Published in final edited form as:

Curr Treat Options Cardiovasc Med. 2012 August ; 14(4): 425–434. doi:10.1007/s11936-012-0182-9.

Strategies to Reduce Dietary Sodium Intake

Laura K Cobb, MS^{1,2}, Lawrence J Appel, MD, MPH^{1,2,3}, and Cheryl A.M. Anderson, PhD, MPH, MS^{1,2,3}

¹Welch Center for Prevention, Epidemiology and Clinical Research, Johns Hopkins University, Baltimore, MD, USA

²Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD

³Department of Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, USA

Opinion

Excess sodium intake has an important, if not predominant, role in the pathogenesis of elevated blood pressure, one of the most important modifiable determinants of cardiovascular disease (CVD). In the United States, almost 80% of sodium in the diet comes from packaged and restaurant foods. Given the current food environment, educational efforts such as clinician counseling are useful, but a comprehensive public health approach is necessary to achieve meaningful reductions in sodium intake. A successful approach includes several key strategies, which together will both promote positive decisions by individuals and change the context in which they make those decisions. The strategies include: (1) public education, (2) individual dietary counseling, (3) food labeling, (4) coordinated, voluntary industry sodium reduction, (5) government and private sector food procurement policies, and (6) FDA regulations, as recommended by the Institute of Medicine, to modify sodium's *generally regarded as safe* (GRAS) status. Population-wide reduction in sodium intake has the potential to substantially reduce the public burden of preventable CVD and reduce health care costs.

Keywords

Salt; Sodium; Blood Pressure; Hypertension; Cardiovascular Disease; Policy

Introduction

Sodium in the Food Supply

Sodium is a major component of our food supply. The primary source is salt (sodium chloride), which provides ~ 90% of dietary sodium. Other contributors include sodium bicarbonate (i.e., baking soda) and mono-sodium glutamate (i.e., MSG). Many people enjoy the taste of salt. It also can deepen other flavors, [1] making it popular with both home and restaurant cooks. The taste for salt, however, is malleable and decreases as people are

Corresponding author: Cheryl A.M. Anderson, Welch Center for Prevention, Epidemiology and Clinical Research, 2024 East Monument St., Suite 2-600, Baltimore, MD 21287, chanders@jhsph.edu, Phone: 410-614-0761.

Lawrence J. Appel, Welch Center for Prevention, Epidemiology and Clinical Research, 2024 East Monument St., Suite 2-600, Baltimore, MD 21287, lappel@jhmi.edu, Phone: 410-955-4156

Laura K. Cobb, Welch Center for Prevention, Epidemiology and Clinical Research, 2024 East Monument St., Suite 2-600, Baltimore, MD 21287, lkobb@jhsph.edu, Phone: 410-955-4156

Disclosure

Cheryl Anderson and Lawrence Appel currently receive funding from the McCormick Science Institute to conduct a study with the objective of assisting the general public in achieving and maintaining the currently recommended sodium intake of 1500 mg/day through a reduced sodium intervention that emphasizes spices and herbs. There are no other conflicts to disclose.

exposed to a lower sodium diet. [2] More importantly, salt is a major component of processed foods, and companies use it because it's cheap, hides bitterness, and maintains texture. [1] Because of its ubiquity in the food supply, even motivated consumers find it difficult to reduce their salt intake. In fact, an estimated 80% of sodium intake in the United States (US) comes from restaurant and packaged food, while only 11% comes from discretionary sources, i.e. added by individuals during meals or while cooking. [3]

Actual sodium intake greatly exceeds recommendations. According to the 2010 US Dietary Guidelines for Americans, adults should consume no more than 2,300 mg per day. For people over age 50, those with hypertension or chronic kidney disease, and Black Americans, the recommendation is to consume no more than 1,500 mg. [4] The American Heart Association recommends that the 1,500 mg daily upper limit be applied to everyone. [5] Recent estimates from 24-hour dietary recalls, collected as part of the National Health and Nutrition Examination Survey (NHANES), indicate that average sodium intake in the US is ~3,600 mg/day. [1] Measures of intake from 24-hour urine collection studies in clinic settings and in adults find similar intake levels. [6, 7]

Scientific Rationale for Sodium Reduction

Blood Pressure (BP)-related diseases (i.e., coronary heart disease, stroke, and end-stage renal disease (ESRD)) are leading causes of morbidity and mortality throughout the world. [8] The relationship of BP with these outcomes has been characterized as strong, consistent, continuous, independent and etiologically relevant. [9] Importantly, the risk of BP-related diseases increases progressively throughout the range of BP, including both hypertensive and non-hypertensive ranges. [10] It has been estimated that 47% of coronary heart disease events and 54% of strokes can be attributed to elevated BP. [8] A cardinal feature of the elevated BP epidemic is the age-related rise in BP, in both children and adults.

Excess sodium intake has an important, if not predominant, role in the pathogenesis of elevated BP. [11, 12] Other lifestyle factors that raise BP include excess weight, insufficient potassium intake, high alcohol consumption, suboptimal dietary pattern, and physical inactivity. [13] Supportive evidence on the adverse effects of excess sodium intake on BP comes from animal studies, migration studies, ecologic studies, longitudinal observational studies, clinical trials, and meta-analyses of trials. The best available evidence strongly supports a direct relationship between sodium intake and elevated BP - on average, as sodium intake increases, so does BP. [14]

By lowering BP, sodium reduction should substantially reduce cardiovascular disease. Recently, several studies have estimated the public health benefits and cost savings attributable to the BP effects of a reduced sodium intake. In one study, reduction of dietary salt intake by 3g per day is projected to save 194,000 to 392,000 quality-adjusted life-years and \$10 to \$24 billion in health care costs annually, while reducing the annual number of deaths by 44,000 to 92,000. [15] Few trials have directly assessed the effects of sodium reduction on hard clinical outcomes. In the largest and longest of these trials, Cook and colleagues documented that persons assigned to a reduced sodium intervention had a 25 – 30% reduced risk of cardiovascular disease events. [16]

Importantly, excess sodium intake has adverse effects, apart from its effects on BP. [17] A large body of evidence indicates that sodium increases LV mass and alters vascular structure and function. [18] Furthermore, excess sodium intake appears to increase the risk of gastric cancer, chronic kidney disease, [19] kidney stones, and osteoporosis. [14] The latter two relationships reflect the well-documented, direct relationship of sodium intake with urinary calcium excretion – as sodium intake increases, so does calciuria. [20]

Still, the evidence base does have limitations. First, the assessment of sodium intake has methodological challenges. [21] Both systematic and random errors in the measurement of dietary sodium intake are commonplace. The gold standard remains urinary excretion of sodium from 24-hour collections, but even these estimates can be inaccurate because of collections problems, most commonly under-collection. Furthermore, because of large day-to-day and within-person variation, repeat measurements on multiple days are needed to obtain precise measurements. Such methodological issues have led to inconsistent and occasionally paradoxical findings. [22, 23] However, the best available evidence strongly supports population-wide sodium reduction as a means to prevent cardiovascular disease and stroke. [24]

Strategies to Reduce Sodium Intake

In this paper, we summarize strategies to lower sodium intake in the general population (see Table 1). While all of these strategies have the potential to be effective on their own, a multi-factorial effort that includes several component strategies will have the greatest impact.

Strategy 1: Public Education

A long-standing public health strategy to reduce sodium intake is to conduct public education campaigns. Since the 1970's, when the National Heart, Lung and Blood Institute began sponsoring the National Blood Pressure Education Campaign, there have been major efforts to educate the public about sodium reduction. [1] Campaigns raised awareness of the connection between sodium and high blood pressure with consumer knowledge of the sodium hypertension relationship rising from 12% in 1979 to 48% in 1984. However, these gains have been hard to sustain; by 2002, awareness declined to 39%. [1] More problematic, the percentage of consumers actively trying to reduce sodium never increased beyond 33%. This may be because Americans do not have a good understanding of their own sodium intake. Thus, despite increased awareness, sodium consumption has not decreased and might even have increased since the 1970s. [1]

Education campaigns are most effective when conducted in conjunction with broader sodium policies and programs, as done in the United Kingdom (UK) and Finland. In Finland, mass media education campaigns were coupled with voluntary efforts by industry and warning labels on high salt packaged foods, all leading to an average sodium reduction of 1,200 mg/day. [25] In 2004, the UK government launched an extensive education campaign focusing on the sodium content of packaged food to complement a major voluntary sodium reduction initiative by the government. As a result, the number of consumers reducing sodium intake increased by a third and the number checking labels for sodium doubled. [26]

A similar trend can be seen in the more recent public education campaigns in the US, which have been coupled with broader policy work. The New York City Department of Health's 2010 ads in the subway system highlighted the high levels of salt in packaged food and urged consumers to compare labels. [27] In Massachusetts in 2011, ads on television and in the transit system provided consumers advice on how to reduce sodium from packaged and restaurant foods. [28] Both New York City and Massachusetts are members of the National Salt Reduction Initiative, a voluntary coalition that aims to reduce the sodium content of packaged and restaurant foods by 25%. [29]

Public education is one of the easiest strategies to implement; it does not require regulatory or legislative action, it's relatively inexpensive, and is generally uncontroversial. However, given the ubiquitous and high levels of sodium in the food supply, achieving sodium

reduction will require lower levels of sodium in packaged and restaurant food. Hence, even though consumer education is a valuable tool to raise consumer awareness and support for more comprehensive initiatives, education alone is unlikely to reduce sodium consumption.

Strategy 2: Dietary Counseling

Individual dietary counseling, whether by physicians or other healthcare providers, is another important strategy for reducing sodium intake. Data show that sodium reduction is achievable through intensive dietary sodium counseling. [30, 31] A caveat is that advice alone will not allow patients to meet sodium and other lifestyle recommendations. [32] However, as demonstrated for smoking cessation [33] and weight control [34], physicians play an important role in the reinforcement and maintenance of behavior change. The physician-patient encounter offers a valuable opportunity for physicians to promote lifestyle changes, of which sodium reduction should be a major goal. A brief supportive message on the benefits of sodium reduction, even without extensive counseling, should be beneficial. Physician effectiveness in this role can be enhanced through their increased knowledge, skills, and a positive attitude towards sodium reduction and other lifestyle modification.

To efficiently and effectively influence patients' efforts towards dietary salt reduction, physicians should be aware of ongoing public health initiatives. There are national efforts spearheaded by the federal government and professional organizations, as well as local public health campaigns that target sodium reduction. Additionally, there have been stories about sodium in the popular media, including a feature article in the November 2010 issue of *Vogue* magazine where sodium was highlighted on the highly coveted cover of the magazine. [35] Not all media stories support sodium reduction, so it is important to reinforce that despite occasional stories to the contrary, an overwhelming body of evidence supports population-wide sodium reduction.

Features of an effective counseling session with patients include: assessment of their readiness for change; discussion of the importance of reduced sodium intake for health; discussion of the overall concept of diet quality, e.g. DASH diet, with tips for successful adoption; assessment of patient barriers to adherence with suggestions for better adherence; goal setting; and distribution of written material (See Table 2). [36] Although clinic visits often do not allow time to cover all elements of an effective counseling session, a good first step is for the physician to protect time in the session to discuss diet and barriers to dietary modification.

Dietary counseling is especially important for medically high-risk patients, and referrals should be made to a registered dietitian or certified health educator. Medicare and other insurance groups provide medical coverage (reimbursement) for dietary counseling in certain patients (e.g. patients with chronic kidney disease and diabetes). Although the impact of the clinician might be limited given the difficulty in changing patient behavior in the current food supply, clinician support is still critical to create demand for the public health approach.

Strategy 3: Food Labeling

Food labeling can help motivated consumers choose lower sodium products. Some types of labeling can even prompt reformulation so that products are lower in sodium. However, as discussed below, the current US labeling system (i.e., the Nutrition Facts Panel) is poorly designed to convey information about sodium.

Nutrition Facts Panels in the US are highly complex and not very effective in motivating dietary behavior change. These labels have been mandatory since the National Labeling and Education Act was enacted in 1990. [1] Sodium information on labels is provided in a

technical format (milligrams per serving and percent daily value of sodium), located on the back of packaged food, written in fine print, and surrounded by other nutrition and ingredient information.

Consumers often find these labels confusing, especially consumers with low literacy or numeracy. [37] Encouraging the use of labels to reduce intake is a common goal of recent sodium reduction campaigns. However, studies indicate that their usage overall and the usage of sodium information in particular has been declining. [38] Furthermore, people who report using Nutrition Facts Panels did not decrease sodium intake. [39]

Front of pack (FOP) labels that interpret nutrition information, as used in Finland and the UK, are more effective. In Finland, high salt warning labels were successful as part of a larger sodium reduction initiative. Packaged foods with sodium levels over a specified threshold determined by the type of food were labeled as a high-salt product. As a result, many companies discontinued high-salt products and introduced products that qualified for the low-salt label. Daily sodium intake in Finland has been reduced by ~1250 mg since 1979. [40] A voluntary FOP labeling system is used in the UK that targets salt and a few other nutrients of concern. A traffic light symbol indicates levels of fat, saturated fat, sugars and salt with green (low), amber (medium) and red (high) color-coding for each nutrient. [41] Although seemingly simple, some studies have questioned the effectiveness of this system in motivating healthier consumer purchases. [42]

In the US, there is increased interest in FOP labels. Reacting to the proliferation of labels designed by industry, the FDA recently solicited comments, information, and data. [43] Concurrently, the US Congress commissioned the Institute of Medicine (IOM) to examine FOP labels. In their 2011 report, they concluded that despite the lack of conclusive evidence, FOP labels would encourage healthier choices than the current Nutrition Facts Panel and would be easier to understand. Specifically, they recommended the creation of a FDA-mandated system that lists calories and then rates products from zero to three stars, based on levels of sodium, saturated fat, trans fat and added sugars. [43] However, even the development of a voluntary system by the FDA has been opposed by the packaged food industry, which has been working to create their own labeling system called Nutrition Keys. [44]

In summary, food labels help consumers choose packaged foods with lower sodium, but the labeling system can be improved. Labels that are prominently placed and consistent have the potential to influence consumer decisions. Additionally, labeling that indicates high levels of sodium can encourage manufacturers to reduce sodium voluntarily. Without reductions in the overall sodium levels in packaged food, even the best labeling system will not be sufficient to reduce sodium intake.

Strategy 4: Coordinated voluntary reductions

In the US, calls for voluntary industry action related to sodium reduction have been historically unsuccessful. [1] The Center for Science in the Public Interest found an average decrease in sodium content of packaged foods of only 5% from 1983 to 2004, with levels increasing after 1994. [45] However, evidence indicates that coordinated voluntary action that holds companies accountable for their pledges and is backed by authoritative bodies can be more successful. [26, 46]

Lowering the sodium content of packaged and restaurant foods is possible without limiting consumer choice and acceptance. In addition to adapting over time to a lower salt taste; [2, 47] when given lower sodium food and a salt shaker, people only add back a portion of the sodium removed. [48]

One recent and successful example of this approach is the UK Salt Campaign, an initiative of the UK Food Standards Agency (FSA) (now part of the Responsibility Deal overseen by the UK Department of Health [49]). A key aspect of this initiative was category-specific salt reduction targets for 2010 and 2012, set with assistance from industry. The FSA received and announced over ninety formal, public commitments from across the food industry. The government monitors these commitments through the creation of a processed food database, company reports, and periodic measurements of population sodium intake through 24-hour urine collection. To date, many companies have met 2010 targets and the UK saw an approximate 10% drop in sodium intake from 2000/1 to 2008. [26]

This model of coordinated voluntary sodium reductions has been adapted for the United States by the National Salt Reduction Initiative (NSRI), led by New York City. The NSRI consists of 75 signatories, including cities, states and national health organizations. [29] It aims to reduce sodium intake by 20% and sodium in packaged and restaurant foods by 25% by 2014. [1] To do this, the NSRI set 2012 and 2014 voluntary sodium reduction targets for 62 packaged food and 25 restaurant food categories. To date, 28 packaged food and restaurant companies, many of them large national players such as Kraft, Target and Subway, have committed to the targets. [46] As in the UK, monitoring and evaluation are key elements of the initiative. Committed companies are asked to report nutrition information in target years. The NSRI has also created national packaged and restaurant food databases to independently monitor sodium content. [1] To evaluate the impact of the initiative, the NSRI will measure the change in population sodium intake in New York City through population-based 24-hour urinary sodium studies in 2010 and 2014. [50]

This type of voluntary action has a number of advantages. It's significantly less controversial than regulation, both to food companies and the public. In addition, having specific sodium reduction targets and an independent database for monitoring, makes it possible to hold industry accountable for their commitments. Critically, it targets packaged and restaurant food sodium content, rather than consumer behavior. Finally, it is a nuanced system which both reduces intake over time, allowing tastes to adjust, and distinguishes between different types of food, maintaining consumer choice and variety.

The drawback, however, is that a voluntary initiative cannot require the industry to participate and therefore sodium reductions may be limited to the number of companies involved. Commitments, though publicized and monitored, are not binding. Finally, though less controversial than regulation, even voluntary initiatives face strong opposition. In the US, industry backed groups such as Center for Consumer Freedom [51] and the Salt Institute have fought against the NSRI. [52, 53]

Strategy 5: Procurement Policies

Reduction of sodium intake can also be achieved if sodium standards are included in government procurement policies, as well as those of private and non-profit institutions. The US government annually purchases or provides funds to purchase large amounts of food, including more than \$800 million to feed US Military personnel and 1.9 billion pounds of food as part of the National School Lunch Program. [1] Similarly, state and local governments buy food for schools, correctional institutions, senior centers, child-care centers, and other institutions. [1] Including specific sodium standards in the requirements for purchased food can provide additional support to coordinated voluntary reductions by creating measurable demand for lower sodium products and thus a financial incentive to reduce sodium.

Procurement policies with specific sodium standards are a relatively new phenomenon but have already been implemented by a number of government entities, including New York

City, Massachusetts, and the Department of Health and Human Services (HHS). New York City's standards, passed by Mayoral Executive Order in 2008, apply to more than 260 million meals and snacks purchased and served by New York City Agencies and their contractors. [54]The standards require purchased food items to have less than 480 mg sodium, with lower limits for specific food categories such as bread, canned fish, meat and cereal. They also have sodium limits for meals served. [55]The Massachusetts State Agency Food Standards, also passed by executive order, are very similar to those enacted in New York City. [56]The HHS food standards apply to all HHS concessions, conferences, and vending machines and require that all individual items served should have no more than 480 mg sodium and meals no more than 900 mg sodium. Lower standards apply to specific food items. [57]The Centers for Disease Control and Prevention (CDC) encourages local and state health departments to enact similar guidelines. [57]

Procurement policies increase demand for healthy, low sodium food, making it worthwhile for the food industry to produce and market these items. They also ensure that people who depend on the government for food are getting a balanced, low sodium diet. However, despite the reach of these policies, they impact only a fraction of the American food supply, and thus are not a stand-alone solution.

Strategy 6: Regulation of sodium levels in food

The CDC commissioned the IOM to study strategies to reduce sodium intake in the population. In 2010, the IOM recommended that the Food and Drug Administration (FDA) regulate the salt content of both restaurant and packaged food to reduce sodium intake. Salt in the United States is currently classified as GRAS, or Generally Recognized as Safe, a status given to food additives where there is "reasonable certainty of no harm". Food products made with additives without GRAS status need FDA approval prior to marketing. The GRAS status of salt was set in 1958, when the FDA began regulating food additives and before much was known about the adverse health effects of sodium. Since 1979, and most recently in 2007, there have been proposals to revoke salt's GRAS status since excess levels have been shown to be unsafe. The IOM specifically recommended that the FDA modify, rather than revoke, its GRAS status and extend it GRAS to restaurant food. [1]

A modified GRAS status would define levels of salt above which foods would not qualify for GRAS. Separate thresholds would apply to different categories of food and would depend on the need for salt in that food. Over time, as consumer palates adjust, the limits would be lowered in a stepwise fashion. Steps and final levels of GRAS for all categories of food would be defined at the outset, but evaluated and modified if necessary at pre-specified intervals. Foods with salt above the GRAS threshold could still be sold, but only after petitioning the FDA. [1]

Modifying the GRAS status of salt is likely the most effective strategy to reduce sodium intake in a long-term, sustainable way. Similar to the coordinated voluntary reduction strategies, it preserves choice and diversity in the marketplace by distinguishing between different types of food. Because the changes to GRAS will be regulatory, industry will have to participate and will be unable to rollback gains. Finally, GRAS is already under the purview of the FDA and does not require new legislation.

Despite numerous advantages to this approach, it is unclear if the FDA will implement the IOM recommendations. Any changes to the regulatory environment are likely to be strongly resisted by the food industry. Since a modification of GRAS would affect an enormous swath of the industry, the opposition might be considerable. If FDA does implement this recommendation, it would likely take years to draft and get approval, making it important to have interim strategies, such as the NSRI and food procurement policies, in place.

Conclusion

A public health approach will be needed for meaningful reductions in sodium intake. The levels of sodium in packaged and restaurant food are currently too high for individual action to be sufficient. Together, the strategies outlined above form a comprehensive stepwise sodium reduction approach. The most effective single strategy, however, is federal regulation. Currently, the FDA and the USDA are considering action on salt. [58] Unfortunately, regulatory actions are difficult to implement.

As the medical and public health communities advocate for regulatory and other strategies to reduce sodium intake, the support of clinicians is critical. In order to ensure that patients reduce their blood pressure and thus their risk of cardiovascular disease, clinicians need to support both the individual efforts of their patients and the additional public health approaches described herein.

Acknowledgments

Laura Cobb is funded by the T32HL007024 Cardiovascular Epidemiology Institutional Training Grant from NIH/NHLBI and by the Johns Hopkins Bloomberg School of Public Health Department of Epidemiology.

Cheryl Anderson receives grants support from National Heart Lung and Blood Institute, Grant Number K01HL092595.

References and Recommended Reading

Papers of particular interest, published recently, have been highlighted as:

*Of importance

**Of major importance

- 1**. Institute of Medicine. Strategies to Reduce Sodium Intake in the United States. Washington, D.C: National Academy Press; 2010. This report recommends key strategies to reduce population sodium intake in the US. The primary recommendation is that the US Food and Drug Administration regulate levels of sodium chloride (salt) in food by altering the GRAS (Generally Recognized as Safe) status of sodium. In addition, the report contains a comprehensive overview of the issues related to sodium reduction including: scientific evidence for sodium reduction, current sodium intake levels in the US, the role of salt and sodium in taste preferences and food science, and the US regulatory environment
2. Bertino M, Beauchamp GK, Engelman K. Long-term reduction in dietary sodium alters the taste of salt. *Am J Clin Nutr.* 1982; 36:1134–1144. [PubMed: 7148734]
3. Mattes RD, Donnelly D. Relative contributions of dietary sodium sources. *J Am Coll Nutr.* 1991; 10:383–393. [PubMed: 1910064]
4. United States Department of Agriculture, Center for Nutrition Policy and Promotion. [Accessed on September 20, 2011] United States Dietary Guidelines for Americans. 2010. Available at www.dietaryguidelines.gov
5. Lloyd-Jones D, Hong Y, Labarthe D, et al. Defining and setting national goals for cardiovascular health promotion and disease reduction. The American Heart Association's strategic impact goal through 2020 and beyond. *Circulation.* 2010; 121:586–613. [PubMed: 20089546]
6. Bernstein AM, Willett WC. Trends in 24-h urinary sodium excretion in the United States, 1957–2003: a systematic review. *Am J Clin Nutr.* 2010; 92:1172–1180. [PubMed: 20826631]
7. New York City Department of Health and Mental Hygiene. [Accessed December 22, 2011] Health Department announces new company commitments to National Salt Reduction Initiative; Sodium study confirms that New Yorkers eat too much salt. Available at <http://www.nyc.gov/html/doh/html/pr2011/pr005-11.shtml>

8. Lawes CM, Vander Hoorn S, Rodgers A, et al. Global burden of blood-pressure-related disease, 2001. *Lancet*. 2008; 371:1513–1518. [PubMed: 18456100]
9. Chobanian AV, Bakris GL, Black HR, et al. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension*. 2003; 42:1206–1252. [PubMed: 14656957]
10. Lewington S, Clarke R, Qizilbash N, et al. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. *Lancet*. 2002; 360:1903–1913. [PubMed: 12493255]
11. Appel LJ, Brands MW, Daniels SR, et al. Dietary approaches to prevent and treat hypertension: a scientific statement from the American Heart Association. *Hypertension*. 2006; 47:296–308. [PubMed: 16434724]
- 12*. He FJ, Macgregor GA. A comprehensive review on salt and health and current experience of worldwide salt reduction programmes. *J Hum Hypertens*. 2008; 23:363–384. This review article provides an in-depth description of the evidence linking excess sodium intake to high blood pressure, cardiovascular disease, left ventricular mass, cancer of the stomach, and osteoporosis. The authors also discuss worldwide efforts to reduce population sodium intake, including strategies in Finland and the UK. [PubMed: 19110538]
- 13*. Sacks FM, Campos H. Dietary therapy in hypertension. *N Engl J Med*. 2010; 362:2102–2112. This article uses a case study of a patient with hypertension to address best practices for management of hypertension through diet. The authors provide specific dietary recommendations for patients including: sodium reduction, adoption of the DASH diet, and weight loss. The scientific evidence upon which dietary recommendations are based, and guidance on how to counsel patients to adopt a healthier life style is also included. [PubMed: 20519681]
14. Institute of Medicine. Dietary Reference Intakes: Water, Potassium, Sodium Chloride, and Sulfate. 1. Washington, DC: National Academy Press; 2004.
- 15**. Bibbins-Domingo K, Chertow GM, Coxson PG, et al. Projected effect of dietary salt reductions on future cardiovascular disease. *N Engl J Med*. 2010; 362:590–599. Through rigorous modeling, this study estimates the impact of population salt reduction on cardiovascular disease, mortality, and health care costs. It is projected that reducing population salt intake by 3 grams per day will prevent, annually, between 44,000 and 92,000 deaths; 60,000 to 120,000 new coronary heart disease cases; and 32,000 to 66,000 strokes. [PubMed: 20089957]
- 16**. Cook NR, Cutler JA, Obarzanek E, et al. Long term effects of dietary sodium reduction on cardiovascular disease outcomes: observational follow-up of the trials of hypertension prevention (TOHP). *BMJ*. 2007; 334:885. This study uses data from passive follow-up on individuals who completed a randomized control trial. It directly links sodium reduction to reduced incidence of cardiovascular events. Participants in the Trials of Hypertension Prevention (TOHP) studies were followed up 10–15 years after the end of the intervention. Those participants who had been randomized to the sodium reduction arm were 25–30% less likely to develop cardiovascular disease. [PubMed: 17449506]
- 17*. Appel LJ, Frohlich ED, Hall JE, et al. The importance of population-wide sodium reduction as a means to prevent cardiovascular disease and stroke: a call to action from the American Heart Association. *Circulation*. 2011; 123:1138–1143. In this American Heart Association report, the argument is made for action to reduce population sodium intake in the US. It includes a review of the scientific evidence linking sodium intake to increased blood pressure as well as the potential benefits of addressing this public health problem. [PubMed: 21233236]
18. Frohlich ED, Varagic J. The role of sodium in hypertension is more complex than simply elevating arterial pressure. *Nat Clin Pract Cardiovasc Med*. 2004; 1:24–30. [PubMed: 16265256]
19. He FJ, Marciniak M, Visagie E, et al. Effect of modest salt reduction on blood pressure, urinary albumin, and pulse wave velocity in white, black, and Asian mild hypertensives. *Hypertension*. 2009; 54:482–488. [PubMed: 19620514]
20. Lin PH, Ginty F, Appel LJ, et al. The DASH diet and sodium reduction improve markers of bone turnover and calcium metabolism in adults. *J Nutr*. 2003; 133:3130–3136. [PubMed: 14519796]
21. Appel LJ. The case for population-wide salt reduction gets stronger. *BMJ*. 2009; 339:b4980. [PubMed: 19934193]

22. Stolarz-Skrzypek K, Kuznetsova T, Thijs L, et al. Fatal and nonfatal outcomes, incidence of hypertension, and blood pressure changes in relation to urinary sodium excretion. *JAMA*. 2011; 305:1777–1785. [PubMed: 21540421]
23. O'Donnell MJ, Yusuf S, Mente A, et al. Urinary sodium and potassium excretion and risk of cardiovascular events. *JAMA*. 2011; 306:2229–2238. [PubMed: 22110105]
24. Whelton PK. Urinary sodium and cardiovascular disease risk: informing guidelines for sodium consumption. *JAMA*. 2011; 306:2262–2264. [PubMed: 22110109]
25. Webster JL, Dunford EK, Hawkes C, et al. Salt reduction initiatives around the world. *J Hypertens*. 2011; 29:1043–1050. [PubMed: 21546876]
26. UK Food Standards Agency. [Accessed December 21, 2011] UK salt reduction initiatives. Available at <http://www.food.gov.uk/multimedia/pdfs/saltreductioninitiatives.pdf>
27. New York City Department of Health and Mental Hygiene. [Accessed December 21, 2011] Cutting salt, improving health: NYC salt media campaign. 2010. Available at <http://www.nyc.gov/html/doh/html/cardio/cardio-salt-ads.shtml>
28. Lazar, K. Mass ad campaign aims to drive down salt consumption. Vol. 2011. The Boston Globe; Sep 30. 2011 Available at <http://www.nyc.gov/html/doh/html/cardio/cardio-salt-ads.shtml>
29. New York City Department of Health and Mental Hygiene. [Accessed December 22, 2011] National Salt Reduction Initiative - Statement of commitment by health organizations and public agencies. Available at <http://www.nyc.gov/html/doh/html/cardio/cardio-salt-coalition.shtml>
30. The Trials of Hypertension Prevention, phase II. The Trials of Hypertension Prevention Collaborative Research Group. Effects of weight loss and sodium reduction intervention on blood pressure and hypertension incidence in overweight people with high-normal blood pressure. *Arch Intern Med*. 1997; 157:657–667. [PubMed: 9080920]
31. Whelton PK, Appel LJ, Espeland MA, et al. Sodium reduction and weight loss in the treatment of hypertension in older persons: a randomized controlled trial of nonpharmacologic interventions in the elderly (TONE). TONE Collaborative Research Group. *JAMA*. 1998; 279:839–846. [PubMed: 9515998]
32. Appel LJ, Champagne CM, Harsha DW, et al. Effects of comprehensive lifestyle modification on blood pressure control: main results of the PREMIER clinical trial. *JAMA*. 2003; 289:2083–2093. [PubMed: 12709466]
33. Cabezaz C, Advani M, Puente D, et al. Effectiveness of a stepped primary care smoking cessation intervention: cluster randomized clinical trial (ISTAPS study). *Addiction*. 2011; 106:1696–1706. [PubMed: 21561497]
34. Appel LJ, Clark JM, Yeh HC, et al. Comparative effectiveness of weight-loss interventions in clinical practice. *N Engl J Med*. 2011; 365:1959–1968. [PubMed: 22085317]
35. Graves, G. Vogue. New York: Conde Nast; Nov. 2010 White noise.
36. Appel, LJ.; Miller, ER. Promoting lifestyle modification in the office setting. In: Egan, BM.; Basile, JN.; Lackland, DT., editors. *Hypertension: Hot Topics*. Philadelphia: Hanley & Belfus, Inc; 2004. p. 155-163.
37. Rothman RL, Housam R, Weiss H, et al. Patient understanding of food labels: the role of literacy and numeracy. *Am J Prev Med*. 2006; 31:391–398. [PubMed: 17046410]
38. Todd; Variyam, Jessica E.; Jayachandran, N. Economic Research Report. Vol. 63. Economic Research Service, U.S. Dept of Agriculture; 2008. The decline in consumer use of food nutrition labels, 1995–2006. Available at <http://www.ers.usda.gov/Publications/ERR63/ERR63.pdf>
39. Variyam JN. Do nutrition labels improve dietary outcomes? *Health Econ*. 2008; 17:695–708. [PubMed: 17990313]
40. Pietinen P, Valsta LM, Hirvonen T, et al. Labelling the salt content in foods: a useful tool in reducing sodium intake in Finland. *Public Health Nutr*. 2008; 11:335–340. [PubMed: 17605838]
41. UK Food Standards Agency. [Accessed December 21, 2011] Front of pack traffic light signpost labeling: technical guidance. Nov. 2007 Available at <http://www.food.gov.uk/multimedia/pdfs/frontofpackguidance2.pdf>
42. Sacks G, Rayner M, Swinburn B. Impact of front-of-pack 'traffic-light' nutrition labelling on consumer food purchases in the UK. *Health Promot Int*. 2009; 24:344–352. [PubMed: 19815614]

43. Institute of Medicine. Examination of Front-of-Package Nutrition Rating Systems and Symbols: Promoting Healthier Choices. Washington, D.C: National Academies Press; 2011.
44. Neuman, W. [Accessed December 23, 2011] Food makers devise own label plan. The New York Times. Jan 24. 2011 Available at http://www.nytimes.com/2011/01/25/business/25label.html?_r=2
45. Center for Science in the Public Interest. Salt assault: brand name comparisons of processed foods. 2. Washington, DC: Center for Science in the Public Interest; 2008. Available at http://www.cspinet.org/new/pdf/salt_report_update.pdf
46. New York City Department of Health and Mental Hygiene. [Accessed December 22, 2011] Cutting salt, improving health. Available at <http://www.nyc.gov/html/doh/html/cardio/cardio-salt-initiative.shtml>
47. Bertino M, Beauchamp GK, Engelman K. Increasing dietary salt alters salt taste preference. *Physiol Behav.* 1986; 38:203–213. [PubMed: 3797487]
48. Beauchamp GK, Bertino M, Engelman K. Failure to compensate decreased dietary sodium with increased table salt usage. *JAMA.* 1987; 258:3275–3278. [PubMed: 3682116]
49. UK Department of Health. [Accessed December 23, 2011] Public Health Responsibility Deal: pledges. Available at <http://www.dh.gov.uk/en/Publichealth/Publichealthresponsibilitydeal/Pledges/index.htm>
50. New York City Department of Health and Mental Hygiene. Get the facts. The National Salt Reduction Initiative; Cut the salt. Available at <http://www.nyc.gov/html/doh/downloads/pdf/cardio/cardio-salt-nsri-faq.pdf>
51. Strom, S. [Accessed February 8, 2012] Nonprofit advocate carves out a for-profit niche. The New York Times. Jun 17. 2010 Available at <http://www.nytimes.com/2010/06/18/us/politics/18berman.html?pagewanted=all>
52. The Center for Consumer Freedom. [Accessed December 23, 2011] NY health chief summer-salts into the bland. Available at <http://www.consumerfreedom.com/2009/01/3816-ny-health-chief-summer-salts-into-the-bland/>
53. Salt Institute. [Accessed December 23, 2011] New York City risks its greatest culinary achievement. Available at <http://www.saltinstitute.org/News-events-media/Salt-Sensibility/Food/New-York-City-risks-its-greatest-culinary-achievement>
54. New York City Department of Health and Mental Hygiene. [Accessed December 23, 2011] New York City Food Standards. Available at <http://www.nyc.gov/html/doh/html/cardio/cardio-vend-nutrition-standard.shtml>
55. New York City food standards. [Accessed December 23, 2011] Part I: Standards for meals/snacks purchased and served. revised October 2011. Available at http://www.nyc.gov/html/dycd/downloads/pdf/City_Agency_Food_Standards.pdf
56. Nutrition and Physical Activity Obesity Initiative, Bureau of Community Health Access and Promotion, MA Department of Public Health. [Accessed December 23, 2011] Massachusetts State Agency food standards: requirements and recommendations. Available at <http://www.mass.gov/eohhs/docs/dph/com-health/nutrition-phys-activity/eo509-state-agency-food-standards.pdf>
57. Centers for Disease Control and Prevention. Improving the food environment through nutrition standards: a guide for government procurement. U.S. Department of Health and Human Services, Centers for Disease Control, National Center for Chronic Disease Prevention and Health Promotion, Division for Heart Disease and Stroke Prevention; Feb. 2011 Available at http://www.cdc.gov/salt/pdfs/dhdsp_procurement_guide.pdf
58. Department of Health and Human Services, Food and Drug Administration, Department of Agriculture, Food Safety and Inspection Service. Federal Register. Vol. 76. Washington, D.C: United States Government Printing Office; Sep 15. 2011 Approaches to reducing sodium consumption; establishment of dockets; request for comments, data, and information; p. 57050-57054.

Table 1

Summary of six principle sodium reduction strategies, along with their projected impact and speed of implementation

Salt Reduction Strategy	Public Health Impact*	Speed of Implementation
1. Public Education	+	Fast
2. Dietary Counseling	+	Fast
3. Food Labeling	+	Slow
4. Coordinated Voluntary Industry Efforts	++	Medium
5. Food Procurement Policies	++	Medium
6. FDA Regulation of GRAS Status of Sodium	+++	Slow

*
+ = some, ++ = moderate, +++ = substantial

Table 2

Approaches to provider-patient conversations about lowering sodium intake

Strategies for sodium reduction that can be communicated quickly to patients	<ul style="list-style-type: none"> • Make reading food labels a habit • Stick to fresh foods (e.g., meats, fruits and vegetables) rather than their packaged counterparts • Avoid spices and seasonings that contain added sodium • Check restaurant websites before dining out. And, request that your food be prepared without any added salt. • In 6–8 weeks, one can adjust to eating less salt • Cook rice, pasta, and hot cereals without salt • Choose ready-to-eat breakfast cereals that are lower in sodium • Choose “convenience” foods that are lower in sodium • Rinse canned foods to remove some sodium • When available, buy low-sodium, reduced-sodium, or no-sodium versions of foods
Features of an effective counseling session	<ul style="list-style-type: none"> • Assess readiness for change • Discuss importance of reduced sodium intake • Discuss overall concept of DASH diet and give tips for successful adoption • Assess patient barriers to adherence and give tips for better adherence Set goal(s) • Distribute written material
Tools needed for an effective counseling session	<ul style="list-style-type: none"> • Assessment of readiness for change • Attitude that sodium reduction is possible • Assessment for barriers to eating well • Assessment for literacy and numeracy • Sample food label • Written material