

Appendix E-3.11

Sodium: Food Pattern Modeling Analysis

INTRODUCTION

The main purpose of this study was to conduct a sensitivity analysis to determine how the sodium levels of the USDA food patterns (Britten et al., 2006) would change (1) if only currently available lower sodium and no-salt-added foods were selected as representative foods and (2) if foods with typical salt content were chosen. Additional analyses provided some context for this question by describing the current sodium intakes in the U.S. and the intermediate and lower sodium levels targeted in the DASH-Sodium trial (Svetkey, 1999). Results are presented as both absolute levels of sodium (mg) and adjusted for energy (mg per kcal). The tabulations addressed the following specific questions:

1. What are the current mean sodium intakes of the U.S. population?
 - 2.a. What are the sodium levels in the USDA food patterns?
 - 2.b. What are the target sodium levels in the DASH intermediate-sodium-level diet?
3. What would the sodium levels be in the USDA food patterns if “typical” food selections were to be made?
 - 4.a. What lower sodium levels in the USDA food patterns would be possible if only the lowest sodium and no-salt-added food selections were to be made, given currently available foods?
 - 4.b. What are the target sodium levels in the DASH lower-sodium-level diet?

The USDA food patterns represent ideal diets designed to meet adequacy and moderation goals. The goals include no more than 2300 mg of sodium for people age 14 and older and lower levels for younger children (Britten et al., 2006). These targets are the Tolerable Upper Intake Levels set by the Institute of Medicine (IOM, 2004).

Updating of the USDA food patterns, which are the basis for this study and are referred to as the “base” patterns, began in 2009 by identifying amounts of representative foods that would meet all nutritional goals within energy limits, using nutrient-dense forms of each food in all food groups. This means that the food items selected were in forms without added sugars and excess solid fats. Most foods selected were in low salt or no-added-salt form. For example, most vegetables had no salt added during preparation. Nutrient profiles for each food group were calculated using the representative foods. (For a description of the representative foods, how nutrient profiles for each food group are calculated, and how the overall patterns are developed, see online Appendix E-3.1 *Adequacy of the USDA Food Patterns*, available at www.dietaryguidelines.gov, and Britten, 2006.)

Each pattern identified the number of additional calories that would fit within the calorie goal after nutrient needs are met from nutrient-dense food choices. These additional calories were termed

“discretionary calories” since they are not needed to meet nutrient needs. Added sugars, solid fats, and alcoholic beverages are always sources of discretionary calories, and current levels of intake of these dietary components are far above the discretionary calorie allowances (Krebs-Smith et al., 2009). Inclusion of a small number of discretionary calories in the food patterns allows for some flexibility in food choices while still meeting nutrient needs within calorie limits. For example, using the discretionary calorie allowance, a person could choose to consume whole milk, OR 80% lean ground beef, OR regular cheese, rather than a nutrient-dense form of these foods. For almost all individuals, the discretionary calorie allowance is not large enough to allow many such choices. When modeling various scenarios for the patterns, the discretionary calorie allowance is split equally between solid fats and added sugars (by caloric value).

METHODS

- The 2005-2006 mean sodium and energy intakes of the U.S. population were obtained from published tables (USDA/ARS/FSRG, 2008). These estimates do not include salt added at the table.
- The sodium levels of the base USDA food patterns were obtained from Center for Nutrition Policy and Promotion (CNPP) data files, which had been created in 2009 using the USDA/ARS National Nutrient Database for Standard Reference, Release 21 (USDA/ARS/NDL, 2009). (Note that the base USDA food patterns referred to in this report are draft patterns developed in 2009 that have since been updated.)
- The target sodium levels in the DASH intermediate-sodium-level and lower-sodium-level diets were obtained from the literature (Svetkey et al., 1999).
- The sodium content of the USDA food patterns at each calorie level if “typical” food choices were to be made were obtained from a CNPP file created in 2009. The methodology for creating “typical choices” is described in online Appendix E-3.5 “*Typical Choices*” *Food Patterns*, available at www.dietaryguidelines.gov.
- The lowest possible sodium levels that could be achieved while following the USDA food patterns were determined as follows:
 - The sodium content of each representative food was reviewed by a CNPP nutritionist. In the few instances where a salt had been used in preparation, a no-salt-added form of the food was substituted. For example, unsalted French fries and potato chips with no added salt were substituted for salted versions, and unsalted butter and margarine were substituted for salted versions. In the few instances where the food was inherently high in sodium, another representative food was substituted. For example, cucumbers were substituted for olives, and cooked, fresh meats were substituted for luncheon meats. The lowest sodium foods were selected from the USDA/ARS National Nutrient Database for Standard Reference, Release 21 (USDA/ARS/NDL, 2009). All decisions were reviewed by three other CNPP nutritionists. All the changes made to the representative foods to lower their sodium value are listed in the Appendix of this report.

- The grain product specialist at the USDA/ARS Nutrient Data Laboratory (NDL) was asked to locate the breads currently available to consumers that have the lowest sodium content. She conducted a market analysis, and her work was reviewed by another NDL nutritionist. The sodium values for the product with the lowest sodium level, according to label claims, was substituted for the sodium values in the representative white and French breads, quick breads, biscuits, and stuffing. This product is a national brand.
- Using these lowest sodium foods, the sodium levels in the USDA food patterns at each calorie level were calculated in Excel 2007.
- All ratios and correlations were calculated in Excel 2007.

RESULTS

Estimated mean sodium intakes in the U.S.

The mean sodium intake levels by the U.S. population range from 2146 mg/day for 2 to 5-year-old girls to 3187 for 30 to 39-year old men, as shown in Table 1. The correlation of sodium and energy intakes is high ($r = .80$) (USDA/ARS/FSRG, 2010). The mean sodium intake by the U.S. population age 2 and over is about 3400 mg or 1.6 mg/kcal.

Table 1. Estimated sodium intakes, 2005-2006

Sex and age (years)	Energy (kcal)	Sodium (mg)	Na/energy (mg/kcal)
Males:			
2-5	1641	2395	1.46
6-11	2092	3202	1.53
12-19	2707	4266	1.58
20-29	2821	4476	1.59
30-39	2978	4715	1.58
40-49	2753	4350	1.58
50-59	2597	3956	1.52
60-69	2202	3738	1.70
70+	1984	3142	1.58
Females:			
2-5	1486	2146	1.44
6-11	1879	2966	1.58
12-19	1906	2950	1.55
20-29	1959	3107	1.59
30-39	1923	3187	1.66
40-49	1873	3059	1.63
50-59	1718	3001	1.75
60-69	1598	2606	1.63
70+	1495	2395	1.60
All, 2+	2157	3436	1.59

Sodium levels in various versions of USDA food patterns and DASH diets

Although the target level for all food patterns was less than 2300 mg of sodium, the sodium levels of the draft USDA food patterns ranged from 996 mg to 3176 mg, as shown in Table 2 below. The sodium level in the food patterns was 1.0 mg/kcal. The intermediate diet target sodium level is 2300 mg at the 2100 calorie level. Unlike the USDA food patterns, the sodium targets for the DASH diets were designed to be perfectly correlated with energy intake. The sodium level in the DASH intermediate diets was about 1.1 mg/kcal. The absolute sodium levels of the intermediate DASH diets ranged from 1800 mg to 3680 mg, as shown in Table 2 below, and were slightly higher than the USDA food pattern levels. Both were about 40% lower than current sodium intake levels.

Table 2. Sodium levels in USDA food patterns and DASH intermediate diet

USDA calorie level	USDA ¹ sodium (mg)	USDA ¹ Na/energy (mg/kcal)	DASH calorie level	DASH sodium (mg)	DASH Na/energy (mg/kcal)
1000	996	1.00			
1200	1195	1.00			
1400	1392	0.99			
1600	1608	1.01	1600	1840	1.15
1800	1795	1.00			
2000	1993	1.00			
			2100	2300	1.10
2200	2186	0.99			
2400	2381	0.99			
2600	2580	0.99	2600	2760	1.06
2800	2791	1.00			
3000	2979	0.99			
			3100	3220	1.04
3200	3176	0.99			
			3600	3680	1.02

¹Amounts in draft food patterns.

If typical rather than ideal food selections were to be made when following the USDA food patterns, the sodium levels would be much higher, as shown in Table 3:

Table 3. Sodium in USDA food patterns with typical foods

Calorie level	Sodium¹ (mg)	Na/energy¹ (mg/kcal)
1000	1715	1.72
1200	2201	1.83
1400	2533	1.81
1600	3143	1.96
1800	3499	1.94
2000	3527	1.76
2200	4012	1.82
2400	4267	1.78
2600	4635	1.78
2800	4893	1.75
3000	5075	1.69
3200	5078	1.59

¹Amounts in draft food patterns with typical food choices.

In the draft USDA food patterns constructed from the lowest sodium foods, the sodium levels ranged from 500 mg to 1250 mg and have about 0.5 mg/kcal, as shown in Table 4 below. They are also highly correlated with sodium, though not by design ($r = .98$). The sodium level targeted for the 2100-calorie DASH lower sodium diet was 1150 mg/day. The absolute sodium levels of the lower sodium DASH diets ranged from 920 mg to 1840 mg/day, as shown in Table 4 below; and the sodium level was 0.55 mg sodium per calorie. The sodium levels in the USDA food patterns with lowest sodium choices were slightly lower than the DASH lower sodium diets. Both were about 70% lower than current sodium intake levels.

Table 4. Sodium in USDA food patterns with lowest sodium foods and DASH lower sodium level

USDA calorie level	USDA¹ sodium (mg)	USDA¹ Na/energy (mg/kcal)	DASH calorie level	DASH sodium (mg)	DASH Na/energy (mg/kcal)
1000	500	0.50			
1200	600	0.50			
1400	688	0.49			
1600	838	0.52	1600	920	0.58
1800	918	0.51			
2000	934	0.47			
			2100	1150	0.55
2200	1019	0.46			
2400	1092	0.46			
2600	1165	0.45	2600	1380	0.53
2800	1240	0.44			
3000	1279	0.43			
			3100	1610	0.52
3200	1250	0.39			
			3600	1840	0.51

¹Amounts in draft USDA lowest sodium food patterns.

Findings are summarized in the figure found at the end of this report.

DISCUSSION

The amounts of sodium in the standard unit of each food group/component of the draft base USDA food patterns, in the draft food patterns constructed using typical food selections, and in the food patterns constructed using lowest sodium foods are shown below:

Table 5. Sodium in standard amounts of each component of the draft USDA food patterns

Food group or component	Standard unit	Base patterns¹ (mg)	Typical choices¹ (mg)	Lowest sodium choices¹ (mg)
Fruit	1 cup equiv.	4	6	4
Vegetables:				
Dark green	1 cup equiv.	92	249	58
Red-Orange	1 cup equiv.	63	413	36
Dry beans and peas	1 cup equiv.	3	623	3
Starchy	1 cup equiv.	189	326	21
Other	1 cup equiv.	32	273	16
Vegetables:				
Whole	1 oz. equiv.	89	199	50
Nonwhole	1 oz. equiv.	123	156	68
Meat:				
Meats	1 oz. equiv.	113	131	18
Poultry	1 oz. equiv.	61	252	24
Fish (high n-3)	1 oz. equiv.	41	41	37
Fish (low n-3)	1 oz. equiv.	51	120	50
Eggs	1 oz. equiv.	62	94	62
Soy products	1 oz. equiv.	143	143	143
Nuts & seeds	1 oz. equiv.	22	54	22
Milk	1 cup equiv.	187	252	119
Oils	10 grams	5	5	0
Solid fats	10 grams	22	n.a.	0
Added sugars	1 tsp. equiv.	0	n.a.	0

¹Amounts in the components used for draft patterns.

The sensitivity analysis revealed that it would be possible to lower the sodium levels in the USDA food patterns by eliminating luncheon meats, high sodium condiments such as olives, salt from the few starchy vegetables that currently have added salt, and substituting the lowest sodium bread currently available to consumers for all enriched bread, quick breads, and biscuits.

If typical foods with typical sodium levels were to be chosen instead of nutrient dense, lower sodium versions, the sodium content of the food patterns would be much higher, higher even than current intakes. One reason for this is that current dietary intakes are very high in added sugars and solid fats, which carry no sodium or very little sodium. On the other hand, many nutrient-dense foods have naturally occurring sodium, such as milk and meat, or are typically prepared with salt, such as grain products and vegetables.

Work on the USDA base and “typical choices” food patterns continued after this study was completed.

The final base and “typical choices” food patterns are somewhat lower in sodium than what is reported here; for example, in the final base food patterns, all vegetables are prepared without salt. The final base and “typical choices” food patterns are found in online Appendix E-3.1 *Adequacy of the USDA Food Patterns* and online Appendix E-3.5 “*Typical Choices*” *Food Patterns*.

Sodium and energy intakes are highly correlated, which makes analysis and interpretation of the health effects of dietary sodium difficult. Energy-adjustment is often used when modeling the relationships between food and nutrient intakes and a health outcome. The sodium levels recommended by the USDA food patterns are effectively, if not intentionally, energy adjusted.

SUMMARY

The base USDA food patterns include foods in their most nutrient-dense forms and, in most cases, in a low salt form. If typical rather than ideal food choices were to be made, the sodium content of the patterns would be much higher. If only the lowest sodium choices were to be made, sodium levels could be reduced. The base USDA food patterns are similar in sodium content to the DASH intermediate diet, both in absolute amounts and per calorie. The USDA food patterns comprised of only lowest sodium foods would be similar in sodium content to the DASH lower sodium diet. The base USDA food patterns are 40 percent lower in sodium than current intakes, and the lowest sodium patterns are 70 percent lower in sodium than current intakes.

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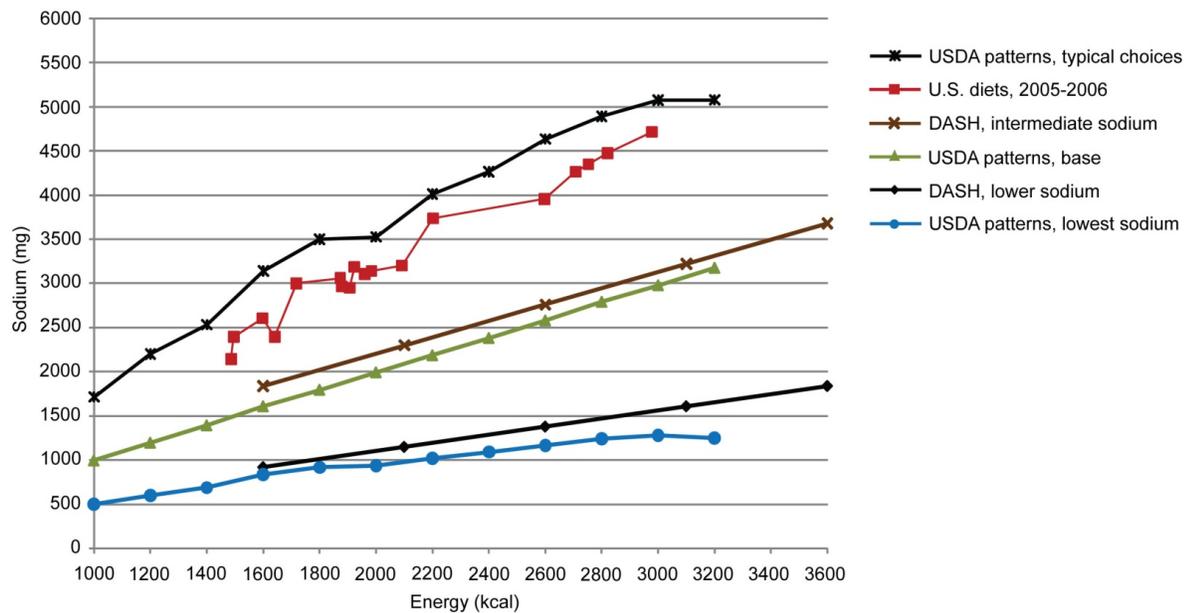
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APPENDIX. Changes made to representative foods in the base USDA food patterns to lower sodium content

Fruit	None
Vegetables	Salted potato products to unsalted Olives to cucumbers Canned hot red pepper to cooked hot red pepper Canned grape leaves to spinach Wakame seaweed to laver seaweed
Non-whole Grains	White bread with sodium value from USDA/ARS National Nutrient Database for Standard Reference, Release 21 (USDA/ARS/NDL, 2009) to the national brand white bread found on the market with the lowest sodium value Pancake (quick breads) to the national brand white bread found on the market with the lowest sodium value Biscuits to the national brand white bread found on the market with the lowest sodium value French bread to the national brand white bread found on the market with the lowest sodium value Bread stuffing to the national brand white bread found on the market with the lowest sodium value Wheat tortilla to corn tortilla Cornflakes to puffed rice cereal Pretzels to unsalted pretzels Grits cooked with salt to grits cooked without salt
Whole Grains	Rye bread to whole wheat bread Whole wheat quick bread to whole wheat bread Oat ready-to-eat cereal to shredded wheat cereal
Meat	Luncheon meats to cooked, fresh meats Anchovies to sardines
Milk	Natural cheese to low sodium cheese Processed cheese to low sodium cheese Cottage cheese to low sodium cottage cheese
Oils	Salted tub margarine to unsalted tub margarine
Solid fats	Salted butter to unsalted butter Salted stick margarine to unsalted stick margarine

Sodium and energy levels in U.S. diets, USDA food patterns¹ at three levels of sodium and DASH diets at two levels of sodium



¹Amounts in draft patterns.

Figure D6.3. Data points. USDA patterns, typical choices.

Energy level (kilocalories)	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200
Sodium level (milligrams)	1715	2201	2533	3143	3499	3527	4012	4267	4635	4893	5075	5078

Figure D6.3. Data points. U.S. diets, 2005-2006.

Energy level (kilocalories)	1486	1495	1598	1641	1718	1873	1879	1906	1923	1959	1984	2092	2202	2597	2707	2753	2821	2978
Sodium level (milligrams)	2146	2395	2606	2395	3001	3059	2966	2950	3187	3107	3142	3202	3738	3956	4266	4350	4476	4715

Figure D6.3. Data points. DASH intermediate sodium.

Energy level (kilocalories)	1600	2100	2600	3100	3600
Sodium level (milligrams)	1840	2300	2760	3220	3680

Figure D6.3. Data points. USDA patterns, base.

Energy level (kilocalories)	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200
Sodium level (milligrams)	996	1195	1392	1608	1795	1993	2186	2381	2580	2791	2979	3176

Figure D6.3. Data points. DASH, lower sodium.

Energy level (kilocalories)	1600	2100	2600	3100	3600
Sodium level (milligrams)	920	1150	1380	1610	1840

Figure D6.3. Data points. USDA patterns, lowest sodium.

Energy level (kilocalories)	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200
Sodium level (milligrams)	500	600	688	838	918	934	1019	1092	1165	1240	1279	1250