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Stakeholder Discussion to Reduce Population-Wide Sodium Intake and Decrease Sodium in the Food Supply

A Conference Report From the American Heart Association Sodium Conference 2013 Planning Group*

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Background—A 2-day interactive forum was convened to discuss the current status and future implications of reducing sodium in the food supply and to identify opportunities for stakeholder collaboration.

Methods and Results—Participants included 128 stakeholders engaged in food research and development, food manufacturing and retail, restaurant and food service operations, regulatory and legislative activities, public health initiatives, healthcare, academia and scientific research, and data monitoring and surveillance. Presentation topics included scientific evidence for sodium reduction and public health policy recommendations; consumer sodium intakes, attitudes, and behaviors; food technologies and solutions for sodium reduction and sensory implications; experiences of the food and dining industries; and translation and implementation of sodium intake recommendations. Facilitated breakout sessions were conducted to allow for sharing of current practices, insights, and expertise.

Conclusions—A well-established body of scientific research shows that there is a strong relationship between excess sodium intake and high blood pressure and other adverse health outcomes. With Americans getting >75% of their sodium from processed and restaurant food, this evidence creates mounting pressure for less sodium in the food supply. The reduction of sodium in the food supply is a complex issue that involves multiple stakeholders. The success of new technological approaches for reducing sodium will depend on product availability, health effects (both intended and unintended), research and development investments, quality and taste of reformulated foods, supply chain management, operational modifications, consumer acceptance, and cost. The conference facilitated an exchange of ideas and set the stage for potential collaboration opportunities among stakeholders with mutual interest in reducing sodium in the food supply and in Americans' diets. Population-wide sodium reduction remains a critically important component of public health efforts to promote cardiovascular health and prevent cardiovascular disease and will remain a priority for the American Heart Association. (*Circulation*. 2014;129:00-00.)

Key Words: AHA Scientific Statements ■ hypertension ■ population ■ sodium chloride, dietary ■ table salt

*The American Heart Association Sodium Conference Planning Group was composed of Elliott M. Antman, MD, FAHA, President-Elect of the American Heart Association; Lawrence J. Appel, MD, MPH, FAHA, Chair of the American Heart Association Sodium Advisory Task Force; Douglas Balentine, PhD, Immediate Past Chair of the American Heart Association Industry Nutrition Advisory Panel; Rachel K. Johnson, PhD, MPH, RD, FAHA, Chair of the American Heart Association Nutrition Committee; Lyn M. Steffen, PhD, MPH, RD, FAHA; and the following American Heart Association staff members: Emily Ann Miller, MPH, RD; Antigoni Pappas, MBA, RD; Kimberly F. Stitzel, MS, RD; Dorothea K. Vafiadis, MS, FAHA; and Laurie Whitsel, PhD.

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The American Heart Association Sodium Conference held June 19 to 20, 2013, in Arlington, VA, allowed stakeholders to converse, receive updates from experts in the field, and share contemporary data. The objectives included the following: (1) To assess the current status and future implications of efforts to reduce sodium in the food supply; (2) to leverage expertise from different disciplines to identify and evaluate sodium reduction strategies and to address opportunities and challenges; (3) to discuss ways to translate sodium reduction strategies into practical application; (4) to identify short- and long-term sodium reduction goals and the factors that impact timelines for achieving these goals; (5) to identify metrics and methodologies for evaluating the collective impact of sodium reduction efforts on the food supply and on health outcomes; and (6) to identify collaboration opportunities among stakeholders.

The conference included plenary sessions that featured presentations by experts, panel discussions, and facilitated breakout sessions. Presentation topics included scientific evidence for sodium reduction and public health policy recommendations; consumer sodium intakes, attitudes, and behaviors; food technologies and solutions for sodium reduction and sensory implications; experiences of the food and dining industries; and translation and implementation of sodium intake recommendations. Facilitated breakout sessions allowed participants to contribute their expertise, insights, and thoughts.

These proceedings took place concurrently with a larger discussion about sodium: Just how much should individuals limit their intake? The health benefits of sodium limits have been at the center of news stories and debates. The American Heart Association (AHA) presented the conference on the heels of publishing 2 peer-reviewed scientific advisories^{1,2} that describe the clear and consistent evidence for the public health benefits of sodium reduction and the AHA's recommendation for all Americans to consume <1500 mg of sodium per day. Although there is variation in sodium intake recommendations,^{3,4,4a} there is consensus within the public health community that Americans' sodium intakes are considerably higher than any public health recommendation's upper level, and reduced intake is critical.

According to the National Health and Nutrition Examination Survey (NHANES), average sodium intake for Americans ≥ 2 years of age is >3400 mg/d,⁵ more than double the AHA's recommended amount. Globally, mean sodium intakes are nearly double the World Health Organization's recommended limit of 2000 mg/d.⁶ In addition, the Centers for Disease Control and Prevention reported that during 2007 to 2010, the prevalence of excess usual sodium intake (defined as exceeding the Institute of Medicine's tolerable upper intake levels of 1500 mg/d at age 1–3 years, 1900 mg/d at 4–8 years, 2200 mg/d at 9–13 years, and 2300 mg/d at ≥ 14 years) ranged from 79.1% for US children aged 1 to 3 years to 95.4% for US adults aged 19 to 50 years.⁷ The conference was designed to coalesce around the shared goals of significantly lowering the amount of sodium people consume and the amount in the food supply.

What follows are summaries of the sessions held during this important conference.

Sodium Reduction: An AHA Priority

Presented by AHA CEO Nancy Brown

The AHA is committed to improving the health of all Americans, and its Impact Goal for 2020 is to improve the cardiovascular health of all Americans by 20% while reducing deaths attributable to cardiovascular diseases (CVDs) and stroke by 20%.⁸ Lowering sodium intake, an important factor in lowering blood pressure (BP) and stroke risk, is a crucial component of the organization's 2020 goal. Reducing population sodium consumption is part of the AHA's measures for achieving dietary goals, described in full elsewhere.⁸ For this reason, the AHA has made sodium reduction a major priority, with strong commitment from leadership and volunteers.

The principal basis for the recommendation to consume <1500 mg of sodium per day is the strength of the evidence relating excess sodium intake to high BP, CVD, and stroke, as well as the capacity of reduced intake of sodium to prevent and treat hypertension and to reduce the risk of adverse CVD and stroke events.² High BP, both prehypertension and hypertension, is a leading cause of preventable morbidity and mortality worldwide.⁹ Reducing dietary sodium offers a significant opportunity to save lives. High BP and high dietary sodium are believed to be responsible for >400 000 deaths annually among US adults.¹⁰

The AHA has an integrated sodium reduction initiative that includes the following priorities: (1) Increase consumer demand for lower sodium content in processed and restaurant/food service foods; (2) increase consumer understanding of their daily sodium intake; and (3) encourage adherence to the AHA's recommended sodium intake. The AHA conducted consumer research and designed consumer messaging campaigns with supporting materials that work toward those priorities.

Session I: National Salt Reduction Initiative

Presented by Thomas Farley, MD, MPH, New York City Department of Health and Mental Hygiene

The New York City Department of Health and Mental Hygiene coordinates the National Salt Reduction Initiative (NSRI), the only national coordinated initiative that endeavors to reduce sodium levels in packaged and restaurant foods in the US food supply. The NSRI is a national partnership of >90 city and state health departments and health organizations. The NSRI's goal was to reduce Americans' sodium consumption by 20% by 2014 by reducing the sodium levels in packaged and restaurant food by 25%. Reductions were to be achieved through voluntary corporate commitments to lower sodium content in 62 categories of packaged food and 25 categories of restaurant food. The targets were based on the sales-weighted average within each category, which created greater potential to impact population-level sodium consumption and gave industry flexibility to achieve the target in a number of different ways. The sodium targets were set for 2012 and 2014 by the NSRI on the basis of sodium levels in each food category, food safety and technical considerations, and feedback from food manufacturers, restaurant chains, trade associations, and other industry representatives.

Given that >75% of sodium consumption comes from sodium added to food before it is sold,¹¹ Americans have relatively little

control over how much sodium they consume, and it is often challenging to choose diets that are lower in sodium. There are wide ranges in sodium levels among packaged and restaurant foods, which suggests that there is an opportunity for substantial reductions in sodium that can go unnoticed by consumers.

Twenty-one companies, including several multinational food manufacturers, restaurants, and food retailers, committed to and met the 2012 sodium targets. The companies achieved the targets by introducing lower-sodium products, phasing out higher-sodium lines, reducing sodium levels in existing products, or a combination of approaches. The companies have received positive press coverage and have been publicly applauded by NSRI partners and their supporters across the nation. Although progress has been made, the degree of industry commitment to meet the targets will determine the success of this effort.

Session II: Scientific Evidence for Reducing Sodium Intake and Establishing Policy Recommendations

(A panel discussion including several speakers moderated by Elliott Antman, MD, MACC, FESC, FAHA, Harvard Medical School and Brigham and Women's Hospital and Mariell Jessup, MD, FAHA, FACC, FESC, University of Pennsylvania School of Medicine. Speakers included Frank M. Sacks, MD, FAHA, Harvard University School of Public Health; Alice H. Lichtenstein, DSc, FAHA, Tufts University; and Paul K. Whelton, MB, MD, MSc, Tulane University.)

Sodium, Hypertension, and CVD

Excess intake of salt (sodium chloride) has a major role in the pathogenesis of elevated BP, a risk factor for CVD, stroke, left ventricular hypertrophy, and kidney disease. Excess sodium intake also has BP-independent effects, promoting both left ventricular hypertrophy and fibrosis in the heart, kidneys, and arteries.¹² In addition, emerging data suggest that increased dietary salt intake might also represent an environmental risk factor for the development of autoimmune diseases via the induction of pathogenic interleukin-17-producing CD4⁺ helper T cells, which trigger pathways that lead to inflammation.¹³

Evidence on the adverse health effects of excess sodium intake includes results from animal studies, epidemiological studies, clinical trials, and meta-analyses of trials.¹⁴ To date, >50 randomized trials have tested the effects of sodium reduction on BP in adults. A meta-analysis of these trials documented that a median reduction in urinary sodium of ≈ 1800 mg/d lowered systolic and diastolic BP by 2.0 and 1.0 mm Hg, respectively, in nonhypertensive individuals and by 5.0 and 2.7 mm Hg, respectively, in hypertensive individuals.¹⁵ In a subsequent meta-analysis of trials in children, a reduced sodium intake lowered mean systolic and diastolic BP by 1.2 and 1.3 mm Hg, respectively, in children and adolescents and lowered systolic BP by 2.5 mm Hg in infants.¹⁶ The benefits of sodium reduction in people with poorly controlled BP are striking. In a trial of patients with resistant hypertension, a reduction in sodium intake by 4600 mg/d lowered systolic and diastolic BP by 22.7 and 9.1 mm Hg, respectively.¹⁷

Some of the most persuasive evidence on the effects of sodium on BP comes from rigorously controlled dose-response trials.^{18–20} Each of these trials tested at least 3 sodium levels,

and each documented statistically significant, direct, progressive dose-response relations. The lowest level of sodium intake in each trial was ≈ 1500 mg/d, the level currently recommended by the AHA.⁸ Importantly, the BP response to sodium reduction, although direct and progressive, was nonlinear. Specifically, decreasing sodium intake by ≈ 900 mg/d caused a greater reduction in BP when the starting sodium intake was ≈ 2300 mg/d than when it was ≈ 3500 mg/d.

The DASH (Dietary Approaches to Stop Hypertension)-Sodium trial, the largest of the 3 major dose-response trials,^{21,22} documented that reduced sodium intake significantly lowered BP in each of the major subgroups studied (ie, nonhypertensive individuals, hypertensive individuals, men, women, blacks, and nonblacks). Results showed that the greatest reduction in BP was achieved when the DASH diet was combined with sodium intakes at the lowest of 3 levels, 1500 mg/d. Some of the BP reductions observed in going from the highest sodium level (3300 mg) to 1500 mg were similar to what could be achieved with the use of 2 antihypertensive medications. In addition, fewer headaches were reported by participants consuming the lower-sodium diet,²⁰ and participants deemed this diet to be acceptable.²³ The benefits of sodium reduction in nonhypertensive individuals were corroborated in the Genetic Epidemiology Network of Salt Sensitivity (GenSalt) feeding study, which documented that lowering sodium intake to ≈ 1500 mg/d reduced BP in ≈ 2000 Asian adults with mean systolic/diastolic BP $< 120/80$ mm Hg.²⁴

In addition to lowering BP, sodium reduction also blunts the age-related rise in BP. Because BP rises with age, $\approx 90\%$ of adults eventually become hypertensive.²⁵ The DASH-Sodium trial demonstrated that sodium reduction to a level of ≈ 1500 mg/d lowers BP more in older adults than younger adults.²² Systolic BP decreased by 8.1 mm Hg in those aged 55 to 76 years compared with 4.8 mm Hg in adults aged 23 to 41 years. In people without hypertension, BP decreased by 7.0 mm Hg in those > 45 years of age compared with 3.7 mm Hg in those ≤ 45 years of age. These results demonstrated that sodium reduction can lessen the rise in BP with age²⁶ and also confirmed the well-documented observation of a reduced age-related rise in BP in isolated populations with low sodium intake.²⁷ Consistent with this evidence, a major trial in the United States documented that a reduced sodium intake can reduce the incidence of hypertension by $\approx 20\%$.²⁸

Behavioral intervention studies can help individuals reduce sodium intake and improve BP and health outcomes. Three randomized, controlled trials with large sample sizes and long periods of follow-up have demonstrated the capacity of modest reductions in sodium to lower BP and prevent hypertension and also provide results that are consistent with a beneficial effect in preventing CVD complications.^{28–32} Modeling suggests a substantial health benefit from even modest reductions in sodium intake.³³

In the Trials of Hypertension Prevention and the Trial of Nonpharmacologic Interventions in the Elderly, the intervention goal was to reduce sodium intake to 1600 to 1800 mg/d. The study participants were assisted by nutrition counseling and behavioral skills training. A major challenge was finding lower-sodium foods in the marketplace, where many of the foods had sodium added during processing. In each of the

trials, the sodium reduction intervention was most effective at 6 to 9 months, but sodium intake was still reduced by approximately one third after 18 months.^{28–30}

In extended posttrial follow-up, CVD end points were accrued among 2275 participants who were not part of a sodium reduction intervention with 10 years (Trials of Hypertension Prevention II) or 15 years (Trials of Hypertension Prevention I) of posttrial follow-up. Previous analyses found a linear association of the sodium-potassium ratio with CVD. Median sodium excretion was 3630 mg/d, with 1.4% of the participants having intake <1500 mg/d and 10% <2300 mg/d, consistent with national levels. Compared with those with sodium intake from 3600 to <4800 mg/d, risk for those with sodium intake <2300 mg/d was 32% lower after multivariable adjustment (hazard ratio, 0.68; 95% confidence interval, 0.34–1.37; *P* for trend, 0.13).

There was a linear 17% increase in risk per 1000 mg/d (*P*=0.05). The Trials of Hypertension Prevention were conducted in a low-risk group and included several 24-hour urine excretions, thus reducing the possibility of reverse causation and incomplete sodium measurement. These results are consistent with overall health benefits of reducing sodium intake to the 1500- to 2300-mg/d range and support current dietary guidelines.³⁴ Plans are under way for a 10-year extension of mortality follow-up through 2013, or 24 years from the end of phase 1 and 19 years from the end of phase 2. The goal is to assess the impact of the randomized sodium reduction intervention and average usual sodium intake, as well as the randomized weight loss intervention, on later mortality. A unique aspect of the extended follow-up of the Trials of Hypertension Prevention is that it will build on the efforts already invested in the trials and will help answer important questions unlikely to be addressed with further randomized trials.

Sodium Intake and Health Outcomes: 2013 Institute of Medicine Report

The Centers for Disease Control and Prevention asked the Institute of Medicine (IOM) to convene a committee to review the scientific evidence published since 2003 concerning the potential benefits and adverse effects on health outcomes of sodium intake, particularly intakes of 1500 to 2300 mg/d. The prespecified health outcomes to be examined included CVD, heart failure, myocardial infarction, diabetes mellitus, mortality, stroke, bone disease, fractures, falls, headaches, kidney stones, skin reactions, immune function, thyroid disease, and cancer and did not include intermediate outcomes such as BP. Subgroups of interest included people >51 years of age, blacks, and people with diabetes mellitus, chronic kidney disease, or congestive heart failure.

The committee found a positive relationship between sodium intake \geq 2300 mg/d and risk of CVD, which supports current efforts to reduce population sodium intakes.³⁵ Data for other outcomes and in subgroups were too limited to draw conclusions. For health outcomes, it also found that there was little evidence for an effect of sodium intake \leq 1500 mg/d to support sodium reduction to levels to 1500 mg/d for the general population or subgroups of interest. In all cases, concern was noted about the limited amount of data and the quality of the available data, particularly the inability to rule out reverse causality

for those individuals reporting very low sodium intakes and the potential for spurious findings related to inaccurate measurement of sodium. The findings highlighted the need for additional research to clarify potential associations between sodium intakes of 1500 to 2300 mg/d and health outcomes both in the general population and in population subgroups.

The IOM report reinvigorated an important discussion for the field of nutrition about the appropriateness of using hard outcomes or end points versus intermediate outcomes or end points to form dietary recommendations. It also noted challenges in terms of feasibility and resources available to conduct nutrition intervention trials that last long enough to detect health outcomes.

Perhaps because of the scientific complexities of the IOM report or because of the desire to create an appealing headline, many news stories about the IOM's report included inaccuracies and misrepresentations of its conclusions. Some stories suggested that people should not be concerned with current levels of sodium intake, which created the potential for consumer confusion.^{36,37} It is important to focus the public on what the totality of the data show, as clearly indicated in the IOM report: Americans are consuming much more sodium than is recommended by any public health authority, and lowering sodium confers benefits in terms of both BP and CVD. In a subsequent communication, intended to clarify their position, IOM committee members reaffirmed the importance of population-wide reductions in sodium intake.³⁸

Public Health Recommendations for Sodium Intake

Although physiological requirements for sodium are small (<500 mg/d), an adequate intake of 1500 mg/d for most adults* has been established,³⁹ which allows people to meet other nutrient requirements, cover sodium sweat losses, and avoid the adverse effects of higher levels of sodium on BP.

The 2010 Dietary Guidelines for Americans⁴⁰ recommend sodium intake of <2300 mg/d for all Americans on the basis of the establishment of this level as a tolerable upper intake, according to the adverse effects on BP observed above this level. Further reduction to 1500 mg/d is recommended for groups particularly responsive to the BP-raising effects of sodium, including blacks; people with hypertension, diabetes mellitus, or chronic kidney disease; and people aged \geq 51 years.⁴⁰ These groups constitute \approx 48% of Americans aged \geq 2 years.⁴¹

Sodium intake recommendations are similar outside the United States. The World Health Organization recommends <2000 mg/d for adults, and lower levels for children, adjusting downward on the basis of energy requirements of children relative to those of adults.³ The United Kingdom's National Institute for Health and Care Excellence aims to reduce adult sodium intake to 2400 mg/d by 2015 and 1200 mg/d by 2025, with lower target levels for children.⁴ In Australia and New Zealand, adequate intakes are set at 460 to 920 mg/d and upper levels at 2300 mg/d, with lower recommendations for children.⁴²

In summary, there is general uniformity in the recommendations to reduce sodium intake from current levels, with a range that spans from 1200 to 2300 mg/d; however, estimates of Americans' sodium intake, whether obtained by dietary

* Adequate intake is set at 1500 mg/d for individuals aged 9 to 50 years, 1300 mg/d for those aged 50 to 70 years, and 1200 mg/d for those aged \geq 71 years.

assessment or the biomarker of 24-hour urinary sodium excretion, indicate that sodium consumption in the United States is considerably higher than any of these recommendations. Furthermore, among those for whom the 2010 Dietary Guidelines for Americans recommend a sodium intake of 1500 and 2300 mg/d, approximately 99% and 95%, respectively, exceed this level.⁴³

In Finland, a substantial reduction in sodium intake has been achieved through a combination of approaches that include education and cooperation with the food industry. Pansalt, which replaces part of the sodium in salt with potassium, has been used commercially and at the table. Over 20 years, there has been an $\approx 25\%$ reduction in sodium intake, or $\approx 1\%$ per year.⁴⁴ In the United Kingdom, strategies involving education and a reduction in the amount of sodium added during food processing have resulted in reductions of approximately 10% to 15% over 10 years,⁴⁵ which again suggests that an $\approx 1\%$ reduction in population-wide sodium intake per year is a reasonable goal.

Session III: Sodium and the Consumer

Dietary Assessment and Biomarkers of Sodium Intake

Presented by Lyn M. Steffen, PhD, MPH, RD, FAHA, University of Minnesota School of Public Health

Sodium intake can be estimated by either dietary or biomarker assessment. Dietary assessment is typically based on self-report and might take the form of a 24-hour recall interview, a food diary/record, or a food frequency questionnaire. Each instrument has strengths and limitations, and each is prone to measurement error, such as inaccurate recall, underreporting, or not accounting for sodium from water intake or salt use at the table. Errors occur because food and nutrient databases are not updated frequently enough to keep pace with changes in the food supply, and there is wide variation in the sodium content of manufactured and restaurant foods. Furthermore, there is wide individual variability in day-to-day sodium intake, which leads to random error in the estimation of average sodium intake.

Urinary sodium excretion is a biomarker that provides a direct measurement of sodium intake. A 24-hour urine collection is considered the “gold standard” to capture usual sodium intake, because in a steady state of normal individuals, nearly 100% of dietary sodium is excreted in the urine. Ideally, multiple 24-hour urine samples are collected to quantify usual dietary sodium intake because of the wide variability in daily sodium intakes, although this presents a high participant burden. Overnight (8-hour) urine collections have been used to reduce the burden on participants, and the number of these collections required to quantify usual sodium intake ranges from 3 to 12 collections.⁴⁶ A “spot” or “casual” urine sample (a single voiding of the bladder) is another more convenient method to overcome the burden of collecting 24-hour urine samples; however, measurement error is greater with fewer urine collections and a shorter time period for the collection. Importantly, there is the potential for systematic errors and bias in estimating dietary sodium intake from spot and timed urine collections compared with 24-hour collections.

Correlations between sodium intake and 24-hour urinary sodium were greatest when urine samples were collected for a longer period of time.⁴⁷

Sodium Intakes of Americans and the Food Environment

Presented by Alanna Moshfegh, MS, RD, US Department of Agriculture Food Surveys Research Group

The NHANES is the federal surveillance program for measuring Americans’ health and nutritional status, including sodium intakes. Every year, a new sample of 5000 people of all ages completes 2 interview-administered 24-hour dietary recalls, collected 3 to 10 days apart, using the US Department of Agriculture’s automated multiple-pass method. The survey assumes salt is used in cooking unless otherwise specified. Use of table salt is not quantified. A validation study of this method that compared the self-reported dietary intake with a urinary biomarker showed that self-reported sodium consumption was 90% and 93% accurate among women and men, respectively. Mean intakes were underreported by ≈ 300 mg/d.⁴⁸

Estimated average sodium intakes in Americans of 3400 mg/d appear to be unchanged since the mid-1990s, as indicated in Figure 1.† Intakes appeared unchanged over this time period when examined on a per-1000-calorie basis. Males in each age group consumed greater amounts than females, largely because on average, men consume more calories than women. The reductions in the food supply over the past few years may not be reflected in the latest population sodium intake data from 2009 to 2010. The reductions have not been across all foods or brands and have been gradual, as reported by the food industry.

The distribution of sodium intakes across all people aged ≥ 2 years shows that 7% are consuming <1500 mg and 15% are consuming >5000 mg (Figure 2).

Across people’s daily intake, lunch and dinner account for 29% and 43% of sodium consumed, respectively, compared with 14% for both breakfast and snacks. Food eaten away from home contributed 33% of sodium, and restaurant/fast food contributed 26%. There was little change from 2005 to 2010 in the number of people who reported frequency of salt use in food preparation (40% say they do so very often, 25% say never or rarely) or at the table (32% say rarely, 14% say very often).

The primary contributor to sodium in the US diet is salt, which is composed of 40% sodium and 60% chloride. Sodium is also found in a number of compounds used in food manufacturing and preparation, as well as in medications and some water supplies.⁵⁰ The food categories that contribute the most to sodium intake are shown in the Table and include mixed dishes such as pizza, sandwiches, and soups; protein foods

† The 2009 to 2010 data shown in Figure 1 were not subjected to a data-processing step that adjusts for salt used in preparing food, a step that was applied to the earlier data. Changes in the food environment and consumption habits have led to conclusions that the salt-adjustment step is no longer needed, so it has been discontinued.⁴⁹ Sodium intake estimates calculated without the salt-adjustment step are $\approx 4\%$ higher (≈ 130 mg of sodium) than estimates calculated with the step. When intake data are compared, it is important to use estimates of US sodium intake in 2007 to 2008 or earlier that have been calculated without the salt-adjustment step, so that there is a proper comparison with 2009 to 2010 or later data.

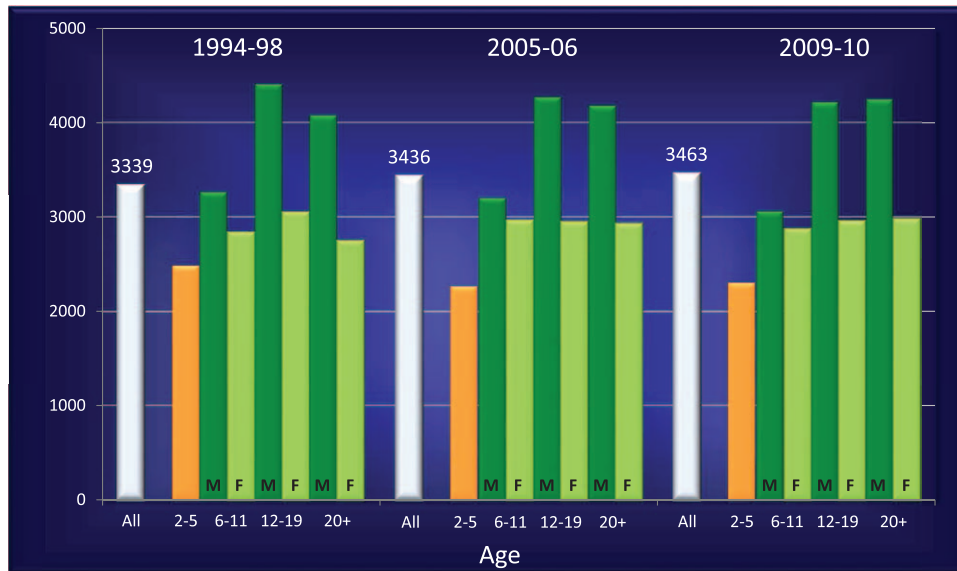


Figure 1. Sodium intakes of Americans (daily averages in milligrams). F indicates females; and M, males. Data derived from the US Department of Agriculture, 1994–1998 Continuing Survey of Food Intakes by Individuals and the 2005–2006 and 2009–2010 What We Eat in America, National Health and Nutrition Examination Survey (1 day; aged ≥ 2 years, excludes breastfed children).

(led by cold cuts and poultry); and grains (led by breads and rolls).⁵¹ These 3 food categories contributed two thirds of sodium intake. The wide variability of foods in these categories and the ubiquity of sodium in the food supply contribute to the challenge of creating messages to help people reduce sodium.

In addition to measuring sodium intake, the monitoring of sodium in the food supply is also important. A US Department of Agriculture project conducted in collaboration with the Centers for Disease Control and Prevention has been under way for 2 to 3 years and is monitoring ≈ 130 sentinel foods (those high in sodium and with potential for sodium reduction) to be sure that changes in sodium content are captured. These

foods will serve as indicators of whether further monitoring is needed across these types of foods, and this will enable more timely data updates in the nutrient databases used to measure population sodium intake. Food and nutrient databases that quantify the sodium content of foods do not always reflect the current sodium content of all foods in the marketplace, because the food supply is constantly changing. It is important to have current estimates of the relative contributions of dietary sodium sources to accurately target sodium reduction approaches. A Centers for Disease Control and Prevention–funded study is currently examining sources of sodium intake and will provide an update to these estimates.

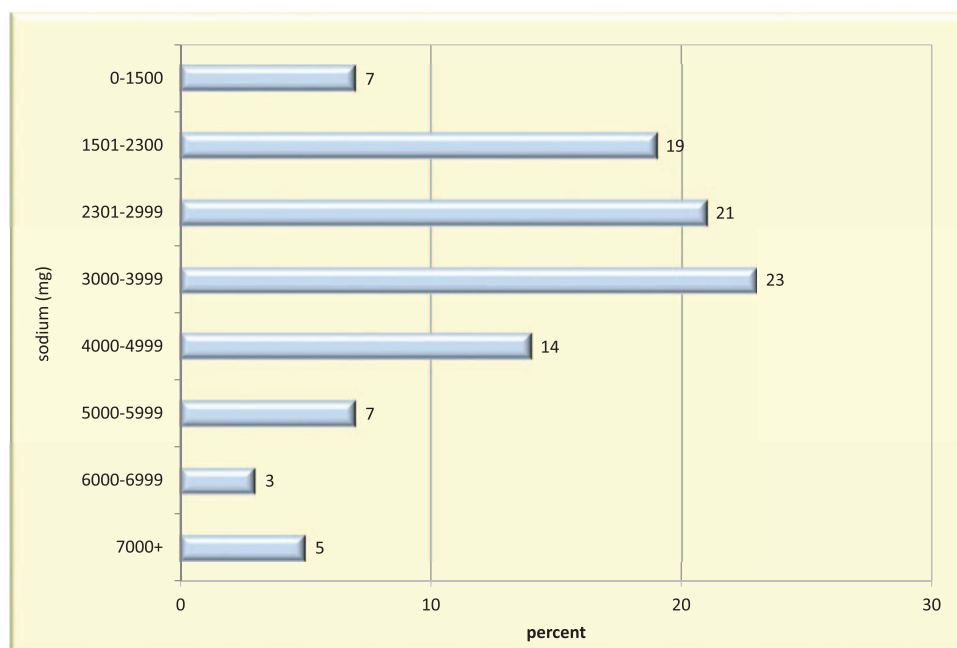


Figure 2. Distribution of sodium intakes for Americans aged ≥ 2 years. Data derived from the US Department of Agriculture, What We Eat in America, National Health and Nutrition Examination Survey 2009–2010 (1 day; aged ≥ 2 years, excludes breastfed children).

Table. Ten Food Categories Account for 44% of Consumed Sodium

Breads and rolls (7.4%)
Cold cuts and cured meats (5.1%)
Pizza (4.9%)
Fresh and processed poultry (4.5%)
Soups (4.3%)
Sandwiches (4.0%)
Cheese (3.8%)
Pasta mixed dishes (3.3%)
Meat dishes (eg, meat loaf with tomato sauce, 3.2%),
Snacks (eg, chips and pretzels, 3.1%)

Data derived from Centers for Disease Control and Prevention.⁵¹

Consumer Knowledge, Attitudes, and Behaviors Toward Sodium

Presented by Emily Krol, MS, Mintel Group Ltd.

Mintel Group Ltd conducted tailored consumer research in November 2012 to understand consumer attitudes toward sodium among ~2000 adults aged ≥18 years with access to the Internet.⁵² Nearly 60% of Americans reported that they are limiting their sodium. The International Food Information Council also found that 60% of Americans reported trying to avoid or limit sodium when buying packaged foods or beverages.⁵³ In Mintel’s research, older Americans, blacks, and Hispanics were more likely to be among this group. Men were only slightly more likely than women to be in this group. As Figure 3 illustrates, the top reason reported for limiting sodium was worry about its link to certain diseases. Other reasons included specific health concerns, worry about weight gain, or a doctor’s advice. Understanding why people are limiting sodium can help shape messages to promote behavior change.

When asked how they were limiting sodium, the top answers were “cook with less salt” (72%) and “salt my food less” (64%). Other answers included reading nutrition labels (54%) and buying fewer packaged (39%) and restaurant foods (32%). Females who reported that they were limiting their

sodium and those who were aged ≥45 years were slightly more likely to engage in sodium-limiting behaviors.

Most consumers did not think sodium substitutes (such as no- or low-sodium seasoning blends) or sodium alternatives (such as sea salt or kosher salt) were healthier than regular table salt. The top products people used to limit sodium intake were seasonings, spices, and herbs. Infused oils, sugar, and other salts were also used. Although most sea salts contain the same amount of sodium as table salt, >80% of respondents said they were either using or interested in using sea salt as a replacement for table salt.

Consumer perceptions about the taste and cost of low-sodium products may be changing. Taste and cost did not appear to be large barriers to consuming products low in sodium. Twenty-one percent agreed that foods low in salt/sodium do not taste as good, and 9% thought that low- or reduced-sodium foods were more expensive (Figure 4). Another survey of ~1000 adults⁵⁴ reported that 10% strongly agreed and 29% somewhat agreed that low-sodium products do not taste as good.

Session IV, Part A: Food Technology and Solutions for Sodium Reduction and Sensory Implications

Summary of panel discussion moderated by Eric A. Decker, PhD, University of Massachusetts at Amherst

Salt occurs inherently in many foods. In some foods, salt plays a crucial role in food safety because it can manage microbial activity, which results largely from its ability decrease the water activity of a food. It also has functional effects; to name a few, salt solubilizes proteins, improves water-holding capacity in a food matrix, and is used to help kosher meat and poultry. Salt also enhances thickness, fullness, sweetness, flavor strength and balance, and saltiness, and it reduces bitterness and metallic or chemical off notes (Figure 5). It is crucial to understand the multifunctional role that sodium plays. Because of the myriad roles salt plays in different foods, there must be various food-specific approaches to reduce sodium in the food supply.

In the food industry, sodium reduction has been occurring for decades, and anecdotal evidence indicates many

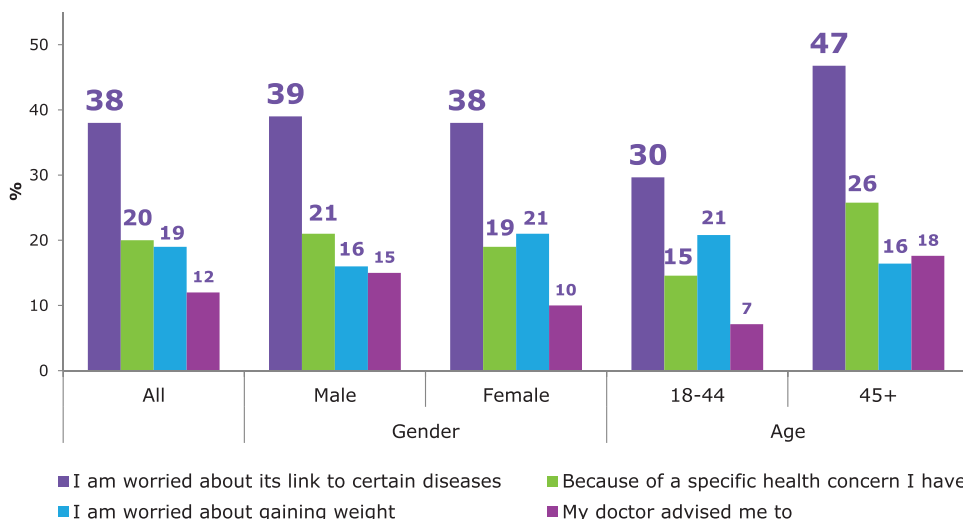


Figure 3. Reasons for limiting sodium by demographic. Sample size: ~2000 adults aged ≥18 years with access to the Internet. Reproduced with permission from Mintel Group Ltd. Copyright ©2013, Mintel Group Ltd.

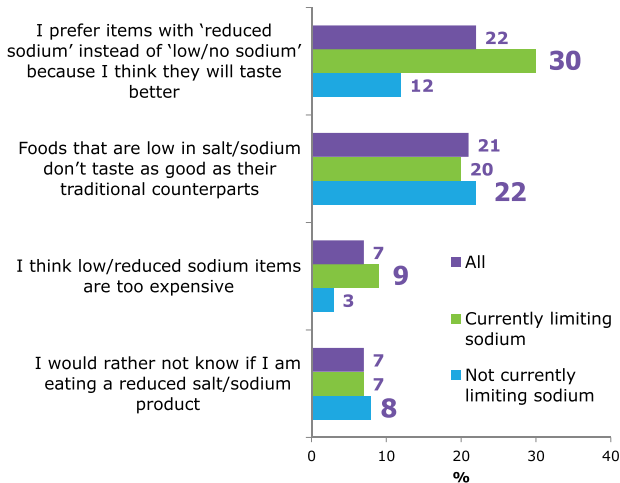


Figure 4. Attitudes toward taste and cost of lower-sodium products. Sample size: ≈2000 adults aged ≥18 years with access to the Internet. Reproduced with permission from Mintel Group Ltd. Copyright ©2013, Mintel Group Ltd.

companies can lower sodium by ≈20% to 30% through gradual reductions; however, it becomes more difficult over time to continue reducing sodium. New techniques and combination approaches are often needed to maintain flavor and texture.

When companies begin reducing sodium in a food product, they must identify a target and determine whether they are going to make a nutrient content claim or a stealth reduction. The next step is to review the sodium-containing ingredients in the formulation and the roles those ingredients play. After that, consideration must be given to alternative ingredients that will provide the same functionality. Companies must also consider whether the product must have parity in terms of taste and cost compared with the original formulation. Generally, replacing salt increases costs unless concessions are made on other ingredients. Finally, research and development testing must be conducted, such as bench-top development, food safety, shelf life, and sensory aspects. A product may have many sodium-containing ingredients. For example, in pizza, sodium is in the dough, sauce, cheese, and some toppings. Food scientists must consider the consumer's experience when determining where to reduce sodium in complex food products.

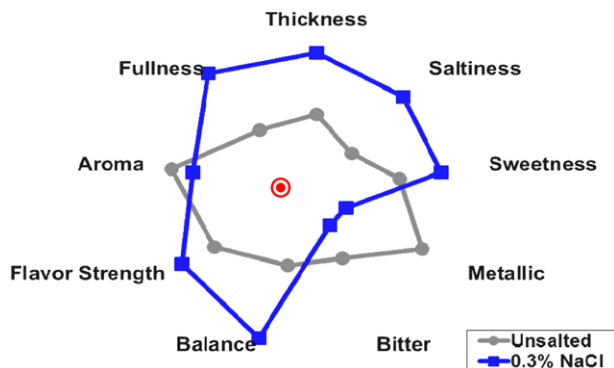


Figure 5. The flavor effects of salt using the example of split-pea soup. Reprinted from Gillette et al⁵⁵ courtesy of Food Technology magazine, Institute of Food Technologists, www.ift.org. Copyright ©1985, Institute of Food Technologists.

The timeline for reducing sodium in a product may be months or even years. Figure 6 shows a generic timeline for a sodium reduction project. Milestones in the process may vary significantly depending on success of formulation and testing, whether claims support is necessary based on existing claims, the number of formulas included, and alignment with planned shelf resets. Obstacles such as negative consumer test results can lengthen this timeline or even terminate the project altogether if the product would not be acceptable to consumers.

Potassium Chloride and Sea Salt Blends

Presented by Linda Kragt, Morton Salt

Morton Salt has been working on sodium reduction since the 1960s, starting with blends of salt and potassium chloride. Its current portfolio includes salt and potassium chloride blends and seasoning blends, both of which are available to consumers or the food processing industry. In a 2013 survey of research and development professionals within the food industry, the number 1 ingredient they reported subtracting from formulations was sodium.⁵⁶

Sodium reduction techniques can be combined and include gradual reductions, intensification of other flavor notes such as spices or umami, or use of a different salt size particle or crystal form. The crystal form of salt can affect how it dissolves in the mouth and releases its taste. Finer particles lead to a faster release, providing a quick burst of saltiness that is often desirable in topical applications.

Potassium chloride has a history of use as a salt alternative. Its physical properties are similar to those of salt, and it provides dietary potassium. It enhances saltiness, but it is form-specific and does not work the same in all food categories. Although it has a salty taste, many consumers describe it as bitter or metallic, so masking agents are often used to block these undesirable taste notes. It is also more expensive than salt, and if it is used in foods that have certain regulatory standard of identity, the food may fail to meet the standard. A food may deviate from the standard of identity if it is making a nutrient content claim, but this requires at least a 25% sodium reduction. Although potassium chloride is a natural mineral, its ingredient declaration may preclude a product from having a clean label (that is, made with ingredients that consumers recognize and do not perceive as chemical sounding), which can be a barrier to reaching the subset of consumers who desire only familiar ingredients.

Sea salt is available in many varieties and particle sizes, which makes it useful for a number of culinary uses. Lower-sodium sea salts have varying levels of sodium chloride depending on how they are processed, but most varieties do not reduce sodium. An analysis of 4 standard sea salt products from a grocery store showed that all were between 97% and 100% sodium chloride. Most sea salts contain calcium and magnesium, but they are not significant sources of these minerals.

Salt Microspheres

Presented by Andrew Hoffman, PhD, Tate & Lyle

A new sodium reduction ingredient available to food manufacturers by Tate & Lyle is SODA-LO[®], a hollow salt microsphere that is <10% of the size of regular salt crystals and reduces salt levels by 25% to 50% in selected food applications. The

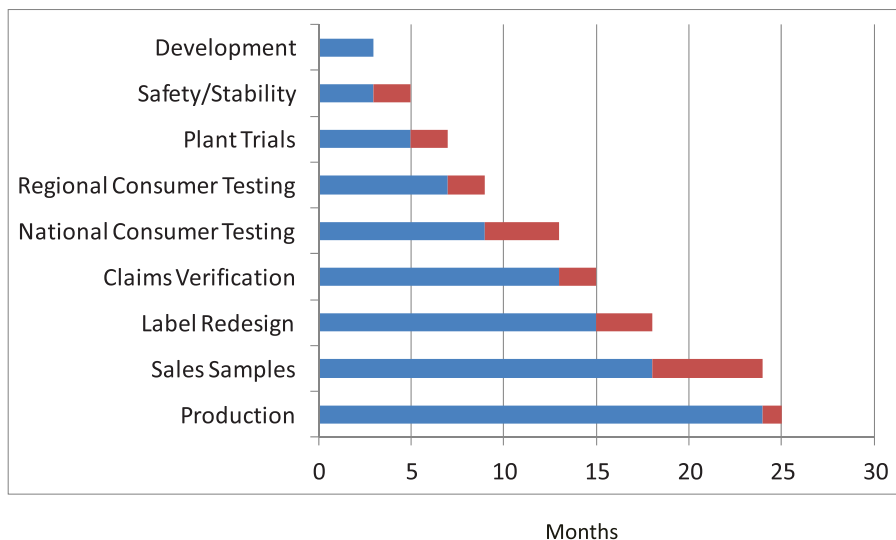


Figure 6. Generic sodium reduction timeline. Red portions of each bar indicate the time of each individual step in the timeline. Blue portions of each bar indicate the cumulative time of all prior steps in the timeline. Courtesy of Unilever, shared in presentation by Lisa Carlson, ©2013 Unilever Food Solutions.

physical properties of these salt microspheres allow them to dissolve rapidly in the mouth, which provides an efficient delivery of salty flavor. Unlike some other salts, they are free flowing and do not need anticaking additives, thus allowing a clean label. The cost is competitive with other salt alternatives.

Because SODA-LO is sodium chloride, it tastes and functions the same as traditional table salt. Sensory tests have shown overall sensory acceptance of products prepared with SODA-LO, and even a slight preference for the SODA-LO product compared with the control product. This may be because the small particle size of SODA-LO allows for more uniform distribution and improved adhesion to foods compared with regular salt. SODA-LO is best suited for food categories such as breads, baked goods, nuts, popcorn, potato chips, french fries, some soups and sauces, and mayonnaise. It acts the same as table salt once dissolved, so it is not ideal for applications such as broths and drinks.

Using NHANES 2007 to 2010 data, the potential impact of SODA-LO on sodium intake in the US population was modeled on the basis of potential usage levels in 953 foods. The modeling showed that a 20% to 30% salt reduction in the 953 foods using SODA-LO, assuming a 50% or 100% market penetration, could decrease sodium intakes by 4% to 9% across age, sex, and ethnic groups. These decreases in sodium intake are equivalent to a meaningful reduction of approximately 130 to 360 mg/d. This indicates that SODA-LO can be one of the multiple-ingredient solutions that are needed to help decrease population sodium intake.

Spices and Herbs

Presented by Guy H. Johnson, PhD, McCormick Science Institute

The use of herbs and spices can be part of sodium reduction solutions, because the positive flavor effects of salt are replicated in part by these ingredients. Herbs and spices have no negative nutritional consequences because they are virtually free of calories, sugars, and fats.

Research is under way in the hope of generating data to show the ability of herbs and spices to make lower-sodium foods more acceptable and more likely to be chosen by consumers.

The use of herbs and spices in food preparation and dietary patterns is being studied for its ability to help subjects reduce sodium intake in the context of a 1500-mg sodium DASH diet. Another study is testing an educational intervention that focuses on herbs and spices to improve diet quality among high school students. Other research has shown that broccoli seasoned with spices was consumed in higher amounts than plain broccoli.⁵⁷

Culinary techniques maximize the potential of herbs and spices in flavor enhancement. Garlic, red pepper, and ginger are natural flavor enhancers that serve as fundamental base flavors in cuisines. For foods with long cooking times, whole spices or herbs can infuse layers of flavor and build depth in the final product. Alternatively, the addition of herbs and spices at various stages of the cooking process or only at the end provide another type of desirable flavor, as can roasting, toasting, or frying the spices.

One seasoning company that set out to reduce sodium while maintaining consumer acceptance was successful using a reduced-sodium version of its seasoning largely by significantly increasing the concentration of herbs and spices. When presenting the reduced-sodium food to consumers, the company focused on the delicious flavor rather than which ingredient had been reduced or eliminated.

Sensory Experiences Related to Sodium Reduction Technologies

Presented by Gary K. Beauchamp, PhD, Monell Chemical Senses Center

Salt imparts many desirable sensory attributes. Among the most notable are a pleasant saltiness, the enhancement of desirable flavors, and the suppression of undesirable flavors (Figure 5). The sodium ion of salt is responsible for its ability to suppress many bitter compounds. To produce an acceptable product, the consumer's sensory experience must be considered when a sodium reduction approach is chosen.

One approach is a simple removal of salt. This is a particularly promising option for some foods that have a range of optimum salt levels that do not affect the consumer's sensory experience. Salt can also be removed abruptly, as was the case in a small feeding study in which participants were provided

typical diets followed by diets much lower in sodium that also allowed ad libitum use of salt shakers. Over 13 weeks, sodium intake (as measured by 24-hour urine samples) decreased from an average of 3100 to 1600 mg/d, and participants' ad libitum use of the salt shakers (which they did not know was being measured) resulted in replacement of <20% of the overall sodium removed during food preparation.^{57a} These data are inconsistent with the argument that humans are driven to consume certain levels of salt and suggest that changes in taste preferences occur and enable people to maintain lower-sodium diets.

Behavioral strategies to reduce sodium could be carried out through public education or the promotion of gradual reductions of sodium in the food supply, the latter via voluntary initiatives or regulations.⁵⁰ These approaches are based on the hypothesis that a gradual reduction of sodium in foods will shift taste preferences so that people prefer the lower levels of sodium. Several studies have validated this hypothesis, which suggests that there is adaptation over time to a diet lower in sodium.⁵⁸⁻⁶¹ Infancy and childhood may be particularly important times to ensure reduced sodium intake, because preferences developed early in life may foster sustained preferences.⁶²

Technological approaches are a third tactic to reduce sodium. Functional substitutes (such as potassium chloride), variations in salt structure (such as salt microspheres), and alternative flavor agents (such as herbs and spices) hold promise to make significant contributions to reducing sodium.

It is difficult to find a true functional substitute for salt, because the stimulus for salty taste appears to be highly specific. It is fully triggered only by sodium and lithium, although the latter cannot be used because it is toxic to humans. However, less specific salt taste mechanisms may also exist that could account for other taste attributes of salt, such as mouthfeel and body, but these mechanisms are unknown. Functional research on salt taste mechanisms, such as an exploration of the mechanisms that cause people to perceive potassium chloride to be bitter, provides promise for improvement of current and future developments of new salt taste enhancers and substitutes.

Session IV, Part B: Food Industry Successes, Challenges, and Opportunities: Experiences of Processors, Food Service Providers, and Culinary Professionals

Many companies in the food industry are voluntarily reducing sodium, whether by stealth reformulation or as part of an attempt to openly market lower sodium content. Several representatives from various food companies discussed their experiences reducing sodium in foods that have sodium as a key ingredient. Below is a brief summary of the discussions concerning each case.

Presentations moderated by Priscilla Samuel, PhD, Tate & Lyle

Case 1: Cold Cuts, Cured Meats, and Poultry

Presented by Betsy Booren, PhD, American Meat Institute Foundation

Approximately 80% of the meat and poultry industry is actively involved in efforts to reduce sodium. Some companies are promoting their efforts with nutrient content claims,

and others are quietly making reductions without alerting consumers.

Members of the American Meat Institute, a trade organization, are actively working to improve and maintain the safety of meat and poultry products while providing a variety of nutrient-dense protein products that fit in a healthy lifestyle. In cold cuts and cured products, salt is added to prevent pathogen activity. The primary organism of concern is *Listeria monocytogenes*, which can be inhibited by 3 common sodium-containing ingredients. Sodium reduction in meat and poultry must be achieved in a way that preserves the food safety of a product as well as the functions it has when salt is added, such as binding water (thereby increasing tenderness).

A safe meat or poultry product can be produced with lower levels of sodium-containing ingredients, but reformulations can take several months and may often involve a trade-off such as reduced shelf life, the use of ingredient substitutes that are not familiar to the consumer, or increased price. Consumer expectations must be considered in the evaluation of trade-offs. When meat and poultry products are reduced in sodium, they must undergo extensive testing to validate their safety, which may take up to 4 months per product variation. Additional tests follow for quality, shelf life, and sensory acceptability. Changing the formulation of a product can also result in losses that had been gained in manufacturing efficiency, because when products are altered, more change over time is required as the product moves through various facilities in the food-supply chain. Product distribution is critical to ensure the safety of the product, for instance, adequate cold storage to prevent spoilage and pathogenic growth. New formulations also necessitate allergen control, approval of new ingredients, and revisions to the label, for which meat and poultry products must receive regulatory approval after reformulation and all safety testing are complete. Finally, sensory tests are conducted for consumer acceptance. As indicated in Figure 6, the full reformulation process can take many months and may be delayed if barriers are encountered along the way.

In sum, members of the American Meat Institute support the prudent use of sodium in meat and poultry products without compromising safety. They also strive to offer consumers a choice of foods with various levels of sodium. There are a number of technologies available to the meat and poultry industry for reducing sodium. As it becomes difficult to achieve further reductions, new technologies and ingredients will play a key role in the continuation of progress.

Case 2: Grains

Presented by Janice Johnson, PhD, Cargill

Grains are part of several of the top 10 foods that contribute most to Americans' sodium intakes,⁵¹ which makes this category a particularly important target for sodium reduction. Sodium in grain products is contributed by salt, microbial spoilage inhibitors (salts of organic acids), and chemical leavening agents (such as sodium bicarbonate). Salt serves several functions, including development of gluten, control of yeast fermentation and water activity (important in reducing spoilage and maintaining shelf life), contribution to flavor, and formation of color.

When reducing sodium in grains, the consequences of using less sodium and alternative ingredients must be considered.

For example, nonsodium chemical leavening agents react at different rates than sodium and have a different taste, and generally a higher price. Food manufacturers want to maintain the same taste and price point that consumers are accustomed to, so this may be an unacceptable trade-off. There may be an opportunity to vary the flavor profile by reducing sodium and increasing other flavor components and still maintain an acceptable product.

Tests of sodium reduction in white bread showed that altering the salt content and replacing all or part of it with potassium chloride had meaningful effects on the bread's proof time (the time it takes bread to rise), texture, and flavor. Sensory tests showed that consumers gave similar "liking" and "saltiness" scores for the control bread and the bread that was 33% reduced in sodium. It is difficult to conduct side-by-side sensory tests of some control products and reduced-sodium products, because people probably will attempt to detect a difference. Testing may be performed on a separate day for each product.

New analytical techniques that use equipment such as electron microscopes and x-ray tomography can help advance sodium reduction by providing highly detailed information about how salt acts in foods. For example, it may be possible to examine the dispersion of salt on a food's surface or to determine how salt is interacting with other components in the food matrix and affecting the sensory experience.

Case 3: Cheese

Presented by Bill Graves, MS, MBA, Dairy Research Institute

The cheese industry is actively engaged and investing in research and development to discover and implement sodium reduction solutions, largely through a task force comprising 25 companies representing $\approx 80\%$ of national cheese volume. The reduced-sodium segment (products labeled as "reduced/less sodium") is small and declining rapidly, and the industry has found that gradual stealth reductions are more likely to succeed.

The 2010 Dietary Guidelines recommend 3 daily servings of low-fat and fat-free milk and milk products for Americans ≥ 9 years of age.⁴⁰ Milk is the top food source of 3 "nutrients of concern" in US diets: calcium, potassium, and vitamin D. Average intake of dairy products (milk, cheese, and yogurt) is 1.8 servings per day, which contributes 51% of the calcium and 58% of the vitamin D, 10% of the calories, and 14% of the fat in US diets.⁶³ Cheese is the number 2 source of calcium in the diet and contributes $\approx 8\%$ of the sodium in US diets, whether eaten alone or as part of pizza, sandwiches, and other mixed dishes.

Salt has a critical role in the cheese-making process. It is a pivotal part of helping to control the growth of pathogens and spoilage microorganisms, the latter creating the potential for reduced shelf life and quality of sodium-reduced cheese. The taste of cheese and its flavor development during the aging and ripening process is highly affected by salt. Sodium also impacts the texture and performance of cheese, such as its ability to melt.

Caution and extensive testing are necessary to avoid compromises in quality, safety, or nutrient intakes when reducing sodium in cheese. There are 72 standards of identity cheeses and >300 types of cheese, each with its own taste, texture,

nutrition profile, and sodium content. According to US Food and Drug Administration (FDA) labeling rules, cheddar cheese made with potassium chloride as a partial substitute for sodium must be called "cheddar cheese product," which may impact consumer acceptance. Consumers can detect small changes in sodium in cheese; therefore, reductions must be gradual to avoid dissatisfaction. Other negative consequences of sodium reduction may include reduced dairy consumption and nutrient intake, higher retail costs, or compromises in safety.

The cheese industry's ongoing commitment to sodium reduction includes continued investment in research, efforts to reduce the variability of sodium within a given type of cheese, and exploration of the minimum amounts of sodium required to provide safe, lower-sodium processed cheese. As in other food categories, the sodium thresholds for food safety vary by product.

Case 4: Soups

Presented by Joshua Anthony, PhD, MBA, Campbell Soup Company

Campbell Soup Company has made substantial progress in reducing sodium, achieving reductions of up to nearly 40% in selected products while increasing the percentage of its portfolio that is decreased in sodium. The degree of achievable reduction varies across product categories, within product categories, and within varieties of the same product category. Sodium plays multiple roles in taste and recipe functionality, so a one-size-fits-all reduction approach is not feasible in all foods. Recipes must be individually designed and consumer tested.

Changes in sodium levels have the potential to impact consumer liking and purchase intent, 2 key factors in the success of a new product. Case studies have shown that consumer liking is not compromised until sodium reductions exceed a certain level, which varies by product. One attempt to decrease sodium in a soup line was not met with repeat consumer purchases, resulting in some of the sodium being restored. Consumers may give a new product only a single chance before deciding whether to purchase it again, and if initial liking is not achieved, it can be difficult to sell them on healthier products in the future. Whether a product has what consumers perceive to be a clean label may influence liking and purchase intent. As stated previously, use of salt replacers such as potassium chloride precludes a product from having a clean label, which can be a barrier to reaching the subset of consumers who want to see only familiar ingredients.

Campbell offers a variety of products to help consumers meet Dietary Guidelines. For example, its Campbell's Healthy Request line of soups was reported to be successful as a lower-sodium product because of its association with heart health, its consistent introduction of new varieties within the line, and an effective dialogue with consumers about the benefits of a heart-healthy diet.

Campbell believes that education and meal solutions are practical strategies that can facilitate reduction in consumer sodium intake and that these efforts have helped raise awareness of heart disease, for example, and focused on how to eat and cook for a heart-healthy lifestyle. Providing recipes makes it easy for consumers to understand how to incorporate products with less sodium into their lifestyle. Because

recipes involve more ingredients than single foods, there are more options for reducing the overall sodium content without affecting consumer acceptance.

Case 5: Prepared Foods

Presented by Lisa Carlson, MS, RD, Unilever Food Solutions

Unilever's strategy is to gradually reduce sodium across all products (versus creating lower-sodium options) to target consumer intakes of 2000 mg/d by the end of 2020, the World Health Organization's recommended goal for population sodium intakes.³

A number of Unilever products have been successfully reduced in sodium (up to nearly 40% in some products), mostly by stealth reformulation instead of calling it out on the label. A product's label influences taste perception in lower-sodium products. In research conducted in the Netherlands of 4 identical soups with different labels, consumers perceived the soup labeled as "NOW with reduced salt" as the least salty, as well as less tasty than the other soups.⁶⁴ If nutrition statements are made on a package's label, pairing them with a statement about the product's great taste can be helpful in driving positive consumer perception.

The challenges of reducing sodium in prepared foods are similar to those in other product categories. The process of identifying the adjustments required to ensure the product is not compromised in safety, quality, or taste is complex, because the adjustments are specific to individual products. In food service, the degree of acceptable sodium reduction varies by the setting in which the products are served. Consumers' judgment of what is acceptable is also influenced by the sodium levels in the rest of the food supply. Over the past 5 years in the United States, Unilever has gradually reduced sodium in its soups and other products (up to 40%) over time so that no one would notice the difference. Increasingly, consumers are asking for less salty foods, and this demand is what will help to advance sodium reduction in the food supply.

Food Service and Culinary Perspectives

Approximately one quarter of sodium intake comes from restaurant foods,⁵¹ for which there are unique opportunities and challenges in sodium reduction. The food service industry generally sources ingredients that it then assembles and serves. There is some control over how much salt is added, but a large portion of the sodium in these foods is already in the ingredients once they arrive at the establishment. This creates an opportunity for the food service industry to develop innovative, sustainable solutions appropriate for its model.

Food service industry representatives at the conference indicated their sector would prefer approaches to sodium reduction that involve voluntary leadership and public-private partnerships as opposed to government mandates, although they acknowledged that government can be helpful in setting voluntary targets. Restaurant foods are not required to carry the nutrition label that is required of packaged foods and thus may not face some of the same pressures to reduce sodium. However, consumers are starting to request dishes that are not overly salty, for taste or health reasons.

Presented by Lanette Kovachi, MS, RD, Subway

Subway's efforts to reduce sodium began in 2008 as a way to enhance its commitment to health and nutrition and to help consumers meet global sodium recommendations. The company's research and development team and vendors worked cooperatively to find solutions and to set sodium goals and reduce sodium. New technology and ingredients made it possible to deliver reduced-sodium products that were safe and tasted the same. Although sodium reductions were successful in some products, potassium chloride and other flavoring agents were added to others. Internal staff tests followed by consumer tests in a central location had to be passed before a new product was tested in the market. The market testing provided an opportunity to identify issues with the new product from an operational basis. New products were tested in the market only if they tasted exactly the same or had the same consumer perception of flavor as the current product.

Since 2009, Subway's 8 Fresh Fit 6-inch sandwiches that had baseline sodium levels >1000 mg have been reduced in sodium by an average of 32% in the United States. This was accomplished primarily by focusing on the bread and meat. The sodium reductions allowed selected Subway meals to carry the AHA's Heart-Check Mark to announce its certification as a heart-healthy meal. Sodium reduction was announced after the products had been rolled out in stores, and the focus of the message was on overall nutrition quality.

Subway's sodium reduction efforts extend globally, with average reductions in low-fat sub sandwiches of 29% in Canada, 39% in Australia, 53% in New Zealand, and 66% in Europe. The large reductions in Europe may have been facilitated by the United Kingdom Food Standards Agency's voluntary program to reduce sodium, which led to a level playing field for manufacturers, and the corresponding change in palates.

There must be motivation to reduce sodium, because there are significant challenges to developing lower-sodium products. Subway's consumer base is nutritionally savvy, which helped motivate the company to reduce sodium. Educating consumers about the negative health consequences of excess sodium can help build the demand for more lower-sodium foods that would help motivate industry.

Presented by Jennifer Ignacio, MS, RD, Compass Group

Compass Group North America has used a number of strategies to reduce sodium in the 6 million meals it serves each day in its contract food service business. These strategies include ingredient sourcing, culinary techniques, nutrition guidelines that have been developed internally or provided by clients, and customer education and information. Compass has found that customers are often more willing to accept a new offering that is healthy than a revised (healthier) version of an offering they have seen before.

Ingredient sourcing entails comparing the sodium content of products provided by different suppliers and selecting the products with the lower amount of sodium. Because menus vary greatly across its client sites, Compass Group sources a large variety of foods. To create menus that fit clients' demands for healthier foods, it is necessary to talk with the suppliers of every ingredient of a menu item to identify how

the ingredients can fit together to achieve the desired outcome. Compass has been able to source lower-sodium versions of pizza dough, tortillas, shrimp, and seasonings, for example, allowing it to expand the variety of items it can include as part of its “fit” offerings, which must have <600 mg of sodium. Whereas cooking from scratch was once the only way to provide meals within certain sodium levels, sourcing lower-sodium processed items has allowed smaller food service operations, which often do not have the capacity to do scratch cooking on a large scale, to create the same meals without having to cook entirely from scratch.

Educating culinary staff is another component that is important for reducing sodium in food service settings. Chefs can be trained in healthy cooking techniques, recipe evaluation, and reformulation through a proprietary Internet-based menu management program and by collaboration with registered dietitians on programs and promotions. Anecdotal evidence suggests chefs are popular with consumers and can be effective proponents for healthy foods.

Presented by Greg Drescher, The Culinary Institute of America

The culinary and food service industry is responsive to its customers, and chefs in particular have an opportunity to be cultural change agents given their popularity in society and in the media. To be change agents, chefs must be equipped with the science and the strategies to lead consumers.

Chefs have a number of options for reducing sodium. They may simply use less salt or replace some or all of the salt with a substitute, or they may identify suppliers who can provide lower-sodium versions of some ingredients. Another option is to revamp an existing item while maintaining the same concepts and flavors, such as by using less meat or cheese in a sandwich. A more creative approach is to source high-flavor, lower-sodium ingredients (such as peak-of-the-season produce, spices and other aromatics, and umami-rich foods) to build flavors that are less reliant on added sodium. There are also culinary techniques (such as searing and oven roasting) that can build flavor and decrease the need to add sodium, and these techniques generally do not require extra ingredients.

New directions in flavors and menus show a great deal of promise in helping the food service and culinary industry make progress in reducing sodium, as well as addressing other imperatives related to health, nutrition, and sustainability. Because there is a continuous stream of issues facing the food service industry, it is important that menu innovation increasingly follow an integrated model that is able to address not only single issues (such as sodium) but the convergence of many issues.

Most sodium research to date has focused on technical replacement solutions in the packaged foods sector, but relatively little has been done with regard to culinary strategies to reduce sodium. A recent study in this regard, conducted by the University of California Davis and The Culinary Institute of America, examined the sensory effects of replacing some of the ground meat with ground mushrooms in a taco recipe. This reduced the meat, increased the vegetables, and reduced the sodium without flavor loss. Compared with the 100% beef control, many blends were on par or perceived to taste better (J. Guinard and A. Myrdal Miller, University of California

at Davis and the Culinary Institute of America, unpublished data, 2012). This “swapability” concept is an example of culinary insight that is valuable to chefs.

A Culinary Institute of America effort related to sodium reduction is the Healthy Menus R&D Collaborative, which brings together 30 of the country’s largest, most influential volume food service providers to accelerate research and innovation around key health imperatives. When Healthy Menus R&D Collaborative members were surveyed about their attitudes and approaches to sodium reduction, 88% replied that sodium reduction was a long-term trend, and nearly all members reported aggressively working to reduce sodium. The top strategy was the use of flavor development strategies that do not rely on sodium, and another promising opportunity was menu innovation (developing new items with less sodium) rather than reformulation of iconic menu items. When communicating efforts to consumers, Healthy Menus R&D Collaborative members emphasized that it is important to talk about what the item offers, rather than what it lacks (ie, excess sodium). There is also a shared goal of reducing sodium with no or minimal change to the consumer food experience, even while introducing healthy menu innovation.

Session V: Translation and Implementation of Sodium Intake Recommendations

Update on the FDA’s Sodium Activities

Presented by Jessica Leighton, PhD, MPH, US Food and Drug Administration

The FDA’s efforts to reduce sodium have spanned decades. From the 1970s until recently, activities were focused on labeling and education. The FDA’s current education efforts have included helping consumers understand the “Nutrition Facts” panel, proposing that written information about sodium content be available for menu items in chain restaurants and similar retail establishments, working on a proposed rule to revise the Nutrition Facts panel, and considerations for front-of-package labeling.

A 2010 IOM report documented the failure of education efforts alone to reduce population sodium intake and recommended additional approaches.⁵⁰ Its recommendation for a primary strategy was that the FDA should set mandatory national standards for the sodium content of foods. The recommended interim strategy called for voluntary actions by the food industry to reduce sodium. Nutrition labeling, education, and monitoring were put forth as supporting strategies. Setting mandatory national standards for the sodium content of food could be done by revoking salt’s status as “generally recognized as safe” (which would trigger a petition process for approval of salt use in any food) or by modifying that status but specifying its conditions of use, thus allowing salt to be used in foods only within certain “safe” levels.

The FDA’s current sodium reduction efforts focus on the development of draft voluntary sodium targets for packaged and restaurant foods. This process is being informed through technical research to understand the issues that are critical for achievable and safe sodium reduction; review of the literature on behavior and taste to understand how consumers might adapt to lower sodium levels; solicitation of input from

industry stakeholders about technology, implementation, and potential unintended consequences; and an assessment of sodium levels in various food categories.

The FDA is committed to drafting voluntary sodium reduction targets that are evidence based, gradual, achievable, and sustainable. The process must ensure consistent application throughout the food supply, including packaged and restaurant foods, and account for consumer acceptance, food safety, and the functional role of sodium in food. Monitoring of sodium in foods and Americans' sodium intake will be critical. To promote transparency, there will be an opportunity for public input at every step. Meanwhile, the FDA will continue to remain committed to labeling and education as necessary components of its work.

Achieving Nutrient Adequacy With Sodium Intake of 1500 mg/d

Presented by Penny Kris-Etherton, PhD, RD, FAHA, Pennsylvania State University

The 2010 Dietary Guidelines for Americans⁴⁰ emphasize calorie balance to achieve and maintain a healthy weight and nutrient density to achieve nutrient adequacy. Food-based dietary recommendations have been issued at different calorie levels to promote healthy weights and to ensure nutrient adequacy for all nutrients, including potassium and sodium. Unfortunately, most Americans are not meeting recommendations for either of these nutrients. US Department of Agriculture eating patterns at various calorie levels do not always meet guidelines for sodium and potassium.⁴⁰ Both sodium and potassium are highly correlated with calories, with correlation coefficients of 0.81 and 0.72, respectively.⁶⁵ Thus, at higher calorie intakes, it is easier to meet potassium recommendations and more difficult to meet those for sodium, whereas at lower calorie intakes, the opposite is the case.

Although some scientists have demonstrated (using NHANES 2003–2008 data) that it is not possible to meet both sodium and potassium recommendations simultaneously and maintain a nutritionally adequate diet,⁶⁵ this can be done by carefully making appropriate food choices within food categories. For example, the DASH eating plan⁶⁶ meets the daily recommendation for potassium (4700 mg) and either 2300 or 1500 mg of sodium. These diets are high in fruits and vegetables and replace higher-sodium foods with lower-sodium foods, such as Swiss cheese (lower sodium) instead of cheddar cheese, in the 1500-mg sodium plan.

The potassium content of fruits and vegetables varies widely. Some higher-potassium foods are commonly consumed, such as bananas and tomatoes, whereas others are not. Choosing more higher-potassium options is essential for meeting potassium recommendations, although this may limit variety, increase costs, and require more frequent consumption of fruits and vegetables that are not commonly consumed, such as papaya and pumpkin. Substituting fruits and vegetables for other foods higher in sodium and lower in important nutrients will reduce both sodium intake and BP.

To achieve current sodium recommendations, it is important that the sodium content of the food supply be decreased and that consumers understand how to implement a healthy eating

pattern that incorporates lower-sodium, high-potassium foods. Existing consumer messages and educational tools, such as those developed by the AHA and the Dietary Guidelines for Americans, are helpful resources that provide guidance for reducing dietary sodium.

Modeling Scenarios for Sodium Reduction in the Food Supply

Presented by Victor L. Fulgoni, III, PhD, Nutrition Impact, LLC

Significant food supply changes are required to achieve population-wide sodium intakes that meet public health recommendations. The AHA provided funding for modeling scenarios that were conducted to identify the proportion of Americans who could achieve intakes of either 1500 or 2300 mg with various degrees of sodium reduction. The scenarios discussed at the conference included the following:

1. Reduce all foods indiscriminately: 5%, 10%, 15%, 25%, 50%, and 75%.
2. Reduce the top 10, 25, or 50 contributors to sodium intake: 5%, 10%, 15%, 25%, 50%, and 75%.
3. Combine the approaches of reducing all foods indiscriminately (10% and 25%) and reducing the top 25 and top 50 contributors (25% and 50%).
4. Use the lowest quartile of sodium levels for food groups,⁵¹ weighting data in this quartile by consumption frequency.

NHANES data from 2007 to 2010 were used for the analyses, with the exclusion of people <2 years of age and pregnant and lactating females, as well as those who had unreliable dietary records. The resulting sample size was ≈16800 people. Unadjusted sodium values were used, which means that sodium in some foods was not adjusted downward for people who reported not using salt in cooking. Usual sodium intake was determined for each scenario using 2 days of dietary recall data. Means and percentiles of usual intake were determined, and the percentages of the population meeting intake goals of 2300 and 1500 mg of sodium per day were assessed.

The modeling exercise indicated there are various approaches to estimating the impact of reducing sodium in the food supply. Regardless of approach, large changes in the current sodium levels of foods will be required for a majority of the population to meet target intake levels of either 2300 or 1500 mg/d. For example, in scenario 1 mentioned above, reductions between 25% to 50% and 50% to 75% were required to achieve mean daily population intakes of 2300 and 1500 mg, respectively. Reductions of 50% to 75% were required across the food supply for most of the population to achieve an intake of 1500 mg/d, although even reductions as low as 5% helped a small proportion of the population achieve intakes of 2300 and 1500 mg (Figure 7). Further data on all the scenarios are presented in the online-only Data Supplement.

Although a concomitant reduction in calorie intake can also help to reduce sodium, major reductions (eg, >50%) in the sodium content of most foods will be required for large segments of the population to meet current sodium intake goals.

Summary of Breakout Session Discussions

After the plenary sessions, participants in the Sodium Conference divided into 5 preassigned groups (to ensure a mix of disciplines and perspectives) facilitated by preappointed session leaders using a common discussion guide. The breakout sessions generated significant interactions, allowing attendees to contribute thoughts and expertise. The breakout discussions were not intended to develop iron-clad recommendations but to identify potential challenges, opportunities, and areas ripe for future investigation or potential future action. Breakout group leaders reported outcomes to the entire audience. A summary of group discussions of each topic follows.

Major Lessons Learned From Conference Presentations

- Sodium reduction will be a long-term effort because it is a complex challenge with the potential for unintended consequences. There are unique challenges to sodium reduction in individual foods and meals, and there are also different challenges involved in reducing sodium in packaged goods versus restaurant/food service foods.
- There is optimism about progress to date, and this should be celebrated. Still, much work lies ahead to achieve meaningful change in consumer sodium intakes, which appear to be unchanged over many years. However, sodium reductions in the food supply over the past few years may not be reflected in population sodium intake data, because the latest NHANES data are from 2009 to 2010. Furthermore, it is difficult for food and nutrient databases to keep up with the constantly changing food supply, and it is important that these databases reflect the current sodium content of the food supply as much as possible to achieve more precise estimates of population sodium intake.
- To make progress in sodium reduction, innovative, multifaceted collaborative solutions are needed. There is a role for every sector.
- To motivate consumer behavior change and education, there is a need for clear, simple, consistent, positive messages that are culturally appropriate and relevant and come from multiple voices. Consumers will benefit from practical advice and actionable solutions.
- Sodium reduction should be incorporated into a “total health/total diet” approach in which healthy options are

the default and dietary approaches to reduce sodium and increase potassium intake are part of the solution. There is synergy in this kind of approach, because reducing calories by increasing potassium-rich fruits and vegetables can achieve other health benefits alongside sodium reduction, and reducing calorie intake in general can decrease sodium intake because of its high positive correlation with calorie intake.

- Lowering sodium in the food supply is a critical component of reducing population sodium intakes, and the food industry must be committed to that effort. Consumers should have more convenient lower-sodium choices so they are able to achieve dietary recommendations for sodium without the barrier of extended food preparation time.
- It is important to create a level playing field so manufacturers can simultaneously work toward sodium reduction without concern of losing customers to competitors’ higher-sodium products.
- There is tremendous opportunity to innovate, such as developing alternatives for food safety or experimenting with salt substitutes and enhancers. A key question that participants discussed was whether the approach should be to develop products that have less sodium but meet consumers’ expectations for flavor and texture by maintaining the same taste profile or to develop products that have less sodium and attempt to cultivate preferences for a different taste profile. These approaches need not be mutually exclusive. Furthermore, it appears that there is a greater opportunity to shape taste expectations and preferences for new foods rather than to adjust existing expectations and preferences for existing foods. Importantly, although taste is highly important, it is malleable. A level playing field, in which sodium is reduced in a given food across all its sources in the food environment, facilitates changes in taste preferences.

Key Determinants of Success

Participants expected that decreases in population sodium intake might also occur alongside increases in potassium intake, which could lead to a gradual shift in BP and favorable outcomes for CVD end points. Attitudinal and behavioral shifts that could be expected to occur alongside decreases in population sodium intake include greater concern about excess sodium intake and a shift in consumer taste preferences for foods with less salt.

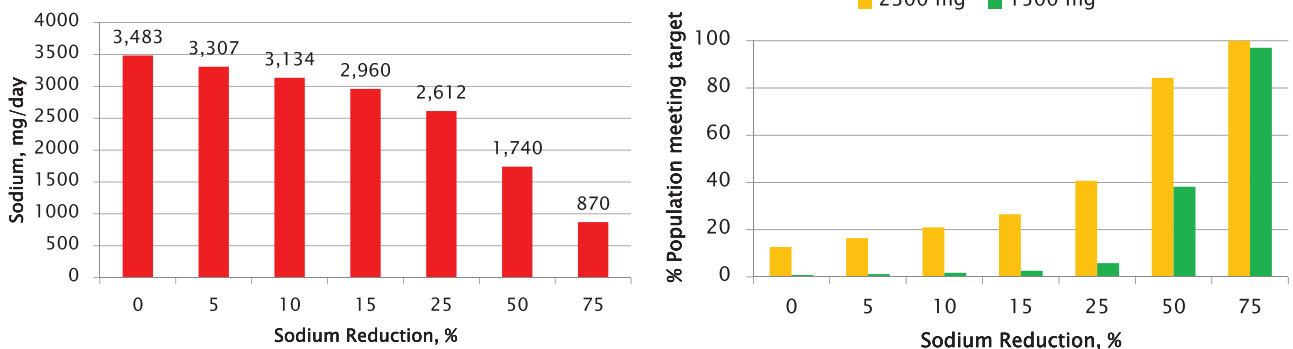


Figure 7. Scenario A. **Left,** Mean population sodium intakes resulting from indiscriminate reduction. **Right,** Proportion of population meeting targets with various degrees of indiscriminate reduction. Average intake for ≥2 years of age, sexes combined. Reproduced with permission from Nutrition Impact, LLC. Copyright ©2013, Nutrition Impact, LLC.

Conference participants identified necessary elements for successful efforts in reducing population-wide sodium intakes and the sodium content of the food supply. These elements included the following:

- Collaboration of multiple sectors and stakeholders at every level of the food supply so that there are multiple approaches and solutions.
- Realistic solutions, for example, gradual reductions in the sodium content of foods.
- Achievement of a win-win for industry and consumers:
 - For consumers, ensure affordability, convenience, availability, and acceptability of lower-sodium foods; achieve a shift in social norms about acceptable sodium levels; and ensure that all consumer segments are educated about the sodium and health connection and are demanding lower-sodium foods.
 - For industry, ensure collaboration is facilitated so one company does not lose a competitive edge if it is the first to lower sodium in a product. Also, it would be helpful to have sodium alternatives that address the multiple functional roles of sodium in foods in addition to its role in taste. This may require incentives and securing a commitment from leaders across the entire food industry, perhaps in an orchestrated manner.
- Facilitation of more research and development, especially in the food service and culinary sectors.
- Couple sodium reduction efforts with other public health efforts, such as obesity prevention. Portion control and a reduction in energy intake are expected to translate into sodium reduction because sodium is positively correlated with calories.

Guiding Principles

Participants compiled a list of principles that should guide sodium reduction efforts, including the following:

- Evidence-based methods that allow for adaptation as deemed necessary over time
- Use of a multisector approach in which there is a constant sense of urgency and balance of burden across all sectors
- Measurable in the short and long term
- Achievable, practical goals driving to meaningful outcomes and the highest possible degree of return on investment
- Inclusion of processes that ensure accountability, monitoring, and compliance
- Allow efforts to be voluntary and gradual, but include incentives and disincentives
- Avoidance of negative consequences, such as an unacceptable increase in cost or a compromise in food safety or consumer acceptance
- Transparency of efforts and data among all sectors
- Efforts must occur in the context of overall healthy eating and emphasize a food-based (as opposed to nutrient-based) approach and proper portion size
- Messages should be clear, simple, consistent, positive, culturally appropriate, and focused on preserving freedom of choice

Top Priorities for Reducing Sodium Intake

Participants varied in their selections of sodium reduction scenarios that they considered as top priorities (based on the modeling that was presented during the conference; see “Modeling Scenarios for Sodium Reduction in the Food Supply”). The scenario that received the strongest support was the combination approach of indiscriminate reductions across the entire food supply combined with reductions in the top contributors to sodium intake. Participants were concerned that a scenario that focused only on top contributors presented a disproportionate burden on those foods, yet it offered more return on investment than an approach involving indiscriminate reductions across the entire food supply. Regardless of the approach, participants emphasized that food safety, food quality, functionality, and consumer acceptance in terms of taste and price must be maintained. They also agreed that any approach must include the food service industry. To promote industry data sharing and collaboration that could expedite progress in reducing sodium in the food supply, some participants suggested considering relaxing the antitrust provisions for health promotion and disease prevention, such as an orchestrated reduction in sodium content of specific food categories over a defined period of time.

Roles for Various Sectors

Participants discussed the roles that various stakeholder sectors could play in sodium reduction efforts:

Academics

- Conduct research to determine the amount and rate of acceptable sodium reduction for food safety, food quality, functionality, and taste
- Determine the most effective education strategies
- Provide technical assistance for sodium reduction efforts

Government

- Fund and conduct research to determine the acceptable amount and rate of sodium reduction (for food safety, functionality, and taste)
- Maintain data on sodium intake and sodium content of the food supply; ensure that food databases reflect the current sodium content of the food supply as much as possible
- Provide both monetary and nonmonetary incentives for schools, industry, etc
- Strengthen the Nutrition Facts panel (food label) to improve consumer understanding of sodium content
- Implement voluntary standards for sodium across different food categories, including packaged and restaurant foods, so there is a level playing field for sodium reduction to occur
- Implement sodium reduction as part of procurement policies, such as in the US General Services Administration/US Department of Health and Human Services “Health and Sustainability Guidelines” for foods offered and served in government buildings
- Implement lower-sodium standards in government nutrition programs such as Child and Adult Care Food



Program and the Special Supplemental Nutrition Program for Women, Infants, and Children

Healthcare Professionals

- Educate patients and the public about the costs of excess sodium consumption and the benefits of sodium reduction
- Point patients toward resources for reducing sodium in their diets
- Advocate for less sodium in the food supply
- Serve as role models and ambassadors for healthy eating

Professional Organizations

- Raise funds for research
- Educate patients and the public about the costs of excess sodium consumption and the benefits of sodium reduction
- Disseminate messaging about the health benefits of policy and environmental solutions to reducing sodium intake
- Advocate for less sodium in the food supply
- Provide technical assistance for sodium reduction efforts

Industry

- Fund and conduct research to determine the amount and rate of sodium reduction that is acceptable (for food safety, food quality, functionality, and taste)
- Invest in the development of technologies or ingredients that enable sodium reduction
- Continue the development of lower-sodium packaged food and food service items
- Commit to specific reductions in sodium content
- Increase transparency of sodium reduction methodologies
- Provide updated food composition data to government so food and nutrient databases reflect the current sodium content of the food supply as much as possible
- Conduct in-store marketing to drive people to lower-sodium choices

Chefs

- Serve as role models and ambassadors for healthy eating
- Innovate to produce delicious lower-sodium meals

Conclusion: Americans Would Be Better Off Eating Less Salt

A healthy diet, including reduced sodium intake, is an important part of a comprehensive approach to cardiovascular health promotion and disease prevention. Sodium reduction is a priority for the AHA.

The AHA believes in the health benefits of reducing sodium to <1500 mg/d based on strong scientific evidence. Although other health organizations suggest a higher target, there is nonetheless agreement across the board that Americans would be better off reducing sodium intake. Currently, Americans consume >3400 mg of sodium per day, which increases their risk of hypertension, stroke, and other serious health problems. Reducing sodium intake will take a multidisciplinary,

multisector effort. This conference provided an opportunity for a diverse group of stakeholders to have a robust discussion about the opportunities for collaboration to continue reducing Americans' sodium intake.

The long-term goal of 1500 mg of sodium per day can be achieved incrementally. Research has shown that behavioral modification techniques can help people reduce sodium, but these techniques alone have not been successful in decreasing population-wide sodium intake.⁵⁰ Environmental and policy approaches to accompany behavior change strategies are needed to achieve a meaningful impact on the public's health. Public policy approaches have successfully decreased population salt intakes in the United Kingdom and Finland, for example.⁶⁷

Food manufacturers are under increasing pressure to reduce sodium. Much has been done, but more work is needed. The association applauds the progress in this area and encourages further innovation and technological advancement that will enable further reductions. The association eagerly awaits the release of the federal government's draft voluntary sodium targets for packaged and restaurant foods, which will be a critically important step for lowering sodium in the food supply.

Other critical government efforts include supporting robust sodium criteria within school nutrition standards, foods advertised and marketed to children, and foods purchased by employers or government feeding programs. The AHA also supports improved food labeling that helps consumers understand how much sodium is in the foods they purchase and consumer education in restaurants to help consumers choose lower-sodium options.

Further research is critical, but calls for more research should not postpone efforts to meet current AHA guidelines for sodium reduction. Monitoring and surveillance should be continued and enhanced with regard to sodium knowledge, attitudes, and behaviors; sodium intake measurement; salt taste preference; and sodium content of foods. In particular, collection of 24-hour urine samples during NHANES or as a separate nationally representative "sentinel site"-type activity will be important to accurately track sodium intakes. Maintenance of food and nutrient databases that reflect the current sodium content of the food supply will also be important to quantify population sodium intake.

Appendix

This article represents a summary of a conference sponsored by the AHA held on June 19 and 20, 2013. The opinions expressed in this article are those of the authors and/or participants and do not necessarily represent those of the editor or the AHA. The publication of these proceedings was approved by the AHA's Science Advisory and Coordinating Committee on February 28, 2014.

The conference focused on approaches to reduce sodium in the US food supply and in Americans' diets. Company-specific information is intended to reflect practical experiences and the expertise of the speakers. The presentations and subsequent information in the report do not necessarily reflect the opinions, support, or endorsement of the AHA. The information is not intended to be exhaustive. It is intended to be informative of the successes and barriers in the reduction of sodium in the food supply.

We thank each speaker for presenting at the conference and for reviewing the draft summary of his or her presentation included herein to ensure accuracy. The following speakers presented at the conference: Rachel K. Johnson, PhD, MPH, RD, FAHA (University of Vermont); Rose Marie Robertson, MD, FAHA, FACC, FESC (AHA); Nancy Brown (AHA); Thomas Farley, MD, MPH (New York City Department of Health and Mental Hygiene); Frank M. Sacks, MD, FAHA (Harvard School of Public Health); Alice H. Lichtenstein, DSc, FAHA (Tufts University); Paul K. Whelton, MB, MD, MSc (Tulane University); Lyn M. Steffen, PhD, MPH, RD, FAHA (University of Minnesota School of Public Health); Alanna Moshfegh, MS, RD (US Department of Agriculture Food Surveys Research Group);

Emily Krol, MS (Mintel Group Ltd); Linda Kragt (Morton Salt); Andrew Hoffman, PhD (Tate & Lyle); Guy H. Johnson, PhD (McCormick Science Institute); Gary K. Beauchamp, PhD (Monell Chemical Senses Center); Betsy Booren, PhD (American Meat Institute Foundation); Janice Johnson, PhD (Cargill); Bill Graves, MS, MBA (Dairy Research Institute); Joshua Anthony, PhD, MBA (Campbell Soup Company); Lisa Carlson, MS, RD (Unilever Food Solutions); Lanette Kovachi, MS, RD (Subway); Jennifer Ignacio, MS, RD (Compass Group); Greg Drescher (The Culinary Institute of America); Jessica Leighton, PhD, MPH (US Food and Drug Administration); Penny Kris-Etherton, PhD, RD, FAHA (The Pennsylvania State University); Victor L. Fulgoni, III, PhD (Nutrition Impact, LLC).

Disclosures

Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/Honoraria	Expert Witness	Ownership Interest	Consultant/Advisory Board	Other
Elliott M. Antman	Brigham & Women's Hospital and Harvard Medical School	None	None	None	None	None	None	AHA President-Elect*
Lawrence J. Appel	Johns Hopkins University	McCormick Science Institute (grant on sodium reduction)*	None	None	None	None	None	None
Douglas Balentine	Unilever North America	None	None	None	None	Unilever North America†	None	None
Rachel K. Johnson	University of Vermont	None	None	None	None	None	None	None
Emily Ann Miller	American Heart Association	None	None	None	None	None	None	None
Antigoni Pappas	American Heart Association	None	None	None	None	None	None	None
Lyn M. Steffen	University of Minnesota School of Public Health	CDC (Assessment of Sodium in Various Food Sources)*	None	None	None	None	None	None
Kimberly F. Stitzel	American Heart Association	None	None	None	None	None	None	None
Dorothea K. Vafiadis	American Heart Association	None	None	None	None	None	None	None
Laurie Whitsel	American Heart Association	None	None	None	None	None	None	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives \$10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns \$10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

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Supplemental Online Material

Modeling Scenarios for Sodium Reduction in the Food Supply

Significant change in the sodium content of the food supply will be required to achieve population-wide sodium intakes that meet public health recommendations. Modeling scenarios were conducted to identify the proportion of Americans who could achieve sodium intakes of either 2300 mg/d or 1500 mg/d with various degrees of reduction in the sodium content of the food supply. Four sodium reduction approaches were presented at the Conference:

1. **Scenario A. Indiscriminate Sodium Reduction Approach:** Reduce 5, 10, 15, 25, 50, and 75% of sodium in all foods indiscriminately;
2. **Scenario B. Top Source Sodium Reduction Approach:** Reduce 5, 10, 15, 25, 50, and 75% of sodium in top 10, 25, and 50 food groups contributing sodium to the diet (**Table 1**). Top contributors of sodium were identified using food grouping approach previously reported by CDC¹;
3. **Scenario C. Multilevel Sodium Reduction Approach:** Reduce sodium (25 and 50%) in top 25 and top 50 sodium contributor food groups and lower level of sodium (10 and 25%) in all other foods.
4. **Scenario D. Weighted 25th percentile by food group:** The bottom quartile of sodium levels for food groups weighted by consumption frequency were used as

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targets for all foods in the food group (e.g., if 25% of foods in a food group could meet these levels, it is anticipated to be likely that other foods could also).

Table 1. Top food sources of sodium in the diet. (Source: NHANES 2007-2010, Total Population, Age 2+ years)

Rank	Food Category	% of Total Dietary Sodium	Rank	Food Category	% of Total Dietary Sodium
1	Breads and rolls	6.84	26	Milk, whole and reduced fat	1.20
2	Pizza	5.35	27	Other vegetables	1.20
3	Cold cuts and cured meats	5.20	28	Legumes and legume mixed dishes	1.19
4	Poultry	4.72	29	Dips, gravies, other sauces	1.14
5	Soups	4.08	30	Beef, excludes ground	1.12
6	Sandwiches (single code)	3.88	31	Savory crackers	1.03
7	Cheese	3.72	32	Rice mixed dishes	1.01
8	Meat mixed dishes	3.22	33	Ground beef	0.99
9	Savory snacks	3.10	34	Tortillas	0.98
10	Pasta mixed dishes, excludes macaroni and cheese	2.86	35	Pancakes, waffles, french toast	0.97
11	Frankfurters and sausages	2.75	36	Cookies, brownies, sweet crackers	0.94
12	Burritos, tacos, tamales	2.62	37	Bacon	0.92
13	Eggs and egg mixed dishes	2.09	38	Fish and seafood mixed dishes	0.89
14	Tomato-based condiments	2.07	39	Doughnuts, sweet rolls, pastries	0.87

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15	Fried rice, lo mein, stir-fry mixtures	1.97	40	Tap and plain bottled water	0.86
16	Rice	1.93	41	Pork	0.76
17	Salad dressings and vegetable oils	1.89	42	Nuts and seeds	0.70
18	Ready-to-eat cereals	1.75	43	Milk, low fat and nonfat	0.69
19	Fish and seafood	1.75	44	Olives, pickles, pickled vegetables	0.69
20	Poultry mixed dishes	1.71	45	Cooked cereals	0.67
21	White potatoes, fried	1.60	46	Vegetable mixed dishes	0.58
22	White potato mixed dishes	1.55	47	Starchy vegetables, excludes white potatoes	0.52
23	Biscuits, muffins, quick breads	1.34	48	Soy-based condiments	0.52
24	Cakes and pies	1.25	49	Butter, margarine, other fats	0.48
25	Macaroni and cheese	1.20	50	Ice cream	0.47

NHANES data from 2007-2010 were used for the analyses, excluding people less than 2 years of age as well as pregnant and lactating females. The resulting sample size was approximately 16800 people. Unadjusted sodium values were used, meaning that sodium in some foods were not adjusted downward for people who reported not using salt in cooking as had been the practice prior to data released in 2009-2010.² Usual intake was determined for each modeling scenario using 2 days of dietary recall data. The National Cancer Institute method was used with recall day and weekend intake flag (weekday versus Friday/Saturday/Sunday) as covariates.³ Mean and percentiles of usual intake were determined and the percentages of the population meeting sodium targets of 2300 and 1500 mg/day were assessed. Data were generated for the total population and various subgroups, namely those: 2+, 2-19, 20+ and 50+ years of age for gender combined, males and females separately, and Non-Hispanic Blacks separately. Usual sodium intake was determined for each scenario, using two days of dietary recall data. Mean and

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percentiles of usual intake were determined and the percentages of the population meeting 2300 and 1500 mg sodium/day were assessed.

- Scenario A projected that reductions of between 25-50% and 50-75% were required to achieve mean daily population intakes of 2300 mg and 1500 mg, respectively. Reductions of 50%-75% were required across the food supply for a majority of the population to achieve an intake of 1500 mg, though even reductions as low as 5% allow a small proportion of the population to achieve intakes of 2300 mg and 1500 mg (Figure 1).

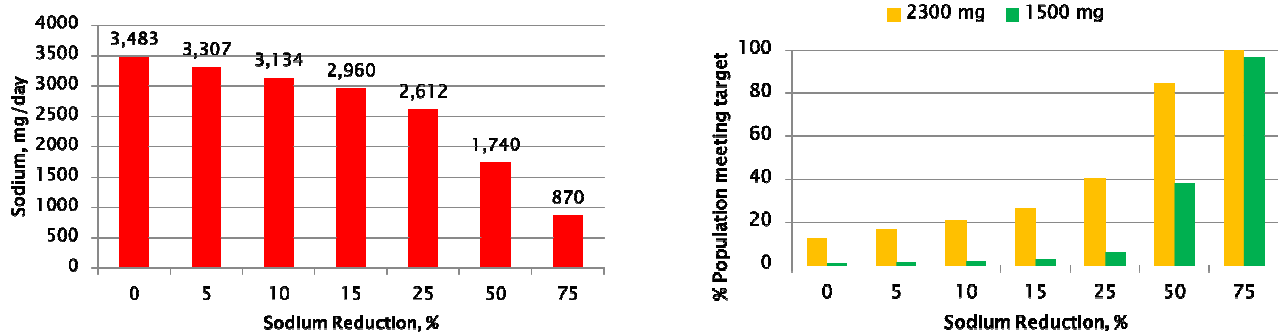


Figure 1. Scenario A. Left = Mean population sodium intakes resulting from indiscriminate reduction. Right = Proportion of the population meeting targets with various degrees of indiscriminate reduction. Average intake for 2+ years of age, gender combined. Reproduced with permission. Copyright ©2013 Nutrition Impact, LLC.

- Scenario B indicated that focusing on only the top 10 sources of sodium intake would require reductions of at least 50% to enable a majority of the population to consume 2300 mg/d or less (Figure 2, left), and even reducing these 10 sources by 75% would enable less than 5% to meet

1500mg (not shown). Reductions of 50% and 75% in the top 25 sources could lead to 50% of population meeting 2300 mg/d, but only around 10% meeting 1500 mg/d (not shown). The same magnitude of reductions in the top 50 sources could lead to more than 80% of the population meeting 2300 mg/d (Figure 2, right). More than 80% could also achieve 1500 mg/d with a 75% reduction in the top 50 sources (Figure 2, right).

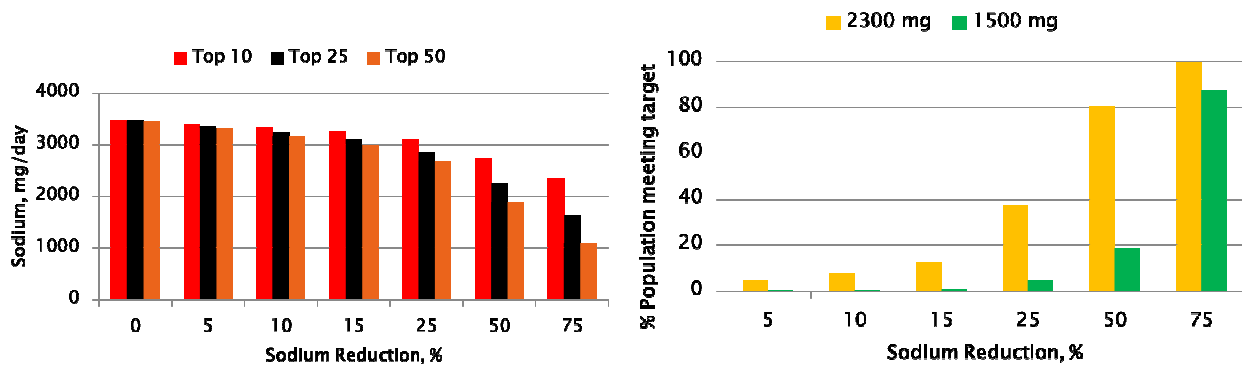


Figure 2. Left = Results: Mean population sodium intakes resulting from top sources reduction. Average intake for 2+ years of age, gender combined. Right = Results: Proportion of the population meeting targets with top 50 sources reduction, 2+ years of age, gender combined. Reproduced with permission. Copyright ©2013 Nutrition Impact, LLC.

- Scenario C with a combination of top sources reduction with some indiscriminate reduction approach showed that a 25% reduction of top 50 sources with a 10% reduction in all other foods resulted in around 40% of the population meeting 2300 mg/d and less than 10% meeting 1500 mg/d. A 50% reduction of top 50 sources with 10% reduction in all other foods leads to about 80% of the population meeting 2300 mg sodium per day and 40% meeting 1500 mg/d (Figure 3).

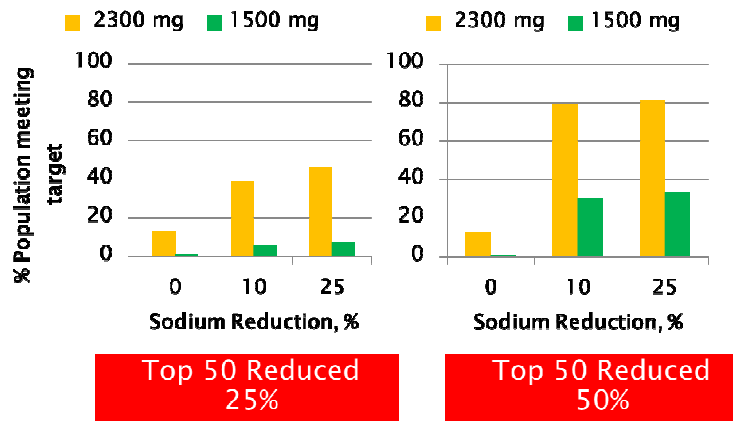


Figure 3. Results: Proportion of the population meeting targets with combination of Top 50 Sources Reduced and Indiscriminate Reduction. 2+ years of age, gender combined. Reproduced with permission. Copyright ©2013 Nutrition Impact, LLC.

- Scenario D weighted 25th percentile by food group approach could lead to a decrease in mean population sodium consumption of close to 900 mg/d (Figure 4) and lead to about 40% of population meeting 2300 mg/d (not shown), though less than 10% would achieve 1500 mg/d (not shown). In addition, examination of the range of sodium content within food categories showed that there is a relatively narrow range in some categories, indicating that there may be food safety or functionality barriers that exist for these categories. Targets for reduction in those categories might need to consider these and other factors.

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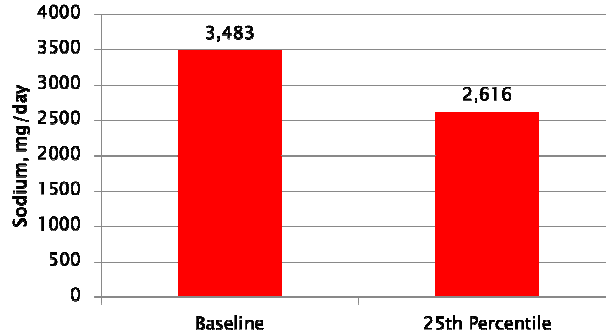


Figure 4. Results: Reduced to 25th Percentile per Food Group Average intake for 2+ years of age, gender combined. Reproduced with permission. Copyright ©2013 Nutrition Impact, LLC.

For all scenarios, smaller degrees of reductions were required for females to achieve intakes of 2300 mg/d or 1500 mg/d than for males because they consumed fewer calories, and calories were positively correlated with sodium intake.

This analysis has some strengths and limitations; strengths include using usual sodium intake measures and using a large national representative sample of Americans while limitations include intakes based on dietary recall and thus may be over- or under-reported, sodium composition data are dependent on data made available by USDA, and data used, while the most current data sets released from NHANES, are more than three years old and as such may not represent recent changes in sodium content of the food supply.

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