

ONLINE FIRST | HEALTH CARE REFORM

Changes in Sodium Levels in Processed and Restaurant Foods, 2005 to 2011

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Importance: Excess consumption of sodium is an important cause of hypertension, a major risk factor for heart disease and stroke. The higher the level of consumption, the greater is a person's likelihood of developing hypertension. Numerous organizations have recommended reductions in sodium intake in the United States. Roughly 80% of the sodium consumed by Americans has been added by food manufacturers and restaurants.

Objective: To compare the mean (SD) levels of sodium for identical products ascertained in 2005, 2008, and 2011.

Design and Setting: Comparison study in an academic research setting.

Participants and Exposures: Center for Science in the Public Interest staff have monitored sodium levels in selected processed foods and fast-food restaurant foods for many years.

Main Outcomes and Measures: The sodium content in identical foods, as measured in 2005, 2008, and 2011.

Results: Between 2005 and 2011, the sodium content in 402 processed foods declined by approximately 3.5%, while the sodium content in 78 fast-food restaurant products increased by 2.6%. Although some products showed decreases of at least 30%, a greater number of products showed increases of at least 30%. The predominant finding is the absence of any appreciable or statistically significant changes in sodium content during 6 years.

Conclusions and Relevance: Based on our sample, reductions in sodium levels in processed and restaurant foods are inconsistent and slow. These findings are in accord with other data indicating the slow pace of voluntary reductions in sodium levels in processed and restaurant foods. Stronger action (eg, phased-in limits on sodium levels set by the federal government) is needed to lower sodium levels and reduce the prevalence of hypertension and cardiovascular diseases.

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HIGH BLOOD PRESSURE, DEFINED as a systolic blood pressure of at least 140 mm Hg or a diastolic blood pressure of at least 90 mm Hg, is a major risk factor for heart disease and stroke. More than 65% of adults in the United States have blood pressure levels higher than optimal, defined as levels of less than 120 mm Hg systolic or 80 mm Hg diastolic.¹ The estimated 70 million persons with blood pressure levels between 120 and 139 mm Hg systolic or 80 to 89 mm Hg diastolic have a 1.5 to 2.5 times greater risk of having a heart attack, a stroke, or heart failure in 10 years than those with normal blood pressure levels.² For every increase of 20 mm Hg in systolic blood pressure above 115/75 mm Hg, the risk of death from coronary heart disease and stroke doubles.³

Hypertension affects almost 75 million American adults and represents an even greater risk.¹ In the United States, the prevalence of hypertension rises dramatically with increasing age; the lifetime probability of developing hypertension is perhaps as high as 90%.⁴ Persons of black race/

See editorial comment

ethnicity have higher blood pressure levels than persons of white race/ethnicity, which is one of several contributors to their higher mortality rates from cardiovascular diseases.¹ Less than 50% of hypertension is controlled to levels below 140/90 mm Hg, usually through the use of medications.⁵ Although controlling high blood pressure reduces the risk of developing

heart disease and stroke, the risk remains higher than for those who have a normal blood pressure level naturally.

Hypertension is a largely preventable risk factor.⁶ The guidelines of the National Heart, Lung, and Blood Institute recommend the following 5 approaches to prevent hypertension: (1) reduction of sodium intake, (2) weight reduction in persons who are overweight, (3) regular physical activity, (4) moderation of alcohol intake, and (5) an eating plan that is rich in fruits, vegetables, and low-fat dairy products and reduced in saturated fat, total fat, and cholesterol.⁶ Because of the high prevalence of elevated blood pressure levels and the associated mortality and morbidity, effective public health interventions that will lead to populationwide reductions in blood pressure are urgently needed. Reduction in sodium intake represents the approach most readily amenable to a public health solution.

There is a clear relationship between habitual sodium intake and blood pressure levels. A National Heart, Lung, and Blood Institute workshop report concluded: "There is an abundance of scientific evidence demonstrating a direct relation between salt intake and [blood pressure]."^{7(p858)} The workshop called the evidence conclusive. This evidence includes numerous animal studies, observational studies, and randomized clinical trials.⁷⁻¹⁴

The World Health Organization also characterizes the evidence linking excess sodium intake to cardiovascular diseases as conclusive.⁸ Others refer to the evidence linking excess sodium consumption to hypertension as overwhelming and state that excess sodium is the primary cause of hypertension.⁹ The evidence that excess sodium intake is a major cause of hypertension was recently reaffirmed by the American Heart Association.¹⁰

Reducing sodium consumption represents an urgent public health need. According to one estimate, at least 150 000 premature deaths per year could be averted in the United States if the sodium content of packaged and restaurant foods was reduced by 50%.¹¹ The US Department of Agriculture and US Department of Health and Human Services,¹² the American Medical Association,¹³ the American Heart Association,¹⁴ the American Public Health Association,¹⁵ the World Health Organization,⁸ and numerous other organizations have called for steep reductions in sodium consumption.

The *Dietary Guidelines for Americans, 2010* advises the following groups to consume no more than 1500 mg/d of sodium¹²: middle-aged or older adults, persons of black race/ethnicity, and people with hypertension, diabetes mellitus, or chronic kidney disease. These groups constitute about two-thirds of all adults.¹⁶ The guidelines advise all other individuals 2 years or older to consume less than 2300 mg/d of sodium.¹² The American Heart Association went further, recommending that Americans 2 years or older should consume no more than 1500 mg/d of sodium.¹⁴ The American Public Health Association made a similar recommendation for sodium intake and adopted a resolution calling for a 75% reduction of sodium in processed and restaurant foods during the next decade, the amount necessary to enable Americans to consume no more than 1500 mg/d of sodium.¹⁵

Current per capita sodium consumption of American adults is about 3300 mg/d.¹⁶ Including salt added in

cooking and at the table and adjusting for underestimates of food consumption bring actual consumption closer to 3800 mg/d. Less than 1% of the population consumes less than 1500 mg/d.¹⁶

Consumer use of the saltshaker provides only about 11% of sodium, and another 12% of sodium occurs naturally in foods.¹⁷ The remainder, almost 80%, comes from salt and, to a lesser extent, from other sodium-containing ingredients (sodium bicarbonate, monosodium glutamate, sodium citrate, and others) added during the processing and preparation of packaged and restaurant foods. It is for that reason that public and private health agencies have called on the food industry to voluntarily reduce sodium levels in their products, at least since the 1969 White House Conference on Food, Nutrition, and Health.¹⁸

Unfortunately, as an Institute of Medicine (IOM) committee concluded in 2010, voluntary reductions have been ineffective.¹⁹ Americans consumed almost a 1200 mg/d (43%) more sodium in 2007 and 2008²⁰ than in the early 1970s,²¹ with some of that increase being due to increased food consumption. Changes in survey methods might also account for some of the increase. Based on the advice of the IOM that the Food and Drug Administration should set gradually decreasing limits on sodium in processed and restaurant foods, the Food and Drug Administration has been considering its options for several years. The food industry contends that voluntary reductions are preferable to regulatory limits.

Because of recommendations that virtually all Americans should reduce their consumption of sodium and because most of the sodium they consume comes from processed and restaurant foods, it is important to assess whether the levels of sodium from those sources is changing. The Center for Science in the Public Interest previously monitored the sodium content of a small sample of approximately 100 processed foods. They found little change from 1983 to 2004 in sodium content.²² In this article, we assess the magnitude of changes in sodium levels in a larger sample of 480 processed and restaurant foods between 2005 and 2011.

METHODS

In 2005, Center for Science in the Public Interest staff ascertained from Nutrition Facts labels the sodium content of commonly eaten processed foods found at 3 supermarkets (GIANT Food store, Safeway, and Whole Foods Market) in Washington, DC, and one Walmart in Elverston, Pennsylvania. For this article, the authors categorized 402 foods still marketed in 2011 into 11 food categories (eg, baked goods, dairy products, and meats) with 88 subcategories (eg, white bread, whole wheat bread, and white tortilla chips). There were 1 to 13 brands per subcategory. Brands included national brands and store brands offered by conventional, upscale, and low-priced supermarkets.

Because the purpose of the initial survey was to estimate progress in lowering sodium where there was ample opportunity to do so, the sample emphasized commonly consumed food categories that had substantial variations in sodium content among the different brands, although categories with little variation in sodium content were also included. Consistent with the focus on opportunities to lower sodium intake in the American mainstream diet, products marketed as low sodium or sodium

Table 1. Sodium Levels per 100 g of Product in 28 Food Subcategories

Product	Sodium Level per 100 g, Mean (SD), mg			Change Between 2005 and 2011, %
	2005	2008	2011	
Processed Foods				
Bacon, smoked (n = 8)	1861 (316)	1815 (225)	1803 (210)	-3.1
Barbecue sauce, original and honey (n = 12)	930 (184)	929 (244)	989 (250)	6.3
Bread, 100% whole wheat (n = 7)	476 (74)	491 (73)	493 (78)	3.6
Bread, white (n = 8)	515 (91)	510 (81)	500 (76)	-2.9
Cheese, cheddar, sliced (n = 5)	770 (264)	771 (264)	645 (21)	-16.2
Chicken, fresh or frozen (n = 6)	77 (25)	68 (23)	77 (28)	0
Hot dogs (n = 8)	985 (129)	966 (117)	927 (120)	-5.9
Macaroni and cheese (n = 4)	824 (54)	868 (108)	831 (22)	0.8
Pizza, cheese (n = 7)	522 (107)	501 (97)	521 (99)	-0.2
Pizza, pepperoni (n = 8)	589 (135)	583 (88)	560 (67)	-4.9
Pork, fresh or frozen (n = 7)	255 (80)	254 (80)	186 (31)	-27.1
Pork sausage, plain, maple or brown sugar, hot, and sage (n = 14)	839 (210)	821 (131)	822 (128)	-2.0
Potato chips and crisps (n = 8)	546 (108)	594 (115)	547 (93)	0.2
Salad dressing, Caesar (n = 11)	1041 (330)	995 (256)	1079 (213)	3.7
Salsa, medium (n = 8)	610 (184)	611 (184)	611 (184)	0.2
Sauce, spaghetti, tomato, marinara, traditional (n = 13)	421 (123)	417 (81)	407 (81)	-3.3
Soup, tomato (n = 4)	310 (55)	329 (83)	286 (8)	-7.7
Soup, vegetable (n = 4)	308 (56)	297 (73)	243 (51)	-21.1
Tomatoes, canned, diced (n = 6)	224 (58)	213 (56)	174 (52)	-22.3
Tuna fish, white albacore, canned, packed in water (n = 4)	337 (130)	283 (74)	261 (62)	-22.6
Turkey breast, sliced, deli (n = 9)	1124 (165)	937 (109)	878 (170)	-21.9
Restaurant Foods				
Cheeseburgers, all sizes (n = 7)	554 (79)	560 (80)	568 (97)	2.5
Chicken strips or tenders (n = 5)	738 (145)	732 (127)	736 (77)	-0.3
French fries, medium (n = 5)	396 (242)	467 (219)	503 (266)	27.0
Grilled chicken sandwiches (n = 4)	493 (100)	494 (76)	525 (100)	6.5
Hamburgers, all sizes (n = 7)	442 (56)	438 (66)	428 (68)	-3.2
Pizza, cheese, hand-tossed style (n = 4)	484 (97)	495 (117)	541 (117)	11.8
Sausage biscuits, breakfast (n = 4)	840 (226)	946 (69)	895 (26)	6.5

free were not included. Fresh produce, soft drinks, bottled waters, alcoholic beverages, and other products that were unbranded or contained low levels of sodium by nature were not included.

The survey was first conducted in 2005 and then repeated in 2008 and 2011. Only foods that were marketed in all 3 years are included in this study (86 products identified in 2005 were no longer available in 2008 or 2011). Center for Science in the Public Interest staff also identified 78 restaurant foods that are comparable between restaurants such as thin cheese pizzas, french fries, and grilled chicken sandwiches. The 8 categories of foods were divided into 27 subcategories. Sodium contents were obtained from the websites of large chain restaurants (Arby's, Au Bon Pain, Blimpie, Burger King, Chick-fil-A, Domino's Pizza, Hardee's, Jack in the Box, KFC, Little Caesars Pizza, McDonald's, Panera Bread, Papa John's Pizza, Pizza Hut, SUBWAY, and Wendy's). These levels were also ascertained in 2005, 2008, and 2011.

The processed and restaurant food categories included 159 products that were in the following top 5 sources of sodium consumed in the United States: bread and rolls (n=39), cold cuts or cured meats (n=31), pizza (n=28), poultry (n=32), and soups (n=29).²³ Sandwiches, frozen dinners, and other multi-ingredient products that did not consist primarily of these 5 types of food were not included in those 159 products.

For both processed and restaurant foods, the mean (SD) levels of sodium were calculated for each subcategory of products. A representative sample of subcategories was selected for inclusion in this article. After performing normalizing (log) transformations to correct for data skewing and back transforming

to the original units, we computed for each period the mean (95% CI) sodium level per 100 g of product. We also assessed the number of foods that had changes in sodium levels that represented increases of at least 5% or at least 30% or did not change.

Implementation of a log transformation is a standard statistical procedure to allow data that are right skewed to meet the normality assumption that underlies statistical comparisons based on the means.^{24,25} If the normalizing log transformation, which is applied to the raw data and affects the means (95% CIs), is not applied to right-skewed data, the means (95% CIs) will be overestimated. Before any data were included in the tables, the means (95% CIs) were back transformed by taking the antilog of results expressed in log units, to return the estimates to the original units.

RESULTS

Of the partial list of food categories surveyed that are given in **Table 1**, smoked bacon had the most sodium of food categories surveyed, followed by Caesar salad dressing. Additional food categories are given in the eTable (<http://www.jamainternalmed.com>). **Table 2** summarizes the overall mean (95% CI) sodium levels in the 3 survey years. Based on these results, we computed the percentage change in each period and the total period. In processed foods, there were small decreases in the mean sodium levels of 1.0% between 2005 and 2008 and 2.5% between 2008 and 2011. The total decrease from 2005 to

2011 was 3.5%, or about 0.5% per year. In restaurant foods, there were slight increases in the mean sodium levels of 1.6% between 2005 and 2008 and 1.0% between 2008 and 2011. The total increase was 2.4%, or 0.3% per year. The sodium levels of all foods for each of the 3 years are available elsewhere.²⁶ Despite narrow confidence limits, none of the aforementioned changes were greater than could be explained on the basis of chance variation. The evidence is most consistent with a lack of any substan-

tial or statistically significant changes in sodium levels across the 6 years.

The sodium content of different brands in a given food category varied widely (eg, one brand of tomato paste had a 5.2-fold higher level than the brand with the lowest sodium). Table 1 gives the means for 28 processed food and 7 restaurant food subcategories in 2005, 2008, and 2011.

The **Figure** shows the small amount of change overall between 2005 and 2011. Of 402 processed food products monitored in both 2005 and 2011, sodium decreased in 168 (41.8%), increased in 119 (29.6%), and did not change in 115 (28.6%). The decreases were at least 5% in 128 products (31.8%) and at least 30% in 25 products (6.2%). The increases were at least 5% in 90 products (22.4%) and at least 30% in 28 products (7.0%). Of 78 restaurant foods monitored in both 2005 and 2011, sodium decreased in 33 (42.3%), increased in 43 (55.1%), and did not change in 2 (2.6%). The decreases were at least 5% in 26 products (33.3%) and at least 30% in 1 product (1.3%). The increases were at least 5% in 29 products (37.2%) and at least 30% in 6 products (7.7%).

Several major companies have committed to lowering sodium levels in some products over the next several years. A sampling of those commitments is given in **Table 3**.

Table 2. Sodium Levels per 100 g of Product in 2005, 2008, and 2011^a

Survey Year	No. of Products	Sodium Level per 100 g, Mean (95% CI), mg
Processed Foods		
2005	402	575 (537-616)
2008	402	569 (532-610)
2011	402	555 (517-595)
Restaurant Foods		
2005	78	493 (455-536)
2008	78	501 (462-543)
2011	78	505 (466-548)

^aThese data were obtained after first performing a log transformation to normalize the data and then back transforming to the original units.

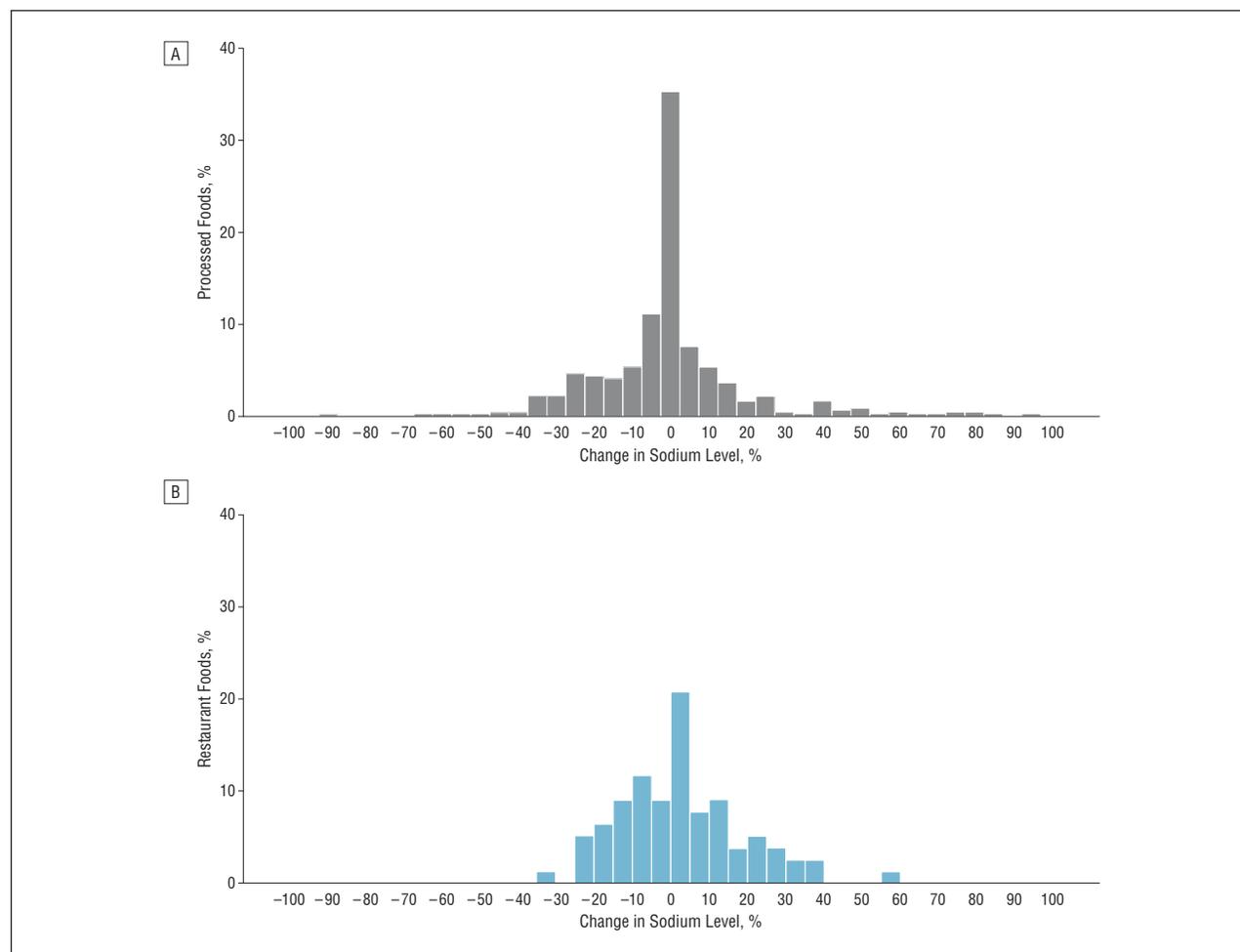


Figure. Distribution of percentage changes in sodium level in processed and restaurant foods, 2005 to 2011. One extreme point, denoting a rise in sodium level above 200%, was removed to avoid distortion.

Table 3. Company Commitments to Reduce Sodium Levels^a

Company	Action
Campbell's Soup	Reduce sodium by 25% in 84 Pepperidge Farm bagels, breads, and rolls
ConAgra Foods	Reduce sodium content of 160 products (including Chef Boyardee, EggBeaters, Healthy Choice, Hunt's, Hebrew National, and Peter Pan) by 20% by 2015
Domino's Pizza	Sodium in Pizza Smart Slice for schools will be cut by 1/3
General Mills	Reduce sodium by 20% in cereals, soups, snacks, and other products (400 products, or 40% of products)
Hormel Foods Corporation	Reduce sodium on average by 15% from entire portfolio by 2015
McDonald's	Reduce sodium by 15% across entire menu of foods by 2015
Smithfield Hams	Reduced sodium levels in marinated pork category by a mean of 25.5%
Sodexo, Inc	Reduce the mean sodium content in the top 100 recipes by 25% by 2013 and by 50% by 2016
SUBWAY	Reduce sodium content in Fresh Fit sandwich line by 28% and in overall sandwich line by 15%
Walmart	Reduced sodium by 70% in fresh steaks and roasts, reduced sodium in canned vegetables and ketchup by a mean of 15%, called on suppliers to reduce sodium content of thousands of processed foods by 25% by 2015

^aInformation was obtained from company announcements.

DISCUSSION

Changes in sodium levels by the food processing and restaurant industries have been minimal. Indeed, although the sodium content of some processed foods in the sample declined by at least 30% between 2005 and 2011, a greater number of foods increased in sodium content by at least 30%. While the mean sodium content of 402 processed foods declined by 3.5%, the mean sodium content of 78 restaurant foods increased by 2.6%.

Given the modest number of products sampled, it is uncertain whether these changes are reflective of the overall food supply. However, as noted above, the categories surveyed included numerous products representative of the top 5 sources of sodium consumed in the United States, and most of the products were widely available national brands, were house brands of major supermarket chains, or were sold by major fast-food restaurants. The slowness of change indicates why the IOM concluded in 2010 that voluntary efforts since 1969 to lower sodium levels have failed and stated that government regulations were necessary to accomplish meaningful reductions.¹⁹

In processed foods, the observed 0.5% mean decrease per year indicates that it would take a long period to lower sodium intake by about 50% from the current 3800 mg/d to the recommended 1500 to 2300 mg/d for most adults. The American Heart Association, the American Public Health Association, and the Dietary Guidelines Advisory Committee²⁷ all recommended that the entire population should consume no more than 1500 mg/d, a target that would take even longer to attain. Worse, the

increase in sodium observed in restaurant foods is distressing given that 33% of calories are obtained from and 42% of the food dollar is spent on food purchased from restaurants and other sites outside of the home.^{28,29}

We found wide variations within numerous food categories. For instance, in 2011, McDonald's Quarter Pounder With Cheese sandwich had 34% more sodium per 100 g (198 g [1190 mg]) than Burger King's similar Original Whopper With Cheese sandwich (315 g [1410 mg]). Burger King's French Fries (medium serving of 148 g [670 mg]) had 98% more sodium per 100 g than McDonald's French Fries (medium serving of 117 g [270 mg]). Examples like those demonstrate that many companies could easily lower sodium levels and still have highly marketable foods. In some countries, the same food processing companies and the same restaurant chains have lowered sodium levels in otherwise identical products much further than they have in the United States.^{30,31}

The scientific research demonstrating the critical need to lower sodium consumption has led to 2 important developments. In 2010, the New York City Department of Health and Mental Hygiene created the National Salt Reduction Initiative, now supported by more than 70 cities, states, and national health organizations.³² Their goal is to persuade companies to lower sodium levels by a mean of 25% by 2014 and, consequently, to lower sodium intake by 20%.

Also in 2010, the IOM report advised the Food and Drug Administration to take regulatory actions.¹⁹ Those actions, as well as substantial national publicity about the dangers of high-sodium diets, have led several major companies to commit to lowering sodium levels in some products over the next several years (Table 3). Another promising development is that the nation's largest supermarket chain, Walmart, has called on its suppliers by 2015 to lower sodium levels in their products by 25%.³³

However, even if fulfilled, these commitments would not nearly address the amount of necessary reduction. Most Americans need to consume far less salt and other sodium-containing ingredients to achieve recommended sodium limits. That will be challenging, considering that decreasing the average daily intake from 3800 mg to 1500 mg would require companies to make major reductions in the sodium content of their products over several years (>70%) and for consumers to eat less cheese, bread, pizza, processed meats, and other major sources of sodium. The only way to achieve that reduction is for manufacturers to gradually and substantially reduce sodium levels over several years.

To our knowledge, this is the only survey that provides information on the sodium level of several hundred individual products over time. A particular strength of the survey is that the foods were chosen without any knowledge of possible future reformulations. Another strength is that the survey includes many foods from the top 5 sources of sodium consumption in the United States. Weaknesses include the following: (1) the sample of 402 processed foods and 78 restaurant products represents only a small fraction of the 15 000 to 60 000 products (including nonfood items and several sizes of many foods) available in supermarkets³⁴ and additional thousands sold by restaurants; (2) the period surveyed was only 6 years; (3) not all brands

and food categories were included; (4) only chain restaurants' products were included; (5) the survey does not capture new, lower-sodium foods; and (6) the data were not sales weighted, so changes in small-selling and large-selling products counted equally. Ideally, large, national, sales-weighted, prospective surveys should be conducted, enabling identification of companies that are making particularly good or poor progress and food categories that represent special challenges.

As the IOM concluded after reviewing dietary intake surveys over recent decades,¹⁹ voluntary action has failed to reduce sodium levels in foods to any meaningful extent. Our survey of 480 foods monitored between 2005 and 2011 leads to the same conclusion. The result of that inaction is that consumption of sodium remains at undesirably high levels. Given the high levels in processed and restaurant foods, it is difficult for consumers to lower their sodium intake. The IOM recommended that, to reduce the risk of cardiovascular disease, the Food and Drug Administration should set maximum use levels based on what is feasible for different categories of foods and gradually lower them.

A traditional recommendation among physicians for treating and preventing high blood pressure is to counsel patients on reducing sodium intake.³⁵ While in an ideal world that recommendation would be sufficient to lower blood pressure in the patient population, in the real world it places unrealistic demands on both patients and physicians given the high sodium levels present in processed and restaurant foods. A recent study³⁶ showed that, although most adults with hypertension received advice to lower sodium intake from their physician, actual intake was more than twice the levels currently recommended. To protect the health of our patients, prompt, strong regulatory action to lower levels of sodium in processed and restaurant foods is necessary. Those limits should be lowered gradually over the next 10 years to ensure that we meet at least a 50% reduction in sodium intake.

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Online-Only Material: The eTable is available at <http://www.jamainternalmed.com>.

REFERENCES

1. Roger VL, Go AS, Lloyd-Jones DM, et al; American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Executive summary: heart disease and stroke statistics—2012 update: a report from the American Heart Association [published correction appears in *Circulation*. 2012;125(22):e1001]. *Circulation*. 2012;125(1):188-197.
2. Vasan RS, Larson MG, Leip EP, et al. Impact of high-normal blood pressure on the risk of cardiovascular disease. *N Engl J Med*. 2001;345(18):1291-1297.
3. Lewington S, Clarke R, Qizilbash N, Peto R, Collins R; Prospective Studies Collaboration. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. *Lancet*. 2002;360(9349):1903-1913.
4. Vasan RS, Beiser A, Seshadri S, et al. Residual lifetime risk for developing hypertension in middle-aged women and men: the Framingham Heart Study. *JAMA*. 2002;287(8):1003-1010.
5. Egan BM, Zhao Y, Axon RN. US trends in prevalence, awareness, treatment, and control of hypertension, 1988-2008. *JAMA*. 2010;303(20):2043-2050.
6. Whelton PK, He J, Appel LJ, et al; National High Blood Pressure Education Program Coordinating Committee. Primary prevention of hypertension: clinical and public health advisory from the National High Blood Pressure Education Program. *JAMA*. 2002;288(15):1882-1888.
7. Chobanian AV, Hill M. National Heart, Lung, and Blood Institute Workshop on Sodium and Blood Pressure: a critical review of current scientific evidence. *Hypertension*. 2000;35(4):858-863.
8. WHO Forum on Reducing Salt Intake in Populations. *Reducing Salt Intake in Populations: Report of a WHO Forum and Technical Meeting 5-7 October 2006, Paris, France*. Geneva, Switzerland: World Health Organization; 2008.
9. He FJ, MacGregor GA. Reducing population salt intake worldwide: from evidence to implementation. *Prog Cardiovasc Dis*. 2010;52(5):363-382.
10. Whelton PK, Appel LJ, Sacco RL, et al. Sodium, blood pressure, and cardiovascular disease: further evidence supporting the American Heart Association sodium reduction recommendations. *Circulation*. 2012;126(24):2880-2889.
11. Havas S, Roccella EJ, Lenfant C. Reducing the public health burden from elevated blood pressure levels in the United States by lowering intake of dietary sodium. *Am J Public Health*. 2004;94(1):19-22.
12. U.S. Department of Agriculture and U.S. Department of Health and Human Services. *Dietary Guidelines for Americans, 2010*. 7th ed. Washington, DC: US Government Printing Office; December 2010.
13. Dickinson BD, Havas S; Council on Science and Public Health, American Medical Association. Reducing the population burden of cardiovascular disease by reducing sodium intake: a report of the Council on Science and Public Health. *Arch Intern Med*. 2007;167(14):1460-1468.
14. Appel LJ, Frohlich ED, Hall JE, et al. The importance of population-wide sodium reduction as a means to prevent cardiovascular disease and stroke: a call to action from the American Heart Association. *Circulation*. 2011;123(10):1138-1143.
15. American Public Health Association. Implementing effective strategies to reduce sodium in the food supply. November 1, 2011. Policy 201120. <http://www.apha.org/advocacy/policy/policysearch/default.htm?id=1412>. Accessed March 21, 2013.
16. Centers for Disease Control and Prevention (CDC). Usual sodium intakes compared with current dietary guidelines—United States, 2005-2008. *MMWR Morb Mortal Wkly Rep*. 2011;60(41):1413-1417.
17. Mattes RD, Donnelly D. Relative contributions of dietary sodium sources. *J Am Coll Nutr*. 1991;10(4):383-393.
18. National Institutes of Health. Establishing guidelines for the nutrition of vulnerable groups (with special reference to the poor). http://www.nns.nih.gov/1969/full_report/White_House_Report2_S2.pdf. Accessed December 4, 2011.
19. Institute of Medicine. *Strategies to Reduce Sodium Intake in the United States*. Washington, DC: National Academies Press; 2010.
20. Hoy MK, Goldman JD, Murayi T, Rhodes DG, Moshfegh AJ. Sodium intake of the U.S. population: what we eat in America, NHANES 2007-2008. Food Surveys Research Group Dietary Data Brief 8. October 2011. http://www.ars.usda.gov/sp2userfiles/place/12355000/pdf/dbrief/sodium_intake_0708.pdf. Accessed March 29, 2013.
21. Briefel RR, Johnson CL. Secular trends in dietary intake in the United States. *Annu Rev Nutr*. 2004;24:401-431.
22. Grocery Manufacturers Association (GMA). Approaches to reducing sodium consumption. January 27, 2012. <http://www.regulations.gov/#!documentDetail;D=FDA-2011-N-0400-0355>. Accessed April 21, 2012.
23. Jacobson MF. Sodium content of processed foods: 1983-2004. *Am J Clin Nutr*. 2005;81(4):941-942.
24. Centers for Disease Control and Prevention (CDC). Vital signs: food categories

- contributing the most to sodium consumption—United States, 2007–2008. *MMWR Morb Mortal Wkly Rep*. 2012;61(5):92-98.
25. Bland JM, Altman DG. The use of transformation when comparing two means. *BMJ*. 1996;312(7039):1153.
 26. Center for Science in the Public Interest. *Salt Assault: Brand-name Comparisons of Processed Foods*. 2nd ed. <http://cspinet.org/new/pdf/saltupdatedec08.pdf>. Accessed March 25, 2013.
 27. Report of the DGAC (Dietary Guidelines Advisory Committee) on the Dietary Guidelines for Americans. Sodium, potassium, and water. 2010. <http://www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/DGAC/Report/D-6-SodiumPotassiumWater.pdf>. Accessed November 29, 2012.
 28. Morrison R, Mancino L, Variyam J. Will calorie labeling in restaurants make a difference? March 14, 2011. <http://www.ers.usda.gov/AmberWaves/March11/Features/CalorieLabeling.htm>. Accessed May 30, 2012.
 29. What We Eat in America, NHANES 2009-2010: Away from home. http://www.ars.usda.gov/SP2UserFiles/Place/12355000/pdf/0910/Table_9_AWY_GEN_09.pdf. Accessed March 25, 2013.
 30. Dunford E, Webster J, Woodward M, et al. The variability of reported salt levels in fast foods across six countries: opportunities for salt reduction. *CMAJ*. 2012; 184(9):1023-1028.
 31. World Action on Salt & Health. New research reveals huge differences in salt contents in global brands. July 23, 2009. <http://www.worldactiononsalt.com/less/surveys/2009/international/index.html>. Accessed May 30, 2012.
 32. New York City Department of Health and Mental Hygiene. National Salt Reduction Initiative. <http://www.nyc.gov/html/doh/html/cardio/cardio-salt-initiative.shtml>. Accessed February 10, 2012.
 33. Walmart Walmart launches major initiative to make food healthier and healthier food more affordable. January 20, 2011. <http://walmartstores.com/pressroom/news/10514.aspx>. Accessed December 4, 2011.
 34. Food Marketing Institute. Supermarket facts: industry overview 2011. <http://www.fmi.org/research-resources/supermarket-facts>. Accessed September 16, 2012.
 35. Chobanian AV, Bakris GL, Black HR, et al; Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. National Heart, Lung, and Blood Institute; National High Blood Pressure Education Program Coordinating Committee. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension*. 2003;42(6):1206-1252.
 36. Ayala C, Gillespie C, Cogwell M, Keenan NL, Merritt R. Sodium consumption among hypertensive adults advised to reduce their intake: National Health and Nutrition Examination Survey, 1999-2004. *J Clin Hypertens (Greenwich)*. 2012;14(7): 447-454.