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Sodium content of popular commercially processed and restaurant foods in the United States☆

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ABSTRACT

Purpose. The purpose of this study was to provide baseline estimates of sodium levels in 125 popular, sodium-contributing, commercially processed and restaurant foods in the U.S., to assess future changes as manufacturers reformulate foods.

Methods. In 2010–2013, we obtained ~5200 sample units from up to 12 locations and analyzed 1654 composites for sodium and related nutrients (potassium, total dietary fiber, total and saturated fat, and total sugar), as part of the U.S. Department of Agriculture-led sodium-monitoring program. We determined sodium content as mg/100 g, mg/serving, and mg/kcal and compared them against U.S. Food and Drug Administration's (FDA) sodium limits for "low" and "healthy" claims and to the optimal sodium level of <1.1 mg/kcal, extrapolating from the Healthy Eating Index-2010.

Results. Results from this study represent the baseline nutrient values to use in assessing future changes as foods are reformulated for sodium reduction. Sodium levels in over half (69 of 125) of the foods, including all main dishes and most Sentinel Foods from fast-food outlets or restaurants (29 of 33 foods), exceeded the FDA sodium limit for using the claim "healthy". Only 13 of 125 foods had sodium values below 1.1 mg/kcal. We observed a wide range of sodium content among similar food types and brands.

Conclusions. Current sodium levels in commercially processed and restaurant foods in the U.S. are high and variable. Targeted benchmarks and increased awareness of high sodium content and variability in foods would support reduction of sodium intakes in the U.S.

Introduction

Hypertension is a major risk factor for cardiovascular disease, the leading cause of death in the United States. Hypertension is associated with high intakes of sodium (Aburto et al., 2013; U.S. Centers for Disease Control and Prevention (CDC), 2010[1]; Institute of Medicine, 2013). In the U.S., more than 90% of adults consume more than the tolerable upper intake level of 2300 mg/day (Cogswell et al., 2012). Over 75% of U.S. sodium intake comes from commercially processed and restaurant foods to which sodium/salt has been added prior to consumer purchase (CDC, 2012; Drewnowski and Rehm, 2013; Mattes and Donnelly, 1991). The U.S. Food and Drug Administration (FDA) has set guidelines for the sodium content of the food to be considered healthy (less than 480 mg or 600 mg per label serving, depending on type of food) (FDA, 1994). The Healthy Eating Index-2010 gives maximum scores to diets with sodium levels ≤1.1 g per 1000 kcal (Guenther et al., 2013). Recent public health efforts have focused on working with food manufacturers and restaurants to reduce the sodium levels in their products (Levings et al., 2012; City of New York, 2013). Many food manufacturers and restaurant chains have committed to reducing the sodium content of their foods (McDonalds, 2011; ConAgra, 2009; PR Newswire, 2012). Monitoring these changes is important to track and evaluate sodium-reduction efforts and to plan future public health strategies to reduce sodium consumption (Institute of Medicine, 2010).

In 2010, the Nutrient Data Laboratory (NDL) of the U.S. Department of Agriculture (USDA), in close collaboration with other government agencies, expanded the monitoring of the sodium content of commercially processed and restaurant foods in the United States. Information

☆ Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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[1] *Abbreviations:* AOAC, Association of Analytical Chemists; CDC, U.S. Centers for Disease Control and Prevention; FDA, U.S. Food and Drug Administration; NDL, Nutrient Data Laboratory; RACC, Reference Amounts Customarily Consumed; USDA, United States Department of Agriculture; WWEIA, What We Eat In America.

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about this program was published previously (Ahuja et al., 2015) and is presented here briefly. An important component of this program is nationwide sampling and laboratory analysis on a periodic basis of 125 commonly consumed sodium-contributing foods, termed "Sentinel Foods." These foods will serve as indicators for assessing temporal trends in sodium content of commercially processed and restaurant foods. In addition to sodium, related nutrients (potassium, total dietary fiber, total and saturated fat, total sugar) are monitored because their levels may change when manufacturers and restaurants reformulate their products to reduce their sodium content (Institute of Medicine, 2010). USDA then uses these data to update its National Nutrient Database for Standard Reference (USDA, 2014a) and Food and Nutrient Database for Dietary Studies (USDA, 2014b). These databases serve as the foundation for most food composition databases in the U.S. and are used for national nutrition monitoring (Ahuja et al., 2013).

The main purpose of this manuscript is to provide baseline assessments of sodium contents in Sentinel Foods to assess future changes as manufacturers reformulate foods. The secondary aim is to increase awareness among health professionals and public health officials of the sodium content and its variability in foods.

Materials and methods

In 2010, USDA selected 125 Sentinel Foods based on dietary intake data from over 9000 respondents in the nationwide survey, What We Eat In America (WWEIA), a component of the 2007–2008 National Health and Nutrition Examination Survey (USDA and Department of Health and Human Services, 2010a). The Sentinel Foods are commercially processed (92 of 125 foods) or fast-food and restaurant foods (33 of 125 foods) that collectively account for approximately one third of total sodium intakes of U.S. adults and children (excluding breastfed children) (Ahuja et al., 2015).

NDL sampled each Sentinel Food mainly in 2010–2013 from retail outlets in up to 12 counties/cities using standard USDA National Food and Nutrient Analysis Program protocols and the most recent census and annual sales data of grocery store outlets and market share (Pehrsson et al., 2003; Pehrsson et al., 2013). Additional sampling was done in 2014 for three foods (canned corn, cheddar cheese and mozzarella cheese). Each commercially processed Sentinel Food was represented by several national and private label (store) brands. We sampled restaurant Sentinel Foods mainly from major fast-food and family-style restaurant chains. The sampling process and selection of brands and restaurants are detailed elsewhere (Ahuja et al., 2015).

NDL shipped the samples to laboratories at Virginia Tech or Texas Tech (Trainer et al., 2010). Scientists determined metric weights for one or more common household measures or total sample weight, prepared subsamples for chemical analyses, composited samples to reduce analysis costs, and shipped them to prequalified laboratories for analyses. Along with the samples, we also shipped similar matrix-matched controls or standard reference materials, if available. The ~5200 sample units purchased for the 125 Sentinel Foods yielded 1654 composite samples. The form in which each Sentinel Food was analyzed – as purchased or as prepared – was the form of the food used in the Food and Nutrient Database for Dietary Studies, the database used for processing dietary intakes of WWEIA respondents. We measured up to 150 nutrients/food components for these foods, as appropriate (USDA, 2014a). Here we are presenting data for sodium and related nutrients only. Content was analyzed as follows: sodium and potassium by inductively coupled plasma atomic emission spectroscopy using the Association of Analytical Chemists (AOAC) method 985.01 (3.2.06) + 984.27 50.1.15 (50.1.15), total fat by acid hydrolysis (AOAC 922.06, 925.12, 989.05, or 954.02), total sugars by summing amounts of individual sugars (galactose, glucose, fructose, lactose, maltose, and sucrose) measured by liquid chromatography (AOAC 982.14), total saturated fat by summing 14 fatty acids measured by gas–liquid chromatography (AOAC 996.06), and total dietary fiber by enzymatic gravimetric methods AOAC 985.29 or 991.43 (USDA, 2014a). We did not analyze all composites for related nutrients, to save on analytical costs. NDL validated the results from the laboratory analyses against the control composites (Phillips et al., 2006).

We determined estimates of sodium content on per 100 g, per serving size, and per kilocalories (kcal) basis, to provide several nutritional perspectives for evaluation. The laboratory analyses provided sodium content per 100 g for the composites. To determine sodium per kcal for each Sentinel Food, we calculated the energy values for each composite based on the Atwater system (USDA, 2014a) using mainly analytical values and then determined the ratio of sodium per kcal. We assigned a serving size to each Sentinel Food to determine the ratio of sodium per serving. For most packaged foods, we used the household measure on the label for the brand with the highest market share as the serving, and the mean analytical weight corresponding to the label's household measure as the serving weight. For example, the label household measure for mayonnaise is 1 tablespoon, label weight is 14 g, and analytical weight is 13.8 g. We used the latter as the serving weight so that analytical weights corresponded to analytical nutrient values. We used label weights for brand-name breakfast cereals and when analytical weights corresponding to the label household measure were not available. We mainly used label information from samples, when available; otherwise this information came from manufacturer or retailer websites. We used Reference Amounts Customarily Consumed (RACC) (FDA, 1994) weights for some foods, including foods with several popular forms and varied weights (e.g., cheddar cheese: slice, shredded, block) or no labels (e.g., bakery items). For fast foods and restaurant foods, we mainly used mean analytical weights of amounts that restaurants served as serving weights. However, we used analytical weights of household measures comparable to RACC gram weights for some foods, including those served in family-size portions (e.g., pizza), self-serve items (e.g., potato salad), or foods for which amounts served were not available. For example, the mean analytical weight of a slice of thick-crust cheese pizza is 115 g and a whole pie is 922 g, and the RACC weight is 195 g. Hence, we used 230 g (i.e., the mean analytical weight of two slices of pizza) as the serving weight. We weighted the sodium ratios for composites as previously described (Ahuja et al., 2015) to determine a nationally representative estimate for the Sentinel Food.

We grouped the Sentinel Foods by food type (adapted from WWEIA Food Categories; USDA, 2013) to present the data. We compared the sodium mg/kcal to the optimal level of less than 1.1 mg/kcal, extrapolating from the Healthy Eating Index-2010, a measure of diet quality based on conformity to the 2010 Dietary Guidelines for Americans (DGA) (Guenther et al., 2013). In addition, we compared amounts of sodium per serving to FDA limits for a food to be considered low in sodium (140 mg/RACC for individual foods with RACC > 30 g; 140 mg/50 g for individual foods with RACC ≤ 30 g; 140 mg/100 g for meal-type/main dishes) or healthy (480 mg/serving and /RACC for individual foods with RACC > 30 g; 480 mg/50 g for individual foods with RACC ≤ 30 g; 600 mg/serving for meal-type/main dishes) (FDA, 1994; FDA, 2014). We assigned foods such as fried chicken or corn dog as individual foods, even though they are commonly considered as main dish, because their label servings were lower than the FDA criterion of at least 6 oz (170 g). We used sodium values of prepared forms of Sentinel Foods that were analyzed in their dry or condensed form for these comparisons.

Statistical analyses

We determined weighted mean, standard error (SE), coefficient of variability (CV), and range for each Sentinel Food and food type for sodium per 100 g, sodium per kcal, and sodium per serving size using SAS 9.3 (SAS Institute, Cary, NC). We determined the same statistics for potassium, total fat, saturated fat, total dietary fiber, and total sugar per 100 g for all Sentinel Foods.

Results

Supplemental Table A provides the mean and variability information on sodium content (per 100 g, per kcal, and per serving) of 125 Sentinel Foods. Table 1 provides similar information by food type.

Mean sodium values by food types ranged from 205 mg (vegetable products) to 1112 mg (cured meats/poultry) on per 100 g basis and 177 mg (salad dressings and mayonnaise) to 1888 mg (Asian mixed dishes) on per serving basis (Table 1). The latter exceeded the maximum daily intake limit (1500 mg) recommended in the 2010 DGA for over half the U.S. population (USDA and U.S. Department of Health and Human Services, 2010b). None of the categories were low in sodium as per FDA criteria. Over half the food types (13 of 22) had sodium values per serving for either all or over half of the Sentinel Foods exceeding FDA limits for "healthy." All analyzed pizza, sandwiches and mixed dishes (Asian, Mexican, grain based, meat and poultry based), most cured meats and poultry (except pork sausage), poultry products (except rotisserie chicken), and soups (except tomato soup) and many of the cheeses, condiments and sauces, plant-based protein products, poultry products, and quick breads, exceeded FDA limits. Mean sodium per kcal ranged from 0.8 mg to 23.5 mg among sweet bakery products and condiments and sauces, respectively. The former were the only food type that had mean sodium levels of mg/kcal below 1.1.

Mean sodium values for Sentinel Foods ranged from 115 mg (canned tomatoes) to 5493 mg (soy sauce) on per 100 g basis and 55 mg (mustard) to 3581 mg (orange chicken, Chinese restaurant) on per serving basis (Supplemental Table A). Levels of sodium per serving were greater than 1500 mg in eight foods (several pizza and Asian mixed dishes, lasagna, fried shrimp, and mozzarella sticks from restaurants). None of the Sentinel Foods (except tomato sauce, canned) were low in sodium as per FDA criteria. Over half (69 of 125) of the Sentinel Foods, exceeded the FDA sodium limit for using the claim "healthy," including all foods identified as main dishes, and most Sentinel Foods (29 of 33 foods) sampled from fast-food outlets or restaurants. Sodium levels per kcal were also quite varied among Sentinel Foods (Supplemental Table A), ranging from 0.6 mg per kcal for cookies to 103.7 mg per kcal for soy sauce. Only 13 of 125 foods had levels below 1.1 mg/kcal, which were mainly sweet bakery products and high-fat products such as French fries and peanut butter.

The variability of sodium values estimated by the CV for all sodium variables, ranged from 10 to 144% (Table 1) and 1% to 66% (Supplemental Table A) among different food types and Sentinel Foods, respectively. Among the latter, taco shells, coleslaw, and rotisserie chicken had the highest CVs. The range for sodium per 100 g was widest for bologna and barbecue sauce (1212 mg and 986 mg, respectively).

Supplemental Table B provides baseline values for related nutrients (total and saturated fat, total sugar, potassium, and total dietary fiber).

Discussion

The results from this study represent the baselines for sodium and related nutrient values for the Sentinel Foods. We plan to analyze samples of these foods using similar procedures every 4–8 years and compare them to baseline sodium values to track the impact of sodium-reduction efforts. We will also monitor changes in related nutrients, because preliminary data (Ahuja et al., 2015) shows that reduction in sodium may be accompanied by changes in nutrients that the 2010 DGA recommends for reduced consumption (total and saturated fat, total sugar) or increased consumption (potassium, total dietary fiber) (USDA and U.S. Department of Health and Human Services, 2010b). Investigating the changes and trends in these nutrients is important due to potential unintended consequences of reformulations for sodium reduction, such as increase in fat and/or sugar, and their subsequent public health implications.

Our results show that current sodium levels in U.S. commercially processed and restaurant foods are high and variable. These findings support similar results by others in the United States (Gillespie et al., 2015; Dunford et al., 2012; Jacobson et al., 2013; Johnson et al., 2010; Wu and Sturm, 2014) and other developed countries (Arcand et al., 2014; Eyles et al., 2013; Grimes et al., 2008). The sodium values in foods from fast-food outlets or restaurants are of concern as 90% of the Sentinel Foods from these sources did not meet the FDA sodium limit for using the term "healthy". This may have been due to their large serving sizes, for example, the order sizes for lasagna and several Asian mixed dishes were several times higher than the RACC for similar packaged foods. This supports the need for educating consumers and health professionals about serving sizes and portion control and the call for reducing and harmonizing serving sizes at fast-food and family-style restaurants (Young and Nestle, 2012; Cohen and Story, 2014) as public-health strategies. Pizza, mixed dishes (Asian, Mexican, grain based, meat and poultry based), sandwiches, and most cured meats and poultry, poultry products, and soups are of concern. Some food types, such as breads, rolls, tortillas and savory snacks, and crackers, may have moderate amounts of sodium but are frequently consumed in the U.S. Hence, sodium reduction in these foods is paramount to reduce total dietary sodium intakes in the U.S. (CDC, 2012). Sweet bakery products were the only food type that had sodium levels (mg per kcal) below the optimal cut-off level. However, most foods of this type – chocolate chip cookies, cinnamon buns, etc. – are high in fat and sugar and, hence, calories, resulting in low sodium-to-calorie ratios. Therefore, the results should be interpreted with caution. Comprehensive and specific benchmarks for different food types would support sodium reduction across the U.S. food supply.

The intent of this paper is not to compare sodium levels among food items or food types because the Sentinel Foods list includes foods whose uses and amounts consumed vary widely. However, health professionals and consumers may find ranking similar foods within food types helpful in making educated food choices. For example, within the savory snacks and crackers category, plain tortilla chips have one-fourth the sodium per serving (93 $\pm$ 3.122 mg) of hard pretzels (352 $\pm$ 7.227 mg). In addition, we observed a wide range of sodium content among brands. Some of the higher CVs by food type are due to our grouping of foods with varied sodium content and serving sizes and the inclusion of some condensed and dried forms of foods in the soup and grain-based mixed dishes category. In general, foods with one predominant brand, such as soy sauce had low variability, and foods for which private (store) brands had high market share, such as coleslaw and rotisserie chicken had high variability. However, many Sentinel Foods for which only national brands were analyzed as they represented the highest market shares also had high CVs, for example, canned tomatoes and barbecue sauce. For 25 of the 125 Sentinel Foods, the brand with the highest sodium level had about twice the sodium than the brand with the lowest sodium content. For example, for canned tomatoes, the highest sodium brand was almost 4.5 times the lowest sodium brand. Awareness of varying levels of sodium in foods and food types can help consumers and health professional to make or guide patients to make better food choices. For example, for taco shells, 4 of the 16 composite samples (store and national brands) did not have salt as an ingredient or for savory snacks and crackers category, the sodium per serving ranged from 52 mg in one of the tortilla chips brand to 466 mg in one of the brands of pretzels. The wide range of sodium content among brands with high market shares shows the potential for food manufacturers to reduce sodium values in their products while keeping these products acceptable to consumers. In addition, it reinforces the importance of reading labels for selecting products lower in sodium.

Study strengths and limitations

The major strength of the study is the use of nationwide sampling and laboratory analyses for determining baseline sodium and related nutrient values for the Sentinel Foods. This has improved the currency

Table 1
Baseline (2010–2013) sodium content in the U.S. by food type.[a]

Food type	Number of sentinel foods[b]	Number of analytical samples	Mean serving size for food type (g)		Energy (kcal) per 100 g	Sodium (mg) per 100 g		Sodium (mg) per serving			Sodium (mg) per kcal			
			Mean	Range	Mean (SEM)	Mean (SEM)	Range	CV%	Mean (SEM)	Range	CV%	Mean (SEM)	Range	CV%
Asian mixed dishes [c]	3	38	410.2	140.0–693.0	178 (8)	473 (15.912)	273–950	27	1888 (77.392)	561–6156	44	3.1 (0.149)	1.3–7.8	41
Breads, rolls, tortillas	6	80	50.8	25.8–99.0	318 (1)	490 (9.994)	11–818	30	253 (4.207)	3–474	42	1.7 (0.026)	0.0–2.8	34
Breakfast cereals	4	20	43.9	28.0–59.0	363 (1)	443 (5.883)	356–552	11	188 (2.193)	127–237	22	1.2 (0.015)	0.9–1.4	10
Cheese [d]	6	137	89	5.0–245.0	310 (1)	855 (13.43)	267–2350	48	683 (16.957)	72–2597	139	2.9 (0.042)	1.4–5.9	40
Condiments and sauces [d]	10	161	43.2	5.0–134.0	73 (1)	1031 (58.768)	336–5660	104	309 (8.398)	50–906	58	23.5 (1.251)	3.5–106.7	115
Cured meats/poultry [d]	9	125	44.8	15.0–56.8	274 (4)	1112 (27.126)	606–2020	32	477 (8.502)	201–1084	35	5.3 (0.195)	2.0–14.8	57
Grain based mixed dishes [c, e]	9	147	170.5	70.0–457.0	216 (2)	544 (8.879)	203–1670	53	721 (14.901)	295–2523	55	2.6 (0.033)	1.2–5.0	30
Meat and poultry mixed dishes [c]	3	29	207.9	182.0–242.0	164 (3)	409 (6.903)	324–500	11	858 (25.989)	590–1210	22	2.8 (0.115)	1.5–4.9	39
Meats	1	5	114	114.0–114.0	117 (4)	278 (19.164)	204–310	15	317 (21.847)	233–353	15	2.4 (0.218)	1.6–2.7	20
Mexican mixed dishes [c]	4	24	130.8	98.0–185.0	206 (3)	533 (17.592)	351–642	16	690 (42.797)	484–1062	30	2.6 (0.114)	1.6–3.4	21
Pizza [c]	5	60	184	139.0–236.0	274 (1)	574 (6.874)	446–878	18	1103 (15.057)	620–2002	29	2.1 (0.02)	1.7–2.9	14
Plant based protein foods [d]	5	79	96.3	28.4–148.0	292 (3)	393 (6.7)	253–681	19	371 (7.31)	88–771	55	2.3 (0.042)	0.5–4.8	63
Potato products	6	73	86.4	53.0–140.0	210 (2)	370 (6.937)	115–676	37	308 (6.393)	81–626	39	2 (0.05)	0.3–3.9	45
Poultry products [d]	8	88	116.6	85.2–184.0	271 (6)	654 (17.641)	152–1054	27	791 (16.558)	130–1693	45	2.4 (0.054)	1.2–4.6	23
Quick bread products [d]	5	57	67.5	51.0–120.0	325 (1)	685 (7)	258–1130	42	430 (3.84)	142–616	39	2.1 (0.022)	0.7–3.5	42
Salad dressings and mayonnaise	4	48	21.2	13.8–30.0	414 (3)	779 (3.593)	518–1060	21	177 (0.842)	71–312	46	2.3 (0.032)	0.8–4.8	51
Sandwiches [d]	6	72	115.6	78.0–155.0	260 (3)	590 (15.937)	389–790	16	672 (19.901)	386–1163	30	2.3 (0.08)	1.4–3.3	19
Savory snacks and crackers	9	119	25.1	14.9–31.6	493 (1)	734 (7.416)	184–1640	39	180 (1.942)	52–466	45	1.5 (0.015)	0.4–4.4	50
Seafood products	4	58	119.5	56.8–226.0	203 (4)	450 (23.918)	152–1400	58	643 (30.419)	86–2366	102	2.4 (0.074)	1.1–4.4	35
Soups [d, e]	6	83	150.9	43.5–249.0	123 (1)	756 (8.174)	248–2300	76	772 (14.526)	269–1118	24	20.6 (1.549)	3.6–122.6	144
Sweet bakery products	6	62	50.9	36.0–80.0	436 (2)	352 (4.101)	258–526	19	177 (2.844)	111–326	26	0.8 (0.014)	0.6–1.2	20
Vegetable products	6	82	148	67.5–243.0	53 (1)	205 (5.639)	43–464	40	303 (6.457)	51–714	65	7.6 (0.157)	0.6–22.6	77

CV, coefficient of variability; FDA, U.S. Food and Drug Administration

[a] Adapted from What We Eat In America Food Categories (USDAc, 2013)

[b] Sentinel Foods are 125 popular, sodium-contributing, commercially processed and restaurant foods in the U.S. that have sodium added during processing or preparation. These foods will serve as indicators to assess changes over time.

[c] All Sentinel Foods of this type exceed FDA limits for sodium for healthy foods (480 mg/serving and /RACC for individual foods with RACC > 30 g; 480 mg/50 g for individual foods with RACC ≤ 30 g; 600 mg for meal-type/main dishes) (FDA, 2014)

[d] Over half of the Sentinel Foods of this type exceed FDA limits for sodium for healthy foods.

[e] We sampled and analyzed dried or condensed forms for these products. The nutrient values are for the samples we analyzed.

and analytical basis of food composition databases in the U.S. In addition, use of laboratory analyses allows us to monitor changes that food manufacturers have made stealthily and nutrition facts panel may not reflect recently lowered sodium levels (Food Business News, 2013), and changes in the content of potassium and other nutrients whose levels FDA does not currently require to be declared on the Nutrition Facts Panel (FDA, 1994). We sampled major national and private brands, aiming to represent 70–80% of the market share. In the United States, for most food items, a few brands may represent the major share of the market (Ahuja and Thomas, 2013 and Gillespie et al., 2015). An additional strength is the use of dietary intake data from the nationwide survey for selecting Sentinel Foods. These foods are responsible for a major share of sodium intakes in the United States, although they do not include all sodium-contributing foods.

This study has several limitations. The numbers of Sentinel Foods and analytical samples were limited due to the high cost of nationwide sampling and laboratory analysis (Ahuja et al., 2015). We assigned serving sizes to each food item rather than to each composite, influencing the expression of variability in sodium content per serving. The results from this study are limited to the U.S. only, as there is variability in sodium content of similar packaged and restaurant foods across countries (World Action on Salt and Health, 2009 and Dunford et al., 2012). Furthermore, the extrapolation of criteria for diet quality of sodium less than 1.1 mg/kcal for individual foods has not been validated.

Conclusion

The analytical data that this study generated provide baseline sodium values for the USDA-led Sentinel Food sodium-monitoring program. The results from this program along with results from a CDC-led monitoring program (Gillespie et al., 2015) will help public health officials focus sodium-reduction efforts. The study has improved food composition databases and subsequent monitoring of sodium intakes in the United States. The baseline estimates show that the sodium levels are high and variable. A plan of action with targeted benchmarks developed collaboratively by food manufacturers and public health officials is needed to reduce sodium in the U.S. food supply. In addition, increased awareness of the high sodium content and variability in foods and large serving sizes at fast-food outlets and restaurants is important for consumers and health professionals because of their impact on sodium intakes.

Conflict of interest

The authors declare that there are no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.pmedr.2015.11.003.

References

Aburto, N.J., Ziolkovska, A., Hooper, L., Elliott, P., Cappuccio, F.P., Meerpohl, J., 2013. Effect of lower sodium intake on health: systematic review and meta-analyses. Br. Med. J. 346 (f1326), 1–20.
Ahuja, J.K., Thomas, R., 2013. Consumer sales data provide a useful tool for managing databases monitoring the U.S. food supply Internet: http://www.nutrientdataconf.org/PastConf/NDBC37/NNDC37_PosterAbstracts.pdf (accessed 13 February 2015).
Ahuja, J.K.C., Moshfegh, A.J., Holden, J.M., Harris, E., 2013. USDA food and nutrient databases provide the infrastructure for food and nutrition research, policy, and practice. J. Nutr. 143, 241S–249S.
Ahuja, J., Pehrsson, P., Haytowitz, D., et al., 2015. Monitoring sodium in commercially processed and restaurant foods. Am. J. Clin. Nutr. 101, 622–631. http://dx.doi.org/10.3945/ajcn.114.084954.
Arcand, J., Au, J.T.C., Schermel, A., L'Abbe, M.R., 2014. A comprehensive analysis of sodium levels in the Canadian packaged food supply. Am. J. Prev. Med. 46, 633–642.
City of New York, 2013. National Salt Reduction Initiative Internet: http://www.nyc.gov/html/doh/html/diseases/salt.shtml (accessed February 23, 2015).
Cogswell, M.E., Zhang, Z.F., Carriquiry, A.L., et al., 2012. Sodium and potassium intakes among US adults: NHANES 2003–2008. Am. J. Clin. Nutr. 96, 647–657.
Cohen, D.A., Story, M., 2014. Mitigating the health risks of dining out: the need for standardized portion sizes in restaurants. Am. J. Public Health 104 (4), 586–590.
ConAgra Foods, 2009. ConAgra to reduce sodium in products by 20 percent by 2015 Internet: http://www.conagrafoods.com/news-room/news-ConAgra-Foods-to-Reduce-Sodium-in-Products-by-20-Percent-by-2015-1342465 (accessed 13 February 2015).
Drewnowski, A., Rehm, C.D., 2013. Sodium intakes of U.S. children and adults from foods and beverages by location of origin and by specific food source. Nutrients 5, 1840–1855.
Dunford, E., Webster, J., Woodward, M., et al., 2012. The variability of reported salt levels in fast foods across six countries: opportunities for salt reduction. CMAJ 184, 1023–1028.
Eyles, H., Webster, J., Jebb, S., Capelin, C., Neal, B., Mhurchu, C.N., 2013. Impact of the UK voluntary sodium reduction targets on the sodium content of processed foods from 2006 to 2011: analysis of household consumer panel data. Prev. Med. 57, 555–560.
Food Business News, . Shhh! Sodium reduction in progress, 2013 Internet: http://www.foodbusinessnews.net/articles/news_home/Consumer_Trends/2013/10/Shhh_Sodium_reduction_in_progr.aspx?ID=%7B1D24AAE5-DF99-4070-86A1-C945A9C37E85%7D (accessed 13 February 2015).
Gillespie, C., Maalouf, J., Yuan, K., et al., 2015. Sodium content in major brands of U.S. packaged foods, 2009. Am. J. Clin. Nutr. 101, 344–353.
Grimes, C.A., Nowson, C.A., Lawrence, M., 2008. An evaluation of the reported sodium content of Australian food products. Int. J. Food Sci. Technol. 43, 2219–2229.
Guenther, P.M., Casavale, K.O., Reedy, J., et al., 2013. Update of the healthy eating index: HEI-2010. J. Acad. Nutr. Diet. 113, 669–680.
Institute of Medicine, 2010. Strategies to Reduce Sodium Intake in the United States. The National Academies Press, Washington, DC.
Institute of Medicine, 2013. Sodium Intake in Populations: Assessment of Evidence. The National Academies Press, Washington, DC.
Jacobson, M.F., Havas, S., McCarter, R., 2013. Changes in sodium levels in processed and restaurant foods, 2005 to 2011. J. Am. Med. Assoc. Intern. Med. 173, 1285–1291.
Johnson, C.M., Angell, S.Y., Lederer, A., et al., 2010. Sodium content of lunchtime fast food purchases at major US chains. Arch. Intern. Med. 170, 732–734.
Levings, J., Cogswell, M., Curtis, C.J., Gunn, J., Neiman, A., Angell, S.Y., 2012. Progress toward sodium reduction in the United States. Rev. Panam. Salud Publica 32, 301–306.
Mattes, R.D., Donnelly, D., 1991. Relative contributions of dietary sodium sources. J. Am. Coll. Nutr. 10, 383–393.
McDonald's USA, 2011. Commitments to offer improved nutrition choices Internet: http://news.mcdonalds.com/Corporate/manual-releases/2011/McDonald-s-USA–Commitments-to-Offer-Improved-Nutr (accessed 13 February 2015).
Pehrsson, P.R., Haytowitz, D.B., Holden, J.M., 2003. The USDA's Food and Nutrient Analysis Program: Update 2002. J. Food Compos. Anal. 16, 331–341.
Pehrsson, P.R., Perry, C., Daniel, M., 2013. ARS, USDA updates food-sampling strategies to keep pace with demographic shifts. 36th Annual National Nutrient Databank Proceedings. Procedia Food Science 2, pp. 52–59 (Internet: http://www.sciencedirect.com/science/article/pii/S2211601X13000102 (accessed 13 February 2015)).
Phillips, K.M., Patterson, K.Y., Rasor, A.S., et al., 2006. Quality-control materials in the USDA National Food and Nutrient Analysis Program (NFNAP). Anal. Bioanal. Chem. 384, 1341–1355.
PR Newswire, 2012. Kraft Foods on track to meet sodium reduction goals across North American product portfolio Internet: http://www.prnewswire.com/news-releases/kraft-foods-on-track-to-meet-sodium-reduction-goals-across-north-american-product-portfolio-171344191.html (accessed 13 February 2015).
Trainer, D., Pehrsson, P.R., Haytowitz, D.B., et al., 2010. Development of sample handling procedures for foods under USDA's National Food and Nutrient Analysis Program. J. Food Compos. Anal. 23, 843–851.
U.S. Centers for Disease Control and Prevention, 2010. Heart disease and stroke prevention: addressing the nation's leading killers: At a glance 2011 Internet: http://www.cdc.gov/chronicdisease/resources/publications/aag/dhdsp.htm (accessed 13 February 2015).
U.S. Centers for Disease Control and Prevention, 2012. Food categories contributing the most to sodium consumption — United States, 2007–2008. MMWR Morb. Mortal. Wkly Rep. 61, 92–98.
U.S. Department of Agriculture, Agricultural Research Service, 2013. What We Eat In America Food Categories 2009–2010 Internet: www.ars.usda.gov/ba/bhnrc/fsrg (accessed 13 February 2015).

U.S. Department of Agriculture, Agricultural Research Service, 2014. USDA Food and Nutrient Database for Dietary Studies 2011–2012 Internet: http://www.ars.usda.gov/ba/bhnrc/fsrg (accessed 13 February 2015).
U.S. Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory, 2014. USDA National Nutrient Database for Standard Reference, Release 27 Internet: http://www.ars.usda.gov/ba/bhnrc/ndl (accessed 13 February 2015).
U.S. Department of Agriculture, U.S. Department of Health and Human Services, 2010a. What We Eat in America, NHANES 2007–2008 data: Dietary interview – total nutrients intakes – first day (DR1TOT_C) Internet: http://www.cdc.gov/nchs/nhanes/nhanes2007-2008/DR1TOT_E.htm (accessed 13 February 2015).
U.S. Department of Agriculture, U.S. Department of Health and Human Services, 2010b. Dietary guidelines for Americans 2010. 7th edition. U.S. Government Printing Office, Washington, DC.
U.S. Food and Drug Administration, 1994. Guidance for industry: a food labeling guide Published 1994 http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm2006828.htm (Accessed October 14, 2015).
U.S. Food and Drug Adminstration, 2014. Title 21 — Foods and Drugs, Chapter I — Food and Drug Adminstration, Part 101 — Food Labeling, Subpart D — Specific Requirements for Nutrient Content Claims Published 2014 http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=101.61 (Accessed May 6, 2015).
World Action on Salt and Health, 2009. New research reveals huge differences in salt contents in global brands 23 July http://www.worldactiononsalt.com/less/surveys/2009/international/index.html (Accessed October 19, 2015).
Wu, H.W., Sturm, R., 2014. Changes in the energy and sodium content of main entrees in US chain restaurants from 2010 to 2011. J. Acad. Nutr. Diet. 114, 209–219.
Young, L.R., Nestle, M., 2012. Reducing portion sizes to prevent obesity: a call to action. Am. J. Prev. Med. 43 (5), 565–568.