

## Controversial sodium guidelines: Scientific solution or perpetual debate?

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Most clinicians accept epidemiologic evidence of a positive association between increased dietary sodium intake and blood pressure, as well as evidence of blood pressure reduction when dietary sodium is decreased.<sup>1</sup> In the era of evidence-based medicine, they may also assume that national guidelines for dietary sodium intake are supported not only by observational epidemiology, but also by rigorous clinical trials and population-based nutrition studies conclusively showing that reduced sodium consumption is linked to lowered incidence of cardiovascular events. Unfortunately, definitive randomized controlled trials have yet to be performed. Although the linkage between dietary sodium and cardiovascular health seems clear, important research gaps remain, fuelling experts' concerns about poor research methods, biased assessment of evidence and undue influence by the food industry.<sup>2</sup> Optimal sodium intake is likely to remain contentious, and it is of concern that this uncertainty may blunt efforts to reduce excessive consumption in a subset of the population.

International standards, including those of Canada<sup>3</sup> and the United States,<sup>4</sup> recommend reductions of dietary sodium to less than 2300 mg/day and may advocate targets as low as 1500 mg/day. Such goals are elusive, given that the average consumption by Canadians is 3400 mg/day and given that 85% of men and 60%–80% of women consume more than 2300 mg/day.<sup>3</sup> Furthermore, the strength of the evidence supporting available guidelines underwent close scrutiny in a 2013 report from the US Institute of Medicine.<sup>5</sup> The committee that prepared the report expressed concern about the highly variable methodologic quality of available studies, particularly with regard to quantification of sodium intake. The committee reached three main conclusions: that there is a positive relation between higher levels of sodium intake and the risk of cardiovascular disease, consistent with existing evidence on blood pressure as a surrogate indicator of cardiovascular risk; that evidence from studies on direct health outcomes is insufficient and inconsistent regarding an association between sodium intake below 2300 mg/day and either risk or benefit for cardiovascular disease outcomes; and that direct

evidence on health outcomes does not support recommendations to lower sodium intake in high-risk subgroups (those with diabetes mellitus, chronic renal disease or pre-existing cardiovascular disease) to 1500 mg/day or less.

The Institute of Medicine report<sup>5</sup> has energized a vigorous controversy that is attracting strong views from various quarters: basic physiology and pharmacology, cardiology, endocrinology, hypertension and stroke management.<sup>6–10</sup> Meta-analyses of randomized trials<sup>6,7</sup> and of observational studies<sup>7</sup> have generally shown that reducing dietary sodium leads to substantial reductions of systolic blood pressure among individuals with hypertension. Nonetheless, concerns remain about the formulation of firm guidelines too heavily based on relatively limited evidence.<sup>5,8</sup>

A Cochrane review found that reduced sodium significantly increases plasma renin activity; raises concentrations of aldosterone, adrenaline and noradrenaline; and is accompanied by increases in serum cholesterol and triglycerides.<sup>6</sup> In contrast, a subsequent systematic review<sup>7</sup> found no adverse effect on lipids, catecholamine levels or renal function. Compelling arguments have been advanced for striking a delicate balance in the sodium intake target, with the expectation of achieving the beneficial effects on blood pressure that have been consistently observed in patients with hypertension who follow a restricted-sodium diet, while avoiding the possible secondary adaptive hormonal responses that may undermine cardiovascular benefits.<sup>9,10</sup> As for other essential nutrients, intake of sodium outside the optimal

**Competing interests:** John Cairns was a member of the planning committee for a consensus conference on nutrition (which included a symposium on dietary sodium), co-convened by the World Heart Federation and the Canadian Academy of Health Sciences. The conference received sponsorship from several industry, government and philanthropic organizations (see [www.nutritioncvd2014.com/body.cfm?id=19](http://www.nutritioncvd2014.com/body.cfm?id=19)). However, the program committee was independent of conference sponsors. No other competing interests were declared.

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### KEY POINTS

- Strong observational evidence indicates that higher levels of dietary sodium may lead to increased blood pressure and probably increased cardiovascular risk.
- Legitimate scientific uncertainty and debate may place at risk public health efforts to reduce excessive consumption.
- Several recent conflicting studies have amplified the debate, particularly in terms of defining safe and effective lower limits for sodium consumption.
- Effective leadership is required to better define knowledge and research gaps in this controversy and to stimulate the generation of additional valid evidence.

range (not only above, but also below) is likely to have deleterious effects on health.<sup>10</sup>

Two new studies are likely to stimulate further scientific debate. The Prospective Urban Rural Epidemiology (PURE) study of observational data from over 100 000 people in 17 countries identified an optimal range of dietary sodium of 3–6 g daily, with increased rates of cardiovascular events occurring both above and below this intake.<sup>11</sup> About 10% of participants excreted less than 3 g/day, and only 4% excreted sodium in the range of current US guidelines for sodium intake (2.3 or 1.5 g/day). The Global Burden of Diseases Nutrition and Chronic Diseases Expert Group (NutriCoDE) compiled observational and randomized studies to derive a modelled relationship between excess dietary sodium and cardiovascular events, which led to an estimate that 1.65 million cardiovascular deaths in 2010 were attributable to sodium consumption beyond a reference level of 2 g/day.<sup>12</sup> However, as noted by Oparil,<sup>13</sup> the PURE study lacked an intervention component and did not use the accepted model for determining sodium intake (multiple direct 24-hour urine measurements), whereas the NutriCoDE study relied on many assumptions because of a lack of high-quality data.

National guidelines focusing on a very low sodium target (< 2300 mg/day) could compromise efforts to reduce unequivocally excessive levels of sodium intake among some people. Rigid positional thinking and perpetuation of the sodium guideline debate are likely to fuel discord, leaving practitioners understandably confused and failing to advance clinical care.

A more constructive approach would encourage leading scientists to reach agreement on major elements of the evidence, which would in turn facilitate timely implementation of beneficial public policy. Effective leadership might better define current knowledge and research gaps and might also generate agreement on an approach to gathering evidence for the relative benefits and harms of achieving population intakes of sodium substantially below the current North American mean.

Given the general clinical and scientific acceptance that excess sodium intake leads to elevation of blood pressure and higher incidence of cardiovascular events, a guideline focused on sodium intakes somewhat lower than the current national average of 3400 mg/day could be recommended unequivocally as beneficial. From that starting point, appropriate studies should be undertaken to clarify the benefits and potential harms of dietary sodium intakes in a lower range. Planning of such studies should be informed by the design shortcomings of prior epidemiologic studies (e.g., unreliable 24-h urine collection; failure to address the relevance of surrogate markers for cardiovascular

events, including blood pressure; and inadequate control of dietary intake of other nutrients). Sorely lacking is a large randomized controlled clinical outcomes trial comparing reduced sodium intake with usual diet,<sup>13</sup> although such a trial would be logistically and financially challenging.

It is advisable for physicians who are treating patients with potential cardiovascular disease to follow national practice guidelines, but they should remain aware of the wide range of reputable opinions expressed in the current medical literature about dietary sodium and its relations to blood pressure and cardiovascular events.

## References

1. *Guideline: sodium intake for adults and children* [guideline]. Geneva (Switzerland): World Health Organization; 2012. Available: [www.who.int/nutrition/publications/guidelines/sodium\\_intake\\_printversion.pdf](http://www.who.int/nutrition/publications/guidelines/sodium_intake_printversion.pdf) (accessed 2014 June 30).
2. Neal B, Land MA, Woodward M. An update on the salt wars — Genuine controversy, poor science, or vested interest? *Curr Hypertens Rep* 2013;15:687-93.
3. *Sodium in Canada* [website]. Ottawa: Health Canada; modified 2012. Available: [www.healthcanada.gc.ca/sodium](http://www.healthcanada.gc.ca/sodium) (accessed 2014 June 30).
4. *Dietary guidelines for Americans, 2010*. 7th ed. Washington: US Department of Agriculture and US Department of Health and Human Services; 2010. Available: [www.fns.usda.gov/dietary-guidelines-americans-2010](http://www.fns.usda.gov/dietary-guidelines-americans-2010) (accessed 2014 Oct. 28).
5. Strom BL, Yaktine AL, Oria M, editors; Committee on the Consequences of Sodium Reduction in Populations; Food and Nutrition Board; Board on Population Health and Public Health Practice; Institute of Medicine. *Sodium intake in populations: assessment of evidence*. Washington: National Academies Press; 2013. Available: [www.nap.edu/catalog.php?record\\_id=18311](http://www.nap.edu/catalog.php?record_id=18311) (accessed 2014 June 30).
6. Graudal NA, Hubreck-Graudal T, Jürgens G. Effects of low-sodium diet vs. high-sodium diet on blood pressure, renin, aldosterone, catecholamines, cholesterol, and triglyceride (Cochrane review). *Am J Hypertens* 2012;25:1-15.
7. Aburto NJ, Ziolkovska A, Hooper L, et al. Effect of lower sodium intake on health: systematic review and meta-analyses. *BMJ* 2013;346:f1326.
8. Cobb LK, Anderson CAM, Elliot P, et al. Methodological issues in cohort studies that relate sodium intake to cardiovascular disease outcomes: a science advisory for the American Heart Association. *Circulation* 2014;129:1173-86.
9. Kotchen TA, Cowley AW, Frohlich ED. Salt in health and disease — a delicate balance. *N Engl J Med* 2013;368:1229-37.
10. Heaney RP. Sodium: how and how not to set a nutrient intake recommendation. *Am J Hypertens* 2013;26:1194-7.
11. O'Donnell M, Mente A, Rangarajan S, et al. Urinary sodium and potassium excretion, mortality, and cardiovascular events. *N Engl J Med* 2014;371:612-23.
12. Mozaffarian D, Fahimi S, Singh GM, et al. Global sodium consumption and death from cardiovascular causes. *N Engl J Med* 2014;371:624-34.
13. Oparil S. Low sodium intake — cardiovascular health benefit or risk? *N Engl J Med* 2014;371:677-9.

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**Editor's note:** In mid-May 2014, a consensus conference on nutrition was convened at the Population Health Research Institute of McMaster University/Hamilton Health Sciences, where leading Canadian and international researchers reviewed key elements in the dietary sodium controversy. A summary of discussions is available at [www.cahs-acss.ca/completed-projects/](http://www.cahs-acss.ca/completed-projects/)