.53

Our results demonstrate a different rank of sodium intake by food groups compared with NCI (2013). NCI (2013) provides the mean sodium intake for respondents of NHANES 2005-06, and it reports that yeast breads have the highest mean of sodium, followed by chicken and chicken mixed dishes, pizza, pasta and pasta dishes, cold cuts, condiments and Mexican mixed dishes. Meanwhile, by using NHANES 2003-2006 data, both O'Neil et al. (2012) and Keast et al. (2013) report that yeast breads and rolls contribute the most sodium, followed by cheese and frankfurter, sausages, and luncheon meat. Several reasons can explain the difference between our results and previous studies. First, we use a different method to determine the food groups. NCI (2013) classifies food according to a list of specific foods, which includes eight big groups, (1) beverages, (2) bakery/breads, (3) dressings, spreads, other addition, (4) produce, (5) snacks, (6) entrees, (7) refrigerator/frozen and (8) deli. In addition, O'Neil et al. (2012) and Keast et al. (2013) separate salt as an individual food group. Second, because of the need to study the impact of demographic variables on sodium intake, some respondents with missing values of demographic variables are deleted from our sample. Last, our sample includes data from multiple cycles, which take into account the fluctuations of means sodium intake across years.

One obvious problem of only using the means of sodium intake is that this method cannot provide information on the relative sodium contribution of different food groups. For instance, *other grain products* has the highest mean sodium, but it does not necessarily mean that this food group is high in sodium. FDA defines the "low sodium" claim based on the "per reference amount" (FDA 2014a). It may be more reasonable to calculate the sodium intake from different food groups based on per calorie or gram consumption to reflect the sodium levels of food per serving.

Following the concept of energy density of food, we calculate the sodium density in calories and grams as the ratios of the amount of sodium from a food group and the amount of calories or grams from that food group, respectively. Dietary guidelines recommend sodium intake to be equal or below 2,400 mg per 2,000 calories per 24-hours (FDA 2014b); therefore, 1.2 mg per calorie (mg/calorie) can be used as a standard to determine the food groups that meet the recommendation of the guideline. Results in Table 5 show that sodium per calorie of most food groups are higher than 1.2 mg/cal. Food groups with a sodium density lower than 1.2 mg/calorie are similar to the low sodium food groups shown in Table 4, which includes *fruit juices, fruits, fruit products, sugars and sweets*, *milk and milk products*, *cakes*, and *oils.* However, the food groups with the highest sodium density differ significantly from the food groups that contribute the most to means of sodium intake (Figure 1). For instance, *other grain products*, *fish, beef*, *sausages, poultry, pork* and *pancakes* are the food groups that contribute the most to means of individuals' sodium intake. However, the top food groups with the highest sodium per calorie are *other types of meat products*, *tomatoes*, *dry nuts*, *other vegetables, fish, dark-green vegetables, sausages* and *pork*. These results indicate that to reduce the total amount of sodium intake, an individual should try to avoid the food groups with high sodium density if her/his total calorie intake is fixed. Alternatively, she/he needs to add less sodium when cooking the foods with the highest levels of sodium per calorie.

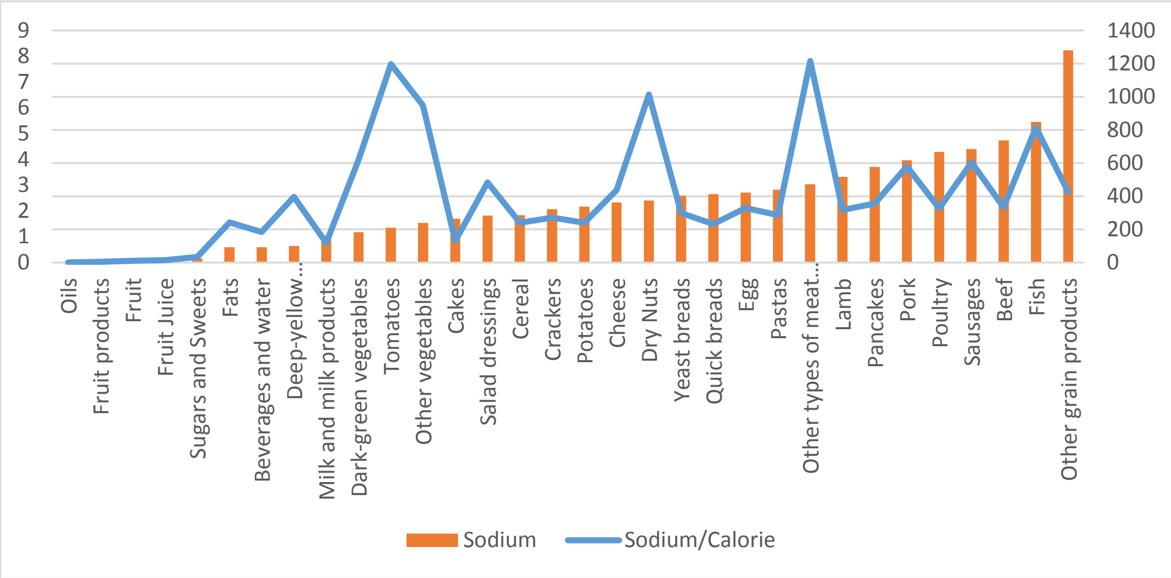

Figure 1. Comparison of Mean Sodium (mg) and Sodium/Calorie by Food Group

We also calculate sodium amount per gram, which can provide information on the food groups that contribute the most to sodium intake based on per gram food consumption. *Pork* has the largest value of sodium/gram, followed by *fish*, *salad dressings*, *cheese*, *crackers* and *fats*. *Oils* has the smallest value of sodium/gram, followed by *fruit juices*, *beverages and water*, *fruits*, *fruit products*, *sugars and sweets and milk and milk products* (Table 4). Although sodium density in calorie can be compared with official standards, calorie of food is not always available for consumers. As a result, using sodium/calorie rank to reduce sodium intake may not always be possible. On the other hand, gram is a direct and easy-understandable amount reference to consumers. Interestingly, although the ranks based on sodium/gram and sodium/calorie differ, many food groups are in the top 10 groups no matter which criteria are used. For instance, *oil*, *fruits, fruit juices, fruit products, sugars and sweets, milk and milk products,* and *beverages and water* are in the top groups with the lowest value of both sodium/calorie and sodium/gram. *Pork, fish, salad dressing, cheese,* and *dry nuts* are in the top 10 groups with highest value of both sodium/calorie and sodium/gram.

Table 4. Sodium Densities in Calorie and in Gram, and Energy Density of Various Food, NHANES 1999-2010

Food Group	**Sodium per Calorie**		**Sodium per Gram**		**Energy Density**	
	Mean	SD	Mean	SD	Mean	SD
Milk and milk products						
Milk and milk products	0.76	0.39	0.76	0.66	0.96	1.21
Cheese	2.80	1.47	8.77	3.90	1.26	1.67
Meat, poultry, fish, and mixtures						
Beef	2.14	2.21	3.94	2.73	0.75	1.11
Pork	3.72	2.52	11.95	8.35	0.64	1.51
Lamb	2.03	1.50	4.68	5.79	0.03	0.26
Poultry	2.10	1.70	4.01	3.20	0.78	1.09
Sausages	3.89	12.98	4.67	5.37	0.27	0.66
Fish	5.24	2.80	10.26	2.36	0.68	1.21
Other types of meat products	7.82	5.34	4.95	1.81	0.06	0.26
Eggs	2.11	1.15	3.56	1.48	0.43	0.79
Dry nuts	6.51	21.17	6.04	10.80	1.08	2.00
Grain products						
Yeast breads	1.91	0.42	5.40	1.26	1.84	1.40
Quick breads	1.50	0.91	4.75	3.17	0.73	1.33
Cakes	0.83	0.28	3.28	1.12	1.59	2.02
Crackers	1.74	0.84	8.01	3.24	1.51	2.23
Pancakes	2.29	0.54	5.52	1.43	0.13	0.55
Pastas	1.84	1.10	2.14	1.39	0.25	0.54
Cereal	1.54	0.66	5.64	2.43	0.78	1.51
Other grain products	2.74	2.06	4.26	1.62	0.72	1.03
Fruits						
Fruits	0.07	0.17	0.06	0.22	0.30	0.39
Fruit juices	0.09	0.18	0.03	0.04	0.12	0.20
Fruit products	0.03	0.04	0.09	0.09	0.08	0.48
Vegetables						
Potatoes	1.54	1.10	3.31	1.84	1.11	1.69
Dark-green vegetables	3.99	3.13	1.44	1.13	0.04	0.13
Deep-yellow vegetables	2.54	2.10	1.27	1.00	0.06	0.21
Tomatoes	7.69	7.50	4.34	4.34	0.20	0.33
Other vegetables	6.10	9.98	2.61	3.14	0.29	0.39
Fats, oils, and salad dressings						
Fats	1.55	1.82	7.41	1.68	1.53	2.72
Oils	0.0004	0.0012	0.0034	0.0105	0.12	1.01
Salad dressings	3.11	3.58	8.96	3.31	1.33	2.32
Sugars, sweets, and beverages						
Sugars and sweets	0.21	0.48	0.68	1.08	2.11	1.90
Beverages and water	1.18	1.17	0.06	0.10	0.21	0.25

Note: Energy Density is the individuals' calorie (kcal) consumption per gram of food.

3. 4 Relationship between Calorie/Gram from Different Food Groups and Sodium Intake

Table 5 and Table 6 present the regression results of the two models that determine the relationship between sodium intake, and calorie intake and gram intake, respectively from food groups. Due to space limitation, the insignificant coefficients of demographic variables are not reported.

Results in Table 5 show that only the intercepts of the 5th and 6th cycles are significantly positive at 5% significance level, which indicates that if all other variables are the same, sodium intake in the last two cycles is significantly higher than the base cycle of 1999-2000. Results in column one show that in 1999-2000, most foods groups are positive and significant correlated with sodium consumption. The food groups that have significant and largest coefficients in a decreasing order are *fish, tomatoes, other types of meat products, dark-green vegetables, crackers, cheese, pancakes, sausage, pork* and *other grain products*. These results suggest that one unit calorie taken from these groups significantly increases the sodium intake of individual in 1999-2000. In the other words, the slope coefficient of a food group measure the sodium/calorie of that food group after controlling all other variables. The coefficients of *milk and milk products* and *cakes* are small and significant at 1% significance level, and the coefficients of *beverages and water*, *sugars and sweets*, *fruits* and *deep-yellow vegetables*, although small, are significant at 10% significance level. This indicates that in general, increase calorie consumption from most food groups would increase sodium intake. In addition, the coefficients of *oils, fruit juices* and *fruit products* are insignificant, indicating that calorie intakes from these food groups does not significantly increase sodium intakes, or the sodium/calorie of these food groups are not significantly different from zero.

The results in columns 2 to 6 of Table 5 present the difference in the marginal effects of calorie intake on sodium intake between other cycles and the base cycle of 1999-2000. For example, the coefficient of *salad dressings* is 0.57 in the second cycle and significantly different from zero at 1% significance level. This indicates that one unit calorie intake from *salad dressing*s in the 2nd cycle would increase sodium intake by 0.57 mg more than the change in sodium intake caused by one unit calorie intake from *salad dressing*s in cycle 1. Therefore a positive coefficient of a food group in the 2nd to 6th cycles (column 2-6 in Table 5) indicates an increase in sodium/calorie of that food group, compared to cycle 1; and a negative coefficient of food groups in the 2nd to 6th cycles indicates a decrease in sodium/calorie of that food group compared to cycle 1. Based on the aforementioned interpretations, results in Table 5 indicate that over the six survey cycles, 15 out of 32 food groups have no significant change at 5% significance level through cycles. These food groups are *cheese, beef, lamb, other types of meat products, dry nuts, cakes, pancakes, cereal, other grain products, fruit juices, fruit products, potatoes, oils, sugars and sweets* and *beverages and water*. The other 17 out of 32 food groups experienced a decrease or increase in sodium/calorie in the 2nd to 6th cycles compared to that of cycle 1. *Fish* shows a significant decrease in the 3rd to 6th cycles, and *salad dressings* show a significant increase in sodium levels per calorie in the 2nd to 5th cycles. The coefficients of all other 15 food groups only show significant at one single cycle. Among these food groups, *milk and milk products, sausages, yeast breads, crackers, fruits* and *fats* show significant decreases in some cycle, and *pork, poultry, eggs, quick breads, pastas, dark-green vegetables, deep-yellow vegetables, tomatoes* and *other vegetables* show significant increases in some cycle. As a complement to previous studies (O'Neil et al. 2012, Keast et al. 2013, NCI 2013) that found *yeast breads, chicken, pizza, pasta, cheese and sausages* as the major sodium contributors, our study shows that these groups still contribute significantly to sodium intake, but not as high as that of *fish, tomatoes, other types of meat products, dark-green vegetables and crackers.*

Among the demographic variables, only the coefficients of education are significant at 1% or 5% significance level in the 1st cycle, and its coefficients decrease over cycles. Individuals with high school degree or higher consume more sodium than those without high school degree. The coefficients of the 4-year College Graduated or Higher have no significant change over cycles compared with the base cycle. However, both coefficients of High School Graduated and College Ungraduated are significantly negative in some cycles.

The model that determines the relationship between sodium intake and gram provides different results from the model that determines the relationship between sodium intake and calories (Table 6). Most of the coefficients of food groups for cycle 1 (1999-2000) are significantly positive, indicating that increased food consumption in gram would significantly increase sodium intake. Meanwhile, the coefficients of *deep-yellow vegetables, fruit juices, fruits, fruit products* and *oils* are insignificant. In addition, less coefficients of food groups show significant decreases or increases in the 2nd to 6th cycles. *Salad dressings* show significant increases in sodium/gram in all five cycles. *Milk and milk products, fish, crackers, and fruits* show significant decreases in sodium/gram in most cycles. *Beef, lamb, sausages, yeast breads, pancakes,* and *beverages and water* only show significant decrease in sodium/gram form some cycles, compared to the sodium/gram of the first cycle. The coefficients of gender, age education and gram at home in base cycle are significant at 5%

significance level. Individuals may consume more sodium if they are male, younger, with some college education but not college graduated, belonging to other races (races other than Mexican American, Hispanic American, non-Hispanic White American and non-Hispanic Black American) and are more frequent to eat away from home. In addition, the coefficients of gram at home are significantly negative for cycle three to five, indicating that food at home in these three cycles may have less sodium per gram.

Table 5. Relationship between Sodium Intake and Food Consumption in Calorie

		Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6
	α_0					
Intercept	310.27*					
	(164.44)			θ_h		
		83.71	175.38	82.96	550.52***	403.31**
		(212.95)	(200.01)	(197.27)	(195.93)	(189.61)
	β_k			β_{hk}		
High school graduated	128.88***	-95.80	-151.79**	-98.39	-137.78**	-133.37**
	(47.67)	(62.26)	(60.10)	(60.95)	(58.59)	(58.51)
College ungraduated	164.75***	-111.26*	-112.26*	-96.31	-181.39***	-110.04*
	(53.14)	(66.91)	(64.49)	(66.28)	(63.62)	(62.63)
College graduated or higher	166.32**	-113.35	-58.96	-57.60	-142.32*	-108.70
	(64.79)	(83.86)	(79.28)	(81.39)	(76.88)	(76.94)
	γ_j			γ_{hj}		
Milk and milk products	0.90***	-0.16	-0.19	-0.24*	-0.31**	-0.09
	(0.12)	(0.14)	(0.14)	(0.14)	(0.16)	(0.14)
Cheese	2.40***	0.47	0.15	-0.18	0.30	0.28
	(0.32)	(0.38)	(0.36)	(0.36)	(0.37)	(0.37)
Beef	1.98***	-0.17	-0.13	-0.18	-0.22	-0.19
	(0.13)	(0.15)	(0.15)	(0.15)	(0.14)	(0.14)
Pork	2.08***	0.22	0.35	0.41	0.60*	1.04***
	(0.25)	(0.30)	(0.32)	(0.31)	(0.33)	(0.32)
Lamb	1.96***	-0.07	-0.34	-0.33	-0.98	-0.09
	(0.61)	(0.81)	(0.69)	(0.71)	(0.78)	(0.73)
Poultry	1.97***	-0.25**	-0.22	-0.04	0.14	0.13
	(0.10)	(0.12)	(0.14)	(0.12)	(0.12)	(0.12)
Sausages	2.09***	-0.14	0.00	-0.08	-0.14	0.54***
	(0.15)	(0.20)	(0.20)	(0.23)	(0.19)	(0.20)
Fish	4.03***	-0.22	-0.44**	-0.76***	-0.64***	-0.68***
	(0.17)	(0.22)	(0.20)	(0.20)	(0.21)	(0.23)

Other types of meat products	2.67***	-0.28	-0.16	0.10	0.70	0.25
	(0.43)	(0.55)	(0.65)	(0.57)	(0.56)	(0.71)
Egg	1.96***	0.27	0.44**	0.21	0.20	0.24
	(0.15)	(0.20)	(0.19)	(0.21)	(0.19)	(0.19)
Dry Nuts	1.53***	-0.42	-0.68*	-0.46	-0.22	-0.48
	(0.33)	(0.35)	(0.35)	(0.35)	(0.36)	(0.35)
Yeast breads	1.97***	-0.18	-0.10	-0.05	-0.20	-0.41**
	(0.16)	(0.19)	(0.19)	(0.19)	(0.18)	(0.18)
Quick breads	1.46***	-0.28	0.43**	0.10	0.10	0.05
	(0.17)	(0.19)	(0.20)	(0.19)	(0.19)	(0.19)
Cakes	0.95***	-0.09	-0.06	-0.02	-0.06	-0.05
	(0.07)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
Crackers	2.40***	-0.22	-0.28	-0.19	-0.20	-0.70***
	(0.19)	(0.25)	(0.22)	(0.22)	(0.26)	(0.22)
Pancakes	2.38***	-0.03	-0.22	-0.22	-0.38	-0.32
	(0.28)	(0.36)	(0.33)	(0.33)	(0.36)	(0.34)
Pastas	1.86***	-0.04	-0.02	0.25	0.07	0.48**
	(0.18)	(0.22)	(0.24)	(0.24)	(0.22)	(0.21)
Cereal	1.36***	-0.13	0.05	0.30	-0.01	-0.09
	(0.21)	(0.29)	(0.25)	(0.26)	(0.25)	(0.25)
Other grain products	2.07***	0.03	0.05	0.11	0.01	0.00
	(0.07)	(0.09)	(0.08)	(0.08)	(0.08)	(0.08)
Fruits	0.43*	-0.23	-0.46*	-0.69**	-0.46*	0.04
	(0.22)	(0.30)	(0.28)	(0.28)	(0.26)	(0.30)
Fruit Juices	0.24	-0.12	-0.38*	-0.24	-0.12	-0.30
	(0.16)	(0.21)	(0.21)	(0.26)	(0.20)	(0.19)
Fruit products	1.78	-1.93	-0.08	-2.12	-2.31	-2.12
	(2.73)	(2.85)	(2.99)	(2.81)	(2.80)	(2.80)
Potatoes	1.43***	-0.25	-0.28	-0.01	-0.13	-0.06
	(0.23)	(0.25)	(0.24)	(0.25)	(0.25)	(0.24)
Dark-green vegetables	2.64***	0.86	-0.38	0.18	1.32	3.10***
	(0.58)	(0.82)	(0.97)	(0.74)	(1.01)	(0.79)
Deep-yellow vegetables	0.96*	0.58	1.15	0.79	1.16	1.86**
	(0.54)	(0.75)	(0.76)	(0.67)	(0.74)	(0.78)
Tomatoes	3.94***	1.33	1.39	0.47	0.05	2.75**
	(1.02)	(1.23)	(1.20)	(1.28)	(1.30)	(1.36)
Other vegetables	1.94***	0.49	0.53*	0.51*	0.80	1.07***
	(0.21)	(0.33)	(0.28)	(0.29)	(0.49)	(0.29)
Fats	1.81***	-0.67	-1.05**	-0.53	-0.73	-0.39
	(0.44)	(0.53)	(0.50)	(0.50)	(0.54)	(0.53)
Oils	0.08	-0.79	-0.19	-0.08	-0.09	2.94
	(0.57)	(0.72)	(0.88)	(1.92)	(0.85)	(1.92)
Salad dressings	1.55***	0.57**	0.61***	0.74***	1.13***	0.39

	(0.18)	(0.23)	(0.23)	(0.28)	(0.26)	(0.25)
Sugars and sweets	0.23*	0.09	-0.06	0.05	-0.07	-0.12
	(0.14)	(0.19)	(0.17)	(0.17)	(0.18)	(0.16)
Beverages and water	0.10*	0.03	0.05	0.00	0.06	0.09
	(0.05)	(0.07)	(0.08)	(0.07)	(0.07)	(0.07)
N			26439			
Adjusted R^2			0.764			

Note: **1.** ***, ** and * respectively indicate significance at 1%, 5% and 10% level. **2.** Only the demographic variables with a significance at 1% or 5% level are presented. **3**. Values in parenthesis is standard error. **4.** Coefficients of variables in column one present the impact of one unit increase of calorie from food group on the changes in sodium at cycle one. **5.** Coefficient of variables in column 2-6 present the calorie from food group on the changes at cycle 2-6 respectively compared with that in cycle one.

Table 6. Relationship between Sodium Intake and Food Consumption in Gram

		Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6
	α_0					
Intercept	597.72***					
	(124.04)			θ_h		
		-71.95	-12.52	-64.11	256.28	166.32
		(169.94)	(164.21)	(160.40)	(156.95)	(152.71)
	β_k			β_{hk}		
Gender	99.68***	-24.31	-45.79	-5.16	5.27	99.68**
	(31.91)	(42.18)	(42.71)	(42.53)	(40.72)	(40.17)
Age	-4.48***	1.02	0.69	0.49	-1.04	-2.11*
	(0.91)	(1.22)	(1.21)	(1.20)	(1.22)	(1.14)
High school graduated	106.54***	-29.31	-102.60*	-59.88	-108.52**	-14.23
	(40.11)	(55.38)	(54.71)	(55.32)	(52.19)	(51.67)
College ungraduated	106.73**	-69.05	-64.80	-69.93	-139.29**	-38.99
	(45.31)	(59.71)	(58.20)	(60.07)	(56.78)	(55.81)
College graduated or higher	40.55	-22.34	-20.66	-24.10	-43.61	-54.73
	(54.99)	(73.27)	(71.17)	(72.32)	(67.32)	(66.47)
Mexican American	-364.09***	139.15	104.43	-28.31	-3.25	65.59
	(104.31)	(144.92)	(132.55)	(128.66)	(129.44)	(122.03)
Hispanic American	-151.49	58.53	-140.79	-166.78	-215.63	-49.07
	(127.62)	(173.00)	(174.45)	(157.93)	(150.18)	(144.74)
Non-Hispanic White	-168.61*	109.12	124.38	49.01	19.34	95.49
	(101.90)	(141.47)	(127.77)	(123.74)	(124.62)	(118.61)
Non-Hispanic Black	-122.13	167.66	136.83	117.17	0.93	30.46
	(107.26)	(146.64)	(134.85)	(129.23)	(130.36)	(124.19)
Ratio of Gram at home to total Food Gram	-216.45***	-69.04	-128.11*	-125.65*	-133.84**	-65.37
	(53.59)	(69.74)	(69.63)	(68.96)	(67.79)	(67.23)
	γ_j			γ_{hj}		

Milk and milk products	0.68***	-0.20**	-0.23***	-0.16**	-0.15*	-0.12
	(0.06)	(0.08)	(0.08)	(0.08)	(0.09)	(0.08)
Cheese	5.35***	2.29*	1.56	1.58	1.86	1.84
	(1.23)	(1.35)	(1.32)	(1.30)	(1.33)	(1.31)
Beef	3.54***	-0.26	0.07	-0.05	-0.18	-0.41**
	(0.14)	(0.20)	(0.20)	(0.19)	(0.18)	(0.19)
Pork	5.43***	0.01	-0.57	0.23	0.48	0.37
	(0.47)	(0.65)	(0.65)	(0.56)	(0.58)	(0.65)
Lamb	2.96***	-1.10	-0.55	0.21	-2.45**	0.55
	(0.70)	(0.99)	(0.94)	(0.84)	(1.21)	(0.85)
Poultry	3.37***	-0.27	-0.20	0.28	0.16	-0.02
	(0.16)	(0.23)	(0.23)	(0.23)	(0.21)	(0.20)
Sausages	3.75***	-0.33	-0.11	-0.63	-0.71**	0.49
	(0.27)	(0.38)	(0.34)	(0.51)	(0.33)	(0.34)
Fish	11.68***	-0.83	-1.33**	-1.68***	-1.71***	-2.06***
	(0.44)	(0.57)	(0.53)	(0.55)	(0.52)	(0.55)
Other types of meat products	3.60***	-0.21	0.15	0.27	0.39	0.11
	(0.38)	(0.63)	(0.62)	(0.54)	(0.59)	(0.53)
Egg	4.12***	-0.12	0.69*	-0.28	0.10	0.53
	(0.28)	(0.38)	(0.37)	(0.41)	(0.38)	(0.39)
Dry Nuts	3.01***	-0.22	-0.73	-0.46	-0.43	-0.19
	(0.41)	(0.48)	(0.45)	(0.46)	(0.46)	(0.44)
Yeast breads	5.15***	-0.29	-0.32	-0.03	-0.15	-0.93**
	(0.34)	(0.44)	(0.45)	(0.45)	(0.42)	(0.42)
Quick breads	3.04***	-0.62	0.72	0.71	0.51	0.04
	(0.49)	(0.58)	(0.59)	(0.58)	(0.56)	(0.58)
Cakes	2.88***	0.08	0.12	0.08	0.10	0.45
	(0.20)	(0.30)	(0.26)	(0.28)	(0.32)	(0.29)
Crackers	10.81***	-1.66*	-1.51*	-1.56*	-0.62	-2.32***
	(0.75)	(0.97)	(0.91)	(0.91)	(1.04)	(0.89)
Pancakes	6.72***	-1.27	-0.99	-1.09	-1.60**	-2.16***
	(0.65)	(0.82)	(0.79)	(0.78)	(0.81)	(0.77)
Pastas	1.82***	-0.15	-0.12	0.02	-0.29	0.22
	(0.19)	(0.26)	(0.27)	(0.25)	(0.25)	(0.24)
Cereal	4.18***	0.43	0.21	1.27	-0.33	-1.06
	(0.56)	(0.89)	(0.81)	(0.78)	(0.77)	(0.70)
Other grain products	3.80***	0.03	0.30*	0.51***	0.22	-0.09
	(0.12)	(0.17)	(0.16)	(0.16)	(0.16)	(0.15)
Fruit	0.01	-0.25	-0.32**	-0.53***	-0.29**	-0.29**
	(0.10)	(0.15)	(0.14)	(0.14)	(0.12)	(0.12)
Fruit Juices	0.06	-0.02	-0.08	-0.12	-0.05	-0.08
	(0.07)	(0.10)	(0.10)	(0.10)	(0.09)	(0.09)
Fruit products	-0.38	-2.45	1.89	-1.81	-3.57	-3.31

	(4.18)	(4.53)	(4.79)	(4.42)	(4.69)	(4.38)
Potatoes	2.77***	0.07	0.03	0.35	0.28	0.59*
	(0.30)	(0.35)	(0.35)	(0.35)	(0.35)	(0.35)
Dark-green vegetables	1.91***	-0.19	-0.22	0.04	0.31	0.85*
	(0.35)	(0.47)	(0.53)	(0.49)	(0.58)	(0.50)
Deep-yellow vegetables	0.47	0.08	0.95	0.52	0.94	1.41**
	(0.42)	(0.57)	(0.62)	(0.61)	(0.62)	(0.67)
Tomatoes	2.38***	-0.03	-0.38	-0.28	-0.16	0.24
	(0.39)	(0.44)	(0.46)	(0.50)	(0.44)	(0.44)
Other vegetables	1.71***	0.38*	0.33	0.27	0.45	0.34*
	(0.18)	(0.23)	(0.22)	(0.22)	(0.35)	(0.20)
Fats	9.16***	-1.09	-4.32*	-2.30	-1.59	-0.82
	(2.17)	(2.96)	(2.60)	(2.61)	(2.54)	(2.57)
Oils	-12.00*	1.03	7.18	11.28	-1.41	6.54
	(6.45)	(7.47)	(9.40)	(8.71)	(8.44)	(9.60)
Salad dressings	4.44***	2.64**	3.65***	3.88***	5.52***	3.35***
	(0.83)	(1.04)	(1.02)	(1.14)	(1.11)	(1.12)
Sugars and Sweets	1.23***	0.09	-0.69	0.35	-0.08	-0.53
	(0.41)	(0.51)	(0.50)	(0.52)	(0.50)	(0.46)
Beverages and water	0.11***	0.00	0.03	-0.04*	-0.05**	-0.04**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
N			26439			
Adjusted R^2			0.788			

Note: **1**. ***, ** and * respectively indicate significance at 1%, 5% and 10% level. **2**. Only the demographic variables with significance levels at 1% or 5% level are presented. **3**. Values in parenthesis is standard error. **4**. Coefficients of variables in column one present the impact of one unit increase of gram of food from food group on the changes in sodium at cycle one. **5.** Coefficient of variables in column 2-6 present the gram of food from food group on the changes at cycle 2-6 respectively compared with that in cycle one.

4. Conclusion

Excessive sodium consumption may cause a significant increase in public health cost because it is associated with diseases such as hypertension heart disease, stroke, and kidney disease (USDA and HHS 2010). Public agents such as the FDA and the USDA have used various instruments to reduce sodium intake among the US population. To reduce sodium intake some individuals may change their whole diet, as sodium is just an ingredient used in most food. For individuals or public agents who develop programs and regulation to reduce sodium intakes it is important to understand the relationship between sodium intake and food consumption so that they can focus on the food groups that contribute the most to sodium intake. Although previous research has tried to determine this relationship, most of them use the ranking method and single cycle NHANES data. Using regression analysis and multiple cycle NHANES data, we determine the contribution to sodium intake and the changes in the contribution to sodium intake of different food groups for American adults. Our results show that the sodium/calorie levels of most food groups are higher than the recommended 2,400 mg per 2,000 calories per 24-hours for American adults. After controlling the impact of demographics, regression results in this study show that *fish, tomatoes, other types of meat products, dark-green vegetables, crackers, cheese, pancakes, sausages, pork* and *other grain products* are the food groups with the highest sodium density per calorie. *Milk and milk products* and *cakes* are the food groups with the lowest sodium density per calorie. In addition, the per calorie consumption of *oils, fruits, fruit juices, fruit products sugars and sweets, deep–yellow vegetables* and *beverages and water* has insignificant impact on individuals' sodium intake. Based on sodium/gram levels, *fish, crackers, fats, pancakes, pork, cheese, yeast breads* and *salad dressings* contribute more sodium for per gram of food consumption. In addition, the per gram consumption of *deep-yellow vegetables, fruit juice, fruit, fruit products* and *oils* are not significant correlated individual's sodium consumption. The contribution to sodium intake of most food groups has no significant changes over cycles for both models.

Some of our results are consistent with previous studies. For example, *cheese* is suggested as the major contributor of sodium intake (O'Neil et al. 2012, Keast et al. 2013, NCI 2013). However *yeast breads* that ranked as the highest in mean sodium level in previous studies (O'Neil et al., 2012; Keast et al., 2013; NCI, 2013) ranks the 12th and 7th highest in our regression results based on sodium/calorie and sodium/gram standard, respectively. The reason may be that *yeast breads* not only provide a large amount of sodium but also a lot of energy. This also indicates that if the required energy for daily activity is fixed, reducing *yeast breads* consumption may not be the best strategy to reduce sodium intake. Instead, reducing consumption of *fish, crackers, cheese, pancakes* and various meat products etc. may be more effective.

As expected, increasing the ratio of food at home to the total food consumption in gram significantly decreases the sodium intake, which implies that consuming more gram of food away from home increases sodium intake significantly. This is consistent with previous findings that foods away from home are high in calorie and salt when compared with foods at home (Lin et al. 1999, Guthrie et al. 2002, Paeratakul et al. 2003, Todd et al. 2010). The results that consuming more calorie of food away from home does not significantly increase sodium intake also confirm that food away from home is not only high in sodium but also is high in calorie, which drive down the ratio of sodium/calorie for food away from home. Although it is unlikely to discourage consumers from consuming foods away from home, regulating sodium amount in food away from home may be possible, which is similar to the concept of reducing sodium in processed food (BNS 2012, Lestch 2014).

Nevertheless, reduced sodium intake is just a part of the heathy diet. Reducing sodium intake should not be the only goal of a diet change (Gao et al. 2013). For instance, although *oil, sugars and sweets,* and *beverages and water* are low in sodium, excessive consumption may result in overconsumption of fat and sugars that will cause other health problems.

Therefore, reducing sodium intake may be more effective by reducing the foods that are high in sodium and increasing the consumption of the foods that are low in sodium, fat and sugars such as *fruits, fruit juices* and *fruit products.*

Further study may focus on the sodium density of processed food, chain restaurant food and other sources. Since these food sources have different types of label, we might understand the relations between consumer behavior and sodium intake in various dining environments. Research should also focus on determining the food groups that are low in sodium as well as in sugar, fat and other ingredients that have negative health effects.

References:

Adams, S. O., Maller, O., & Cardello, A. V. (1995). Consumer acceptance of foods lower in sodium. *Journal of the American Dietetic Association*, 95(4), 447-453.

Batcher, O. M., & Nichols, J. M. (1984). Identifying important food sources of nutrition. *Journal of Nutrition Education*, 16(4), 177-181.

Bureau of Nutrition Science (BNS) (2012). *Guidance for the Food Industry on Reducing Sodium in Processed Foods*. Retrieved from http://www.worldactiononsalt.com/docs/world/78296.pdf.

Cassels, A. (2008). Move over war on transfats; make way for the war on salt. *Canadian Medical Association Journal*, 178(2), 256-256.

Cogswell, M. E., Zhang, Z., Carriquiry, A. L., Gunn, J. P., Kuklina, E. V., Saydah, S. H., ... & Moshfegh, A. J. (2012). Sodium and potassium intakes among US adults: NHANES 2003–2008. *The American journal of clinical nutrition*, *96*(3), 647-657.

Cotugna, N., & Wolpert, S. (2011). Sodium recommendations for special populations and the resulting implications. *Journal of community health*, *36*(5), 874-882.

Cotton, P. A., Subar, A. F., Friday, J. E., & Cook, A. (2004). Dietary sources of nutrition among US adults, 1994 to 1996. *Journal of the American Dietetic Association*, 104(6), 921-930.

Curtin, L. R., Mohadjer, L. K., Dohrmann, S. M., Montaquila, J. M., Kruszan-Moran, D., Mirel, L. B., ... & Johnson, C. L. (2013). The National Health and Nutrition Examination Survey: Sample Design, 2007-2010. *Vital and health statistics. Series 2, Data evaluation and methods research*, (160), 1-24.

Dickinson, B. D., & Havas, S. (2007). *Reducing the population burden of cardiovascular disease by reducing sodium intake: a report of the Council on Science and Public Health*. Archives of Internal Medicine, 167(14), 1460-1468.

Dietary Guidelines Advisory Committee. (2010). *Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2010*, to the Secretary of Agriculture and the Secretary of Health and Human Services. Agricultural Research Service.

Dötsch, M., Busch, J., Batenburg, M., Liem, G., Tareilus, E., Mueller, R., & Meijer, G. (2009). Strategies to reduce sodium consumption: a food industry perspective. *Critical reviews in food science and nutrition*, 49(10), 841-851.

Food and Drug Administration (FDA) (2010). *Guidance for Industry: A Food Labeling Guide (14. Appendix F: Calculate the Percent Daily Value for the Appropriate Nutrition).* Retrived on July 30, 2014, from http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm064928.htm.

Food and Drug Administration (FDA) (2013, November 15). *Lowering Salt in Your Diet*. Retrived on November 13, 2014, from http://www.fda.gov/forconsumers/consumerupdates/ucm181577.htm.

Food and Drug Administration (FDA) (2014a). *CFR-Code of Federal Regulations Title 21*. Retrived on September 29, 2014, from http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=101.61

Food and Drug Administration (FDA) (2014b). *Sodium in Your Diet: Using the Nutrition Facts Label to Reduce Your Intake*. Retrieved on July 31, 2014, from http://www.fda.gov/Food/ResourcesForYou/Consumers/ucm315393.htm.

Fox, M. K., Reidy, K., Novak, T., & Ziegler, P. (2006). Sources of energy and nutrition in the diets of infants and toddlers. *Journal of the American Dietetic Association*, 106(1), 28-e1.

Gao, Z., X. Yu and JY Lee. (2013). Consumer demand for diet quality: evidence from the healthy eating index. *Australian Journal of Agricultural and Resource Economics*, 57(3) , 301-319.

Gregory, C., Rahkovsky, I. M., & Anekwe, T. (2014). Consumers' Use of Nutrition Information When Eating Out. *USDA-ERS Economic Information Bulletin*, (127).

Guthrie, J. F., Lin, B. H., & Frazao, E. (2002). Role of food prepared away from home in the American diet, 1977-78 versus 1994-96: changes and consequences. *Journal of nutrition education and behavior*, 34(3), 140-150.

Hoy, K., Goldman, J., Greenblum, M., Ahuja, J. K., Steinfeldt, L., & Moshfegh, A. J. (2011). Decreases in total cholesterol intake due to decreased cholesterol in eggs in What We Eat In America, NHANES, 2007–2008. *The FASEB Journal*, *2011*(25).

Institute of Medicine (2010). *Strategies to Reduce Sodium Intake in the United States*. Retrieved on July 30, 2014, from http://www.iom.edu/~/media/Files/Report%20Files/2010/Strategies-to-Reduce-Sodium-Intake-in-the-United-States/Strategies%20to%20Reduce%20Sodium%20Intake%202010%20%20Report%20Brief.pdf.

Keast, D. R., Fulgoni, V. L., Nicklas, T. A., & O'Neil, C. E. (2013). Food sources of energy and nutrition among children in the United States: National Health and Nutrition Examination Survey 2003–2006. *Nutrition*, 5(1), 283-301.

Krukowski, R. A., Harvey-Berino, J., Kolodinsky, J., Narsana, R. T., & DeSisto, T. P. (2006). Consumers may not use or understand calorie labeling in restaurants. *Journal of the American Dietetic Association*, *106*(6), 917-920.

Layton, L. (2010, April 20). *FDA plans to limit amount of salt allowed in processed foods for health reasons*. The Washington Post. Retrieved on July 15, 2014, from http://www.washingtonpost.com/wp-dyn/content/article/2010/04/19/AR2010041905049.html.

Lestch, C. (2014, June 17). *FDA to issue salt guidelines for the food industry to reduce sodium consumption*. New York Daily News. Retrieved from http://www.nydailynews.com/life-style/health/fda-issue-salt-guidelines-food-industry-article-1.1833796.

Lin, B. H., Frazão, E., & Guthrie, J. (1999). Away-From-Home Foods Increasingly Important to Quality of American. *Agriculture Information Bulletin No*, *749*.

Lin, B. H., Guthrie, J., & Frazao, E. (1999). Nutrition contribution of food away from home. *America's eating habits: Changes and consequences*, 1999, 213-242.

Lin, C. T. J., Gao, Z., & Lee, J. Y. (2013). Associations between self-reported weight management methods with diet quality as measured by the Healthy Eating Index–2005. *Preventive medicine*, 57(3), 238-243.

National Cancer Institute (NCI) (2013). *Source of sodium among the U.S. population, 2005-2006*. Retrived on July 30, 2014, from

http://appliedresearch.cancer.gov/diet/foodsources/sodium/
Nayga, R. M. (2000). Nutrition knowledge, gender, and food label use. *Journal of Consumer Affairs*, *34*(1), 97-112.
Norat, T., Bowman, R., Luben, R., Welch, A., Khaw, K. T., Wareham, N., & Bingham, S. (2008). Blood pressure and interactions between the angiotensin polymorphism AGT M235T and sodium intake: a cross-sectional population study. *The American journal of clinical nutrition*, 88(2), 392-397.
Ollberding, N. J., Wolf, R. L., & Contento, I. (2011). Food label use and its relation to dietary intake among US adults. *Journal of the American Dietetic Association*, 111(5), S47-S51.
O'Neil, C. E., Keast, D. R., Fulgoni, V. L., & Nicklas, T. A. (2012). Food sources of energy and nutrition among adults in the US: NHANES 2003–2006. *Nutrition*, 4(12), 2097-2120.
Paeratakul, S., Ferdinand, D. P., Champagne, C. M., Ryan, D. H., & Bray, G. A. (2003). Fast-food consumption among US adults and children: dietary and nutrient intake profile. *Journal of the American Dietetic Association*, *103*(10), 1332-1338.
Post, R. E., Mainous III, A. G., Diaz, V. A., Matheson, E. M., & Everett, C. J. (2010). Use of the nutrition facts label in chronic disease management: results from the National Health and Nutrition Examination Survey. *Journal of the American Dietetic Association*, 110(4), 628-632.
Stroehla, B. C., Malcoe, L. H., & Velie, E. M. (2005). Dietary sources of nutrition among rural Native American and white children. *Journal of the American Dietetic Association*, 105(12), 1908-1916.
Subar, A. F., Krebs-Smith, S. M., Cook, A., & Kahle, L. L. (1998a). Dietary sources of nutrition among US children, 1989–1991. *Pediatrics*, 102(4), 913-923.
Subar, A. F., Krebs-Smith, S. M., Cook, A., & Kahle, L. L. (1998b). Dietary sources of nutrition among US adults, 1989 to 1991. *Journal of the American Dietetic Association*, 98(5), 537-547.
Swartz, J. J., Braxton, D., & Viera, A. J. (2011). Calorie menu labeling on quick-service restaurant menus: an updated systematic review of the literature. *International Journal of Behavioral Nutrition and Physical Activity*, 8(8), 135.
Temple, N. J. (2011). Population strategies to reduce sodium intake: The right way and the wrong way. *Nutrition*, 27(4), 387.
Todd, J. E., Mancino, L., & Lin, B. H. (2010). *The impact of food away from home on adult diet quality*. US Department of Agriculture, Economic Research Service.
USDA and HHS (2010). *Dietary guidelines for Americans, 2010*. 7th ed. Washington, DC: U.S. Government Printing Office. Retrieved on February 4, 2013, from http://www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/PolicyDoc/PolicyDoc.pdf.
USDA (2014). *Food Coding Scheme*. USDA, Agricultural Research Service. Retrieved on August 13, 2014, from http://www.ars.usda.gov/Services/docs.htm?docid=12074.
Jalonick, M. C. (2014, June 17). *FDA preparing long-awaited plan to ask food industry to lower levels of salt in foods*. U. S. News & World Report. Retrieved on July 15, 2014, from
http://www.usnews.com/news/business/articles/2014/06/17/fda-prepping-long-awaited-p

lan-to-reduce-salt.

Wootan, M. G., & Osborn, M. (2006). Availability of nutrition information from chain restaurants in the United States. *American Journal of Preventive Medicine*, *30*(3), 266-268.

Wootan, M. G., Osborn, M., & Malloy, C. J. (2006). Availability of point-of-purchase nutrition information at a fast-food restaurant. *Preventive medicine*, *43*(6), 458-459.