Current Nutrition Reports
https://doi.org/10.1007/s13668-021-00357-1

PUBLIC HEALTH NUTRITION (KE CHARLTON, SECTION EDITOR)

Dietary Sodium 'Controversy'—Issues and Potential Solutions

N. R. C. Campbell[1] · F. J. He[2] · F. P. Cappuccio[3] · G. A. MacGregor[2]

Accepted: 19 April 2021

Abstract

Purpose of Review High dietary sodium is estimated to be the leading dietary risk for death attributed to 1.8 million deaths in 2019. There are uniform recommendations to reduce sodium consumption based on evidence that increased dietary sodium is responsible for approximately a third of the prevalence of hypertension, and meta-analyses of randomized controlled trials show that sodium reduction lowers blood pressure, cardiovascular disease, and total mortality. Nevertheless, there is a perception that the beneficial effect of reducing dietary sodium is controversial. We provide experiential evidence relating to some sources of the controversy and propose potential solutions.

Recent Findings Inappropriate research methodology, lack of rigor in research, conflicts of interest and commercial bias, questions of professional conduct, and lack of policies to protect public interests are likely to contribute to the controversy about reducing dietary sodium.

Summary There is a failure to protect policies to reduce dietary sodium from nonscientific threats. Significant efforts need to be made to ensure the integrity of nutritional research and maintain public trust.

Keywords Public health policy · Conflicts of interest · Ethics · Dietary sodium · Dietary salt · Nutrition

Introduction

High sodium intake is the leading dietary risk for death globally and its attributable disease burden is estimated at 1.8 million or more deaths and close to 45 million disability-adjusted life years (DALYs) in 2019 [1••]. Hence, reducing sodium intake is a global population health priority. Analyses indicate reducing dietary sodium is one of the most cost-effective interventions to enhance population health, labeled a "best buy" by the World Health Organization [2]. Unlike many clinical interventions, reducing dietary sodium is cost-saving for governments with returns on investment of between 12 and 78$ for every dollar invested [3, 4].

Current best evidence includes randomized controlled trials that show reducing dietary sodium linearly reduces blood pressure in those with normal or increased blood pressure, in different ethnicities and different age groups with greater blood pressure reductions in those who are older, those who are black, and those with raised blood pressure [5••, 6•, 7•]. Randomized trials examined sodium intake levels as low as 400 mg/day and show a reduction in sodium lowers blood pressure to the same or a greater degree when the initial sodium intake is low and that the reduction in blood pressure is approximately twice as large in studies that are 2 weeks or longer compared to those of shorter duration [6•, 7•]. Approximately, 1/3rd of global hypertension is attributed to high dietary sodium [8, 9]. A meta-analysis of randomized controlled trials shows that a reduction in dietary sodium from 3646 to 2690 mg/day causes a linear 26% and 15% reduction in cardiovascular disease (CVD) and mortality, respectively

This article is part of the Topical Collection on *Public Health Nutrition*

✉ N. R. C. Campbell
ncampbel@ucalgary.ca

F. J. He
f.he@qmul.ac.uk

F. P. Cappuccio
F.P.Cappuccio@warwick.ac.uk

G. A. MacGregor
g.macgregor@qmul.ac.uk

[1] Department of Medicine, Physiology and Pharmacology and Community Health Sciences, Libin Cardiovascular Institute of Alberta, University of Calgary, Calgary, Alberta, Canada

[2] Wolfson Institute of Preventive Medicine, Barts and The London School of Medicine & Dentistry, Queen Mary University of London, Charterhouse Square, London EC1M 6BQ, UK

[3] University of Warwick, WHO Collaborating Centre for Nutrition, Coventry, UK

Published online: 19 June 2021

[5••]. The reductions in CVD are also consistently found in meta-analyses of cohort studies that use quality criteria to exclude studies with low-quality designs and methods likely to produce spurious findings but not in meta-analyses without quality criteria [10–14].

There are multiple independent scientific reviews on dietary sodium overseen by major governmental organizations (e.g., World Health Organization, USA, UK and Ireland, Australia and New Zealand, European Union) [5••, 15]. Most major non-governmental hypertension recommendation processes also review the evidence on dietary sodium and are often overseen by major hypertension and cardiovascular organizations. The World Health Organization and other governmental review processes that we are aware of are exhaustive, comprehensive, and conducted over multiple years; many exclude individuals with conflicts of interest, have rigid evidence-based processes, and have an external review before release. The non-governmental reviews are of variable quality, although several are strongly evidence-based high-quality processes. These reviews are conducted regularly with, in general, at least one major report published in most years. Nearly all independent scientific reviews, whether governmental or nongovernmental, recommend reductions in dietary sodium to be under 2400 mg/day for adults as a minimum; the World Health Organization recommends reductions in dietary sodium to less than 2000 mg/day for adults [5••, 15].

The evidence supporting dietary sodium reduction is one of the strongest available for a dietary intervention given the difficulties in performing very large long-term interventions that alter diet, the ubiquitous addition of sodium to the food supply and salt (and other sodium-containing ingredients used at home), and the consensus that it is unethical to intervene to provide increased dietary sodium long term. Nevertheless, many view that reducing dietary sodium is still controversial [16••]. There are several potential reasons for this. One reason is the lack of large outcome-driven randomized controlled trials which are unlikely to ever be conducted [17]. Also, low-quality observational studies finding a J-shaped relationship between sodium intakes and cardiovascular disease have been widely publicized in major media. However, it is important to note that other nutritional recommendations are supported by less strong evidence and are not viewed as controversial (e.g., fruits and vegetables, reducing dietary sugar, eliminating industrial trans-fat, and increasing dietary potassium).

Health and scientific organizations have expressed concerns that the controversy is largely generated by low-quality research, while others are concerned about conflicts of interest contributing much to the controversy [5••, 18–32]. The reality is that the controversy has been led by a relatively small number of highly vocal scientists and clinicians. The health and scientific opponents to reducing dietary sodium, together with the food and salt industries and their various umbrella and associated organizations, have used the aura of controversy to impede progress in implementing policies to reduce dietary sodium at a population level, a strategy commonly used in the past for other issues of public health relevance (e.g., tobacco smoking) [33]. In this article, we provide some of our personal experiences in interactions with people and organizations opposed to dietary sodium reduction and propose that broad steps be taken to protect public health policies in general and sodium reduction policies specifically. We accept that differing scientific views are important to foster healthy debates for scientific advancement. However, scientific advancement is driven by striving for truth, using rigorous research methods and designs unimpeded by flawed research bias and commercial influence.

Concerns Relating to Advocacy Against Reducing Dietary Sodium

Table 1 indicates some concerns about advocacy against reducing dietary sodium. We have categorized the concerns regarding (1) use of inappropriate research methods and lack of rigor in research; (2) conflicts of interest with, or biases for, commercial organizations; (3) lack of public access to data supporting research; (4) scientific and professional conduct; (5) journal responsibility in publishing low-quality controversial research and inadequate review processes; (7) grants and research and ethics committee approvals for inappropriate study designs and methods; (8) health and scientific organization issues; and (9) lack of government oversight.

Use of Inappropriate Research Methods and Lack of Rigor in Research

A major problem with research is the use of low-quality or inappropriate methods and research designs prone to spurious results. For example, it is now known that the use of estimating formulas that convert spot urine sodium values to 24-h urine sodium estimates produces biased estimates of sodium excretion that change the linear association between sodium intake from multiple 24-h urines samples (gold standard estimate of sodium intake) and mortality to a J-curve [34••, 35]. Several methods, such as food recall surveys, have been demonstrated to be invalid estimates of individuals' customary sodium intake [36–39]. Even using a single 24-h urine sodium collection to estimate intake either attenuates the association with outcomes or can cause a spurious J-curve, relative to multiple 24-h urine samples collected on nonsequential days [40]. Resolving these issues is the responsibility of granting agencies, research committees, ethics committees and journals, and the investigators. Nevertheless, studies of low quality are numerous and often published in journals with high impact factors, partially due to the large sample size of

Table 1 Concerns with research quality and organizational policies related to dietary sodium reduction

Use of inappropriate research methods, study designs, and lack of rigor in research	Requesting participants to reduce their dietary sodium for 5 days, then measuring 24-h urine sodium and using it as "usual sodium intake" in outcome and mechanistic studies [56, 69]
	Conducting research and citing studies that use equations to estimate usual sodium intake from spot urine samples in association with health outcomes when they are known to cause spurious J-curves with outcomes [16••, 63••]
	Conducting research and citing studies that use food surveys to assess an individual's usual sodium intake when they have been found to be invalid or have inadequate data to support their use [16••, 36, 37]
	Inclusion of participants with chronic disease in cohort studies where reverse causality is likely to occur without adequately acknowledging the limitations [5••, 41]
	Use of weak research designs to conclude on the association of dietary sodium to blood pressure and CVD where causation and associations are already established in randomized controlled trials [16••, 46, 63••]
	Inclusion of short-term studies, often with large changes in sodium intake, to assess the long-term impact of dietary sodium on blood pressure and counter-regulatory systems [70, 71]
	Citing studies which removed sodium from that naturally found in animal diets to assess the potential that reducing the very high levels of sodium additives to human foods may cause harm [16••, 72]. Current dietary sodium recommendations are multifold higher than diets would have without added sodium
	Collecting a high proportion of incomplete 24-h urines [46, 73]
	Multiple errata in reproducing the Kawasaki spot urine estimating equation in a publication [46, 73]
Conflicts of interest and commercial bias	Many advocates against dietary sodium reduction have had long-standing associations with the salt, food, and/or pharmaceutical industries [46]
Use of databases that are not in the public domain for independent verification and for additional important analyses	Several databases that support analyses that find harm from reducing dietary sodium are not easily accessed in the public domain to allow independent verification and assessment of additional important analyses [55, 56]
Scientific and professional conduct	Alteration of formula, artifactually increasing the assessment of completeness of 24-h urine collections without overt disclosure [23, 46, 73]
	Failure to provide important data when requested in letters to the editor [23, 46, 73]
	Denial of conflicts of interest when they exist or failure or inconsistency to disclose conflicts of interest [23, 46, 47]
	Erroneous claim that there is no evidence that reducing dietary sodium below 3000 mg/day reduces CVD contrary to a meta-analysis of randomized controlled trials that finds reducing dietary sodium below 3000 mg/day reduces total mortality and CVD [16••, 63••]
	Erroneous claim that reducing sodium has less impact on blood pressure at lower levels of sodium intake [16••, 63••]
	Erroneous claims there are no effective programs to reduce dietary sodium [16••, 63••]
	Claims that sodium intake less than 2300 mg/day is low or very low when it is multifold higher than that humans evolved on and that is still found in natural diets of the few remaining hunter-gather societies [16••, 63••]
	Use of lower quality study designs to claim to "trump" the results of meta-analyses of randomized controlled trials [16••, 63••]
	Claims that current sodium intake levels are "normal" contrary to mainstream research and scientific reviews [16••, 63••, 74]
	(Mis)use of prominent positions in organizations to advocate against sodium reduction policies [46, 75]
	Misleading statements and half-truths in scientific presentations and publications [16••, 63••]
	Using methods known to produce spurious results [23, 46]
	Publishing identical data from different clinical trials and subsequently claiming that all trial data was lost when the data was requested for verification
Journal issues	Failure to ensure the content of manuscripts is an accurate and comprehensive reflection of evidence [16••, 63••] and systematic lack of reference to significant evidence [16••, 65]
	Use of reviewers and authors of reviews and editorials who are in conflict-of-interest positions (including those who are consultants/advisors to the salt or food industry or pharmaceutical industries) [45]
	Accepting manuscripts that have weak methods prone to spurious results and that have controversial findings that can be explained by the methods
	Publishing controversial studies where the data is not easily publicly accessible for independent verification
	Declining "letters to the editor" about articles that have serious methodological flaws that would have led to spurious findings

Table 1 (continued)

	Having editors or editorial board members publicly biased against evidence-based healthy dietary sodium policy
	Failure to withdraw the original articles in a meta-analysis where there are identical data from different trials and no source to verify the data
Granting agencies, research, and ethics committees	Approving and funding research designs that have weak methods and designs
	Lack of funding priority for identifying and assessing the impact of financial interests on research outcomes
	Lack of funding to assess the quality of research, misinformation, and scientific conduct of research as causes of scientific controversy and major threats to the integrity of science
Health and scientific organization issues	Fundraising from commercial entities placing the organization in conflict of interest
	Fostering unwarranted controversy through debate and presentations in forums where fact checks are not available, speakers have conflicts of interest, and low-quality research is presented without a description of the limitations of the methods
	Lack of policies to preclude those who oppose evidence-based organizational policies from holding critical offices (e.g., executive, board, policy, and scientific review committees)
Government issues	Failure to introduce a strong conflict of interest policies to reduce the influence of the food sector on the development and implementation of food policy.
	Failure to regulate food industry disclosure of financial arrangements to individuals and organizations (including "shell companies" or payments to secondary organizations which act as shields for individual conflicts of interest).
	Failure to protect public policy in response to commercial pressure.

some of these studies [41–43]. However, a large sample size cannot make up for erroneous estimations of sodium intake [44]. These low-quality studies seem to bypass critical reviews in journal processes and they even feature editorials by other dissenting scientists and, in one case, by a consultant/advisor to the Salt Institute and a past witness for the tobacco industry [45] (https://www.industrydocuments.ucsf.edu/tobacco/results/#q=Oparil&h=%7B%22hideDuplicates%22%3Atrue%2C%22hideFolders%22%3Atrue%7D&subsite=tobacco&cache=true&count=918, accessed March 17, 2021; https://www.cspinet.org/new/200610022.html, accessed March 18, 2021).

Conflicts of Interest and Commercial Bias

In several instances, scientists with conflicts of interest have denied or been inconsistent in disclosing their conflict of interest [23, 46, 47] https://www.cspinet.org/new/200610022.html. Accessed March 18, 2021); http://www.megaheart.com/pdf/beard140.pdf accessed March 9, 2021). In one particularly grievous example, an American College of Nutrition's entire journal supplement was supported by the International Life Sciences Institute (ILSI), a non-profit research organization funded by industry. The supplement theme opposed dietary sodium reduction and used many authors, including the guest editor, that were advisors or consultants to the food industry and/or Salt Institute (a now-defunct industry trade association), without providing any disclosures [48–50]. Although these omissions overtly violated journal policy and were identified, no corrective action was taken by the journal other than an after-the-fact disclosure by the publisher [51]. The ILSI distributed the supplement free of charge for many years after its publication and still features the supplement on its website in 2021 (https://ilsi.org/search/?kp=2&k=dietary+sodium&ks=1&kt=any). The ILSI still claims that all its scientific activities have a primary public purpose and benefit, that it has a commitment to achieve and maintain the highest standards of scientific integrity, and that all interests, conflicts, and biases are declared. It is notable that there is a close relationship between the published findings of review manuscripts on nutrition topics and the presence of conflicts of interest among authors [43, 52, 53].

Lack of Public Access to Data Supporting Research

We also note that some cohort databases that find adverse effects of reducing dietary sodium have data that are not in the public domain, and hence, the results cannot be easily independently verified [54–56]. This is important for several reasons. In cohort studies, different adjustments for confounding factors can alter the association of sodium to outcomes and cause false J-curves [57]. There is one example of analyses from two public databases, finding adverse outcomes associated with lower sodium intake where independent analyses of the databases did not confirm any harm from lower sodium intake but found harmful effects only from high intake [58–60]. There is at least one instance where a standard formula for assessing the completeness of urine collection was altered in a fashion that enhanced the proportion of complete 24-h urines and important data on a validation study was not

disclosed even after repeated requests [23]. Furthermore, it is often possible to test if the analyses showing harm from lower sodium consumption are independent of sodium by inserting constant sodium values into analyses [35]. The controversial studies have not assessed the independence of their findings from sodium values in their analyses to date.

Scientific and Professional Conduct

It is inconceivable that *responsible* granting agencies and scientific and ethics review processes would approve all the weak and inappropriate research designs that have been published. Controversial results may have derived from post hoc secondary analyses, not originally planned and reviewed by granting bodies and ethics committees. This raises serious questions about the lack of scientific rigor and conduct of authors, given journal requirements for disclosures of research funding and ethics review. In one case, there was a series of single-center randomized controlled trials finding harm from reducing their sodium intake in people who had heart failure [23]. In a meta-analysis, it was noted that there were identical data from different trials with the investigator claiming it was coincidental [23, 61]. When the journal requested the supporting data, the investigator indicated the data (from multiple trials) was lost in a computer failure. Although this led to the withdrawal of the meta-analysis, the journals with the primary publications did not withdraw those publications, knowing there was no data to confirm the study results, even when requested to do so by multiple scientists. These publications are still cited in support of controversial reviews, even after the retraction date (https://pubmed.ncbi.nlm.nih.gov/22914535/ accessed March 18, 2021).

Additional concerns arise when publications and presentations have erroneous or misleading statements or take scientific reviews out of context [23, 46]. This represents a failure of the peer-review system of journals and raises questions of professional conduct. A few examples of documented erroneous and misleading statements are provided in Table 1, under scientific and professional conduct. One recent false statement, repeatedly published, is that there is no evidence that reducing dietary sodium below 3000 mg/day reduces CVD [16••]. The National Academy of Sciences, however, published a meta-analysis of randomized controlled trials which found that reducing sodium on average from 3646 to 2690 mg/day reduced CVD by 26% and mortality by 15%, respectively [5••]. Arguably, the highest quality cohort study conducted to date also found reducing dietary sodium to under 2300/day reduces CVD [62]. Recent reviews also claim there are no successful programs to reduce dietary sodium [16••, 63••]. On the contrary, there are several population interventions that not only reduced dietary sodium significantly but also there were associated reductions in CVD mortality [64, 65, 66•].

Journal Issues

Recently, we have experienced rejections of "letter to the editors" that point out serious methodologic flaws and false statements in published manuscripts. We also note that some editors have made public statements against reducing dietary sodium, a bias against very consistent evidence reviews on a major public health issue [67].

Granting Agencies, Research and Ethics Committees, Health and Scientific Organizational Issues

On preliminary investigation, one of the authors was unable to confirm or refute if a granting agency had reviewed and approved specific secondary analyses on dietary sodium from a large cohort study. This raises concern as to whether these analyses were reviewed and funded as the publications suggest or were carried out post hoc without ethics and scientific review.

Health and Scientific Organization Issues

Health and scientific organizations often feature debates on dietary sodium although their own evidence reviews, and recommendations, support reducing dietary sodium. These debates often have featured low-quality research, as well as erroneous and misleading statements to support that low dietary sodium may be harmful [23, 46]. The debate formats also provide a sense of false equipoise and credibility for dissenting scientists and offer new platforms for the presentation of low-quality research methods creating an aura of controversy. Similar to modern media formats, by allowing "equal representation," these debates "…only succeed in creating 'false equivalence' between two sides of an issue even when there is only one credible side" [68]. We also note that several openly dissenting scientists have achieved high-level positions in scientific and health organizations (e.g., Presidents of the American Society of Hypertension, International Society of Hypertension, American Heart Association, World Heart Federation) and at least two have used the platforms they are provided by their position to advocate against dietary sodium policies even in the face of their organizations support for dietary sodium reduction. In one case, a president even created a committee dominated by dissenting scientists to create a document that did not support reductions in dietary sodium [67].

Government Issues

Governments have largely been complacent about these threats to evidence-based public policy positions. There are several cases where industry lobbying has significantly delayed or deterred policies from being implemented, despite

the government having already described the established evidence in support of the policy.

Action to Support Evidence-Based Dietary Sodium Public Policies

In nutritional science, there has been a long-standing lack of ethical guidance for the industry, health and scientific organizations, health care providers, journalists, and scientists [52, 76–79]. With many millions of lives at stake, solutions can be at the level of providing guidance on standards of acceptable and unacceptable conduct. Very high standards of conduct and rigorous research designs and methods should be expected for everyone involved in policy research, advocacy, and design.

In our view, being able to obtain research funding or personal financial gain from opposing public policy is concerning. Given that definitive research has established that a large proportion of CVD and hypertension have high dietary sodium as a cause [1••], potential conflicts of interest with the pharmaceutical industry, which profits from treating CVD, should be disclosed at a minimum when presenting and publishing research on dietary sodium policy. Opponents of public policy designed to reduce sodium consumption should be held accountable for the accuracy and truthfulness of their statements, in light of the compelling scientific evidence supporting such policies, in the same way as society as a whole today would require from those denying the ill-health effects associated with tobacco smoking or opposing vaccination. Table 2 provides the authors' suggestions for potential policies and actions that could protect dietary sodium public policies from low-quality research, commercial interests, and scientists and clinicians who have displayed questionable conduct.

Academic organizations should have strict guidelines on obtaining research funding or personal financial gain from opposing important public policies such as reducing dietary sodium and reducing tobacco use. Where faculty oppose public policy based on their research findings, academic institutions should ensure there was a full scientific and ethical review of the protocols used and that the research methods and designs were rigorous. Similarly, academic organizations should establish and implement enforcement protocols for false or misleading statements in important public health areas.

Funding bodies should ensure the research they fund that might impact important areas of public policy, such as dietary sodium, and use rigorous designs and methods. They should clarify that when they fund a primary study with specified analyses, that the scientific and ethical review does not cover unspecified secondary analyses. Secondary previously unspecified analyses should require separate scientific and ethical review. Funding bodies should require the databases that are created through research funding are put in an accessible domain once the analyses in the grant are conducted by the investigators, or after a given reasonable time has passed after the study is complete (e.g., 2 years). This is particularly important for research in major public policy areas. Funding bodies can also develop calls for research on the scientific impact of financial interests, low research quality, misinformation, and professional conduct. Currently, financial interests are often disclosed decades after the fact and in the case of tobacco was only through legal actions.

In our opinion, editors have sometimes been negligent in publishing low-quality research on dietary sodium. Large studies using methods highly likely, and now proven, to provide spurious results were and continue to be published and cited, often without acknowledging the weaknesses of the research [16••, 63••, 80]. Low-quality previously published research is used in the introduction and discussion sections of manuscripts to justify further use of low-quality methods and to validate findings. Higher quality research and major scientific reviews are often ignored, dismissed, or taken out of context [16••, 65].

A consortium of international health and scientific organization formed to develop minimum standards for the conduct of clinical and population research on dietary sodium (https://warwick.ac.uk/fac/sci/med/staff/cappuccio/who/true/, accessed March 11, 2021). To date, editors have not implemented the recommendations, and journals continue to publish manuscripts based on substandard research methods. Journals should not accept manuscripts that have findings that are at odds with established evidence and where the data is not publicly accessible for verification or will be in a defined time period. Importantly, editors should require documentation of funding and ethical and scientific review for the specific sodium-related analyses, especially where low-quality research methods are used.

Governments need to protect policy from low-quality research and researchers who have commercial financial interests. Requiring overt public disclosure of commercial financing to the health and scientific sector including individuals, organizations, and "shell" companies would be of great assistance. Government funders can develop investigative bodies that whistleblowers can anonymously submit concerns, for investigation.

Conclusions

In this manuscript, we discuss experiences and observations that relate to undermining the evidence that supports reductions in dietary sodium. Similar issues have been reported with other dietary health concerns and public policies and also plague science outside of the health field (e.g., where the oil

Table 2 Potential solutions to increase protection for healthy dietary sodium policies

Scientists and health care professionals	Avoid financial conflicts of interest and commercial associations with the food and salt industries where you are involved in public policies
	Disclose any financial interests and associations with the food, salt industries, and pharmaceutical industry or their allied organizations
	Ensure that research uses the high methodological and design standards as defined by major health and scientific organizations
	Ensure the research methods and designs cited have the strongest research designs (i.e., randomized controlled trials and high-quality cohort and clinical studies as defined by major health and scientific organizations)
	Ensure the complete accuracy and truthfulness of statements when advocating your positions
	Work through the evidence reviews and recommendations processes of health and scientific organizations to have your opinions voiced. Scientists and health care professionals should advocate public health policies according to the strongest evidence and not beliefs
Universities and academic institutions	Restrict faculty and staff from significant financial conflicts of interest with public policy and, if they are advocating against public policy, ensure they do not have commercial associations (e.g., sit on commercial advisory boards)
	Ensure research and ethics committees are aware of recommended standards for research methods and designs for nutrition studies that have policy implications and that the standards are adhered to
	When original studies were not previously scientifically and ethically reviewed and approved to assess dietary sodium, ensure secondary analyses of studies on dietary sodium have research and ethics committee's assessment and approval and adhere to recommended standards
	Develop strict mechanisms to enforce the above recommendations
	Develop whistleblowing protection policies to protect faculty and staff who report misconduct
Granting agencies and funding bodies	Ensure the rationale for funded studies cite and use research of the highest methodological standards as defined by major health and scientific organizations and that the rationale considers and addresses the mainstream interpretation of science
	Only fund research methods and designs that have strong research designs (i.e., rigorous collection of 24-h urine samples, randomized controlled trials, and high-quality cohort and clinical studies as defined by major health and scientific organizations)
	Ensure any secondary analyses of studies on dietary sodium, where the study was not originally designed to assess dietary sodium, obtains research and ethics committees assessment and approval. Ensure it is understood that secondary analyses that have not been assessed are not "covered" by "blanket approval" of studies stated objectives and analyses. Develop transparent public mechanisms that indicate exactly what has been approved and funded
	Use special care where investigators have a history of advocating against public policy
	Require funded databases to be easily publicly accessible in a timely fashion following publication of the stated primary and secondary analyses
	With a high priority, fund research on the sources and causes of low-quality research (researcher conduct, and the impact of financial interests) as threats to the integrity of research and scientific advancement
	Develop whistleblowing protection policies to protect people who report misconduct and develop investigative mechanisms for their concerns
Journals	Take extra care in the review process for manuscripts with controversial findings that relate to dietary sodium. Use expert methodologists and individuals who have been involved in expert reviews for national and international bodies as reviewers
	Allocate an editorial that addresses main-stream scientific interpretation for articles that have controversial results
	Encourage letters to the editor in response to articles on dietary sodium that use low-quality designs or methods and make controversial claims as a result
	Withdraw the original manuscripts of the meta-analysis of randomized controlled trials on sodium reduction in heart failure where there was 'duplicate data' from different trials and the investigator was not able to produce data for verification
	Do not accept manuscripts that have controversial findings where the data is not easily accessible in the public domain for verification of the results
	Independently "web" search for conflicts of interest of the authors of studies that introduce controversy to well-established evidence or there are concerns about lack of disclosure of interests
	Require financial interests with the pharmaceutical industry to be considered as a possible conflict of interest with nutrition-related research. Require disclosure of requests and applications for financial support as well as having obtained financial support.
	Request evidence that secondary analysis of studies not specifically designed to assess dietary sodium has specifically been assessed and approved in advance by funding bodies, ethics, and scientific review committees

Table 2 (continued)

	Publishers should set a policy to recuse or remove editors and editorial board members that publicly oppose important public health policy and those with potential financial conflicts of interest
	Retract papers which are found to have used methodology now known to produce spurious 'J-curve' results or add a warning label to such papers.
Governmental organizations	Regulate public disclosure of all payments from commercial entities including their umbrella organizations, research institutes, and foundations to health care professionals, scientists, and their associated organizations
	Continue to regularly update dietary evidence and recommendations using strong evidence-based processes conducted by experts who are free of commercial conflict of interest
	Develop investigative bodies that can assess the conduct of individuals and organizations where whistleblowers have concerns and be protected
	Work with ethics groups to develop more rigorous standards of conduct and policies that protect public policy from low-quality research, information, misconduct, and financial conflicts of interest

industry has paid scientists to dispute climate change. https://www.bbc.com/news/stories-53640382; https://www.scientificamerican.com/article/tobacco-and-oil-industries-used-same-researchers-to-sway-public1/). Science is a never-ending quest for truth. The issues we raise are critical for society to address and to support scientific and public policy advancement and maintain public trust.

We find that the opponents of sodium reduction often use low-quality research methods and designs prone to spurious results and databases that are not accessible (or easily accessed) for independent verification; they also may fail to disclose research findings that undermine their contentions. Some attain high-level influential positions in major health and scientific organizations and have used the powers of those positions to advocate against reducing dietary sodium over the organizations stated positions supporting sodium reduction. Several have strong commercial bias, if not frank direct conflicts of interest. These observations suggest a seriously flawed system that threatens not only dietary sodium policies but also the integrity of evidence-based medicine and science itself. It is paradoxical that opponents to a population reduction in dietary sodium often ask for rigorous randomized controlled trials on dietary sodium, while often conducting and citing very low-quality research and making erroneous and misleading statements to support the need for such trials.

We hope this commentary stimulates discussion and interest not just in dietary sodium policies but also in society's approach to protecting healthy nutrition policy and other public policies more broadly. Individual scientists and clinicians, academic institutions, funding bodies, and journals can all play a role to safeguard science and promote its advancement. Major governmental organizations (e.g., World Health Organization) need to collaborate with major ethics groups to develop, implement and enforce higher standards to safeguard public policy (https://apps.who.int/iris/handle/10665/274165, accessed March 18, 2021; https://apps.who.int/iris/bitstream/handle/10665/206554/9789241510530_eng.pdf?sequence=1, accessed March 18, 2021).

Compliance with Ethical Standards

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

Conflict of Interest NRCC reports personal fees from Resolve to Save Lives and the World Bank (RTSL), outside the submitted work; and is an unpaid member of World Action on Salt, Sugar and Health and an unpaid consultant on dietary sodium and hypertension control to numerous governmental and non-governmental organizations. NRCC chairs the International Consortium for Quality Research on Dietary Sodium/Salt (TRUE) which is an unpaid voluntary position. FJH is an unpaid member of Action on Salt, and World Action on Salt, Sugar and Health (WASSH). FH is partially funded by the National Institute for Health Research (NIHR) and the Medical Research Council (MRC). FPC has the following unpaid activities; immediate-Past President and Trustee of the British and Irish Hypertension Society (2017-19), member of Action on Salt, Sugar and Health, member of the TRUE Consortium, and Advisor to the World Health Organization. FPC reports speaker fees from Omron Healthcare and book royalties from Oxford University Press, both unrelated to the present topic. GAM is the unpaid Chair of Action on Salt, Sugar and Health, World Action on Salt, Sugar and Health (WASSH) and Blood Pressure UK. GAM is partially funded by the National Institute for Health Research (NIHR) and the Medical Research Council (MRC).

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

1.•• Institute for Health Metrics and Evaluation, University of Washington. Global Burden of Disease Study. "Global burden of disease study. http://vizhub.healthdata.org/gbd-compare/. Accessed Feb 21 14, 2021. **This website provides the most up-to-date estimates of risks and causes of death and disability at a global and national level.**

2. World Health Organization. The updated Appendix 3 of the WHO Global NCD Action Plan 2013-2020. Best Buys. Geneva: World

Health Organization; 2017. https://apps.who.int/gb/ebwha/pdf_files/EB140/B140_27-en.pdf?ua=1

3. World Health Organization. Saving lives, spending less: a strategic response to noncommunicable diseases. Geneva, Switzerland2018 (WHO/NMH/NVI/18.8). Licence: CC BY-NC-SA 3.0 IGO. Contract No.: WHO/NMH/NVI/18.8. https://apps.who.int/iris/handle/10665/272534
4. Park H-K, Lee Y, Kang B-W, Kwon K-i, Kim J-W, Kwon O-S, et al. Progress on sodium reduction in South Korea. BMJ Glob Health. 2020;5(5):e002028. https://doi.org/10.1136/bmjgh-2019-002028 https://gh.bmj.com/content/5/5/e002028.
5.•• Stallings VA, Harrison M, Oria M, Committee to Review the Dietary Reference Intakes for Sodium, Potassium. The National Academies Collection: Reports funded by National Institutes of Health. Dietary Reference Intakes for Sodium and Potassium. Washington (DC): National Academies Press (US) National Academy of Sciences.; 2019. https://www.ncbi.nlm.nih.gov/books/NBK538102/. **This reference provides an exhaustive review and original research to support the American and Canadian dietary reference intakes for sodium.**
6.• Filippini T, Malavolti M, Whelton PK, Naska A, Orsini N, Vinceti M. Blood pressure effects of sodium reduction: dose-response meta-analysis of experimental studies. Circulation. 2021;143. 10.1161/CIRCULATIONAHA.120.050371. https://www.ahajournals.org/doi/10.1161/CIRCULATIONAHA.120.050371. **This study provides causal evidence for a linear dose-response for increased blood pressure with increased dietary sodium.**
7.• Huang L, Trieu K, Yoshimura S, Neal B, Woodward M, Campbell NR et al. Effect of dose and duration of reduction in dietary sodium on blood pressure levels: systematic review and meta-analysis of randomised trials. BMJ. 2020;368:m315. https://www.bmj.com/content/368/bmj.m315. **This study provides causal evidence for a linear dose-response for increased blood pressure with increased dietary sodium and for an incerased response with a study duration of over 2 weeks.**
8. Joffres M, Campbell NR, Manns B, Tu K. Estimate of the benefits of a population-based reduction in dietary sodium additives on hypertension and its related health care costs in Canada. Can J Cardiol. 2007;23(6):437–43 https://www.sciencedirect.com/science/article/abs/pii/S0828282X07707808.
9. Committee on Public Health Priorities to Reduce and Control Hypertension, Institute of Medicine of the National Academy of Science. A population-based policy and systems change approach to prevent and control hypertension. Washington, DC, USA: National Academies Press 2010. Report No.: 0-309-14810-3. https://www.ncbi.nlm.nih.gov/books/NBK220087/
10. Aburto NJ, Ziolkovska A, Hooper L, Elliott P, Cappuccio FP, Meerpohl JJ. Effect of lower sodium intake on health: systematic review and meta-analyses. BMJ. 2013;346:f1326. https://www.bmj.com/content/346/bmj.f1326#:~:text=Conclusion,sodium%20intake%20reduced%20blood%20pressure.
11. Strazzullo P, D'Elia L, Kandala NB, Cappuccio FP. Salt intake, stroke, and cardiovascular disease: meta-analysis of prospective studies. BMJ. 2009;339:b4567 https://www.bmj.com/content/339/bmj.b4567.
12. Poggio R, Gutierrez L, Matta MG, Elorriaga N, Irazola V, Rubinstein A. Daily sodium consumption and CVD mortality in the general population: systematic review and meta-analysis of prospective studies. Public Health Nutr. 2015;18(4):695–704 https://www.cambridge.org/core/journals/public-health-nutrition/article/daily-sodium-consumption-and-cvd-mortality-in-the-general-population-systematic-review-and-metaanalysis-of-prospective-studies/215BA5FB0AACF84AD0EC1C4E6EFC16FC.
13. Zhu Y, Zhang J, Li Z, Liu Y, Fan X, Zhang Y, et al. Association of sodium intake and major cardiovascular outcomes: a dose-response meta-analysis of prospective cohort studies. BMC Cardiovasc Disord. 2018;18(1):192. https://doi.org/10.1186/s12872-018-0927-9 https://bmccardiovascdisord.biomedcentral.com/articles/10.1186/s12872-018-0927-9.
14. Wang Y-J, Yeh T-L, Shih M-C, Tu Y-K, Chien K-L. Dietary sodium intake and risk of cardiovascular disease: a systematic review and dose-response meta-analysis. Nutrients. 2020;12(10):2934 https://www.mdpi.com/2072-6643/12/10/2934.
15. EFSA Panel on Nutrition Novel Foods, and Food Allergens, Turck D, Castenmiller J, de Henauw S, Hirsch-Ernst K-I, Kearney J, et al. Dietary reference values for sodium. EFSA J. 2019;17(9):e05778. https://doi.org/10.2903/j.efsa.2019.5778 https://efsa.onlinelibrary.wiley.com/doi/10.2903/j.efsa.2019.5778.
16.•• O'Donnell M, Mente A, Alderman MH, Brady AJB, Diaz R, Gupta R et al. Salt and cardiovascular disease: insufficient evidence to recommend low sodium intake. Eur Heart J. 2020. doi:10.1093/eurheartj/ehaa586. https://academic.oup.com/eurheartj/article-abstract/41/35/3363/5917753?redirectedFrom=fulltext. **This commentary illustrates the failure of peer review to ensure an accurate and complete provision and interpretation of evidence.**
17. Strazzullo P. Benefit assessment of dietary salt reduction: while the doctors study, should more people die? J Hypertens. 2011;29(5):829–31 https://journals.lww.com/jhypertension/pages/articleviewer.aspx?year=2011&issue=05000&article=00002&type=Fulltext.
18. Campbell NR, Cappuccio FP, Tobe SW. Unnecessary controversy regarding dietary sodium: a lot about a little. Can J Cardiol. 2011;27(4):404–6 https://www.onlinecjc.ca/article/S0828-282X(11)00342-4/fulltext.
19. Campbell NR, Lackland DT, Niebylski ML, Nilsson PM. Is reducing dietary sodium controversial? Is it the conduct of studies with flawed research methods that is controversial? A Perspective From the World Hypertension League Executive. J Clin Hypertens. 2015;17(2):85–6 https://onlinelibrary.wiley.com/doi/full/10.1111/jch.12437.
20. Campbell NR, Lackland DT, MacGregor GA. Dietary sodium: a perspective on recent sodium evidence–its interpretation and controversies. J Clin Hypertens. 2013;15(11):765–8 https://onlinelibrary.wiley.com/doi/full/10.1111/jch.12187.
21. Campbell NR, Appel LJ, Cappuccio FP, Correa-Rotter R, Hankey GJ, Lackland DT, et al. A call for Quality Research on Salt Intake and Health: From the World Hypertension League and Supporting Organizations. J Clin Hypertens. 2014;16(7):469–71 https://onlinelibrary.wiley.com/doi/full/10.1111/jch.12364.
22. Campbell NR, Lackland DT, Niebylski ML, Orias M, Redburn KA, Nilsson PM, et al. 2016 Dietary Salt Fact Sheet and Call to Action: The World Hypertension League, International Society of Hypertension, and the International Council of Cardiovascular Prevention and Rehabilitation. J Clin Hypertens. 2016;18:1082–4 https://onlinelibrary.wiley.com/doi/full/10.1111/jch.12894.
23. Campbell NR. Dissidents and dietary sodium: concerns about the commentary by O'Donnell et al. Int J Epidemiol. 2016. doi:https://doi.org/10.1093/ije/dyw292. https://academic.oup.com/ije/article/46/1/362/2760167
24. Cappuccio FP, Sever PS. The importance of a valid assessment of salt intake in individuals and populations. A scientific statement of the British and Irish Hypertension Society. J Hum Hypertens. 2019;33:345–8. https://doi.org/10.1038/s41371-019-0203-1. https://www.nature.com/articles/s41371-019-0203-1.
25. Cappuccio FP, Beer M, Strazzullo P, on behalf of the European Salt Action Network. Population dietary salt reduction and the risk of cardiovascular disease. A scientific statement from the European Salt Action Network. Nutr Metab Cardiovasc Dis. 2019;29:107–14. https://doi.org/10.1016/j.numecd.2018.11.010. https://www.nmcd-journal.com/article/S0939-4753(18)30352-1/fulltext.

26. Cappuccio FP, Capewell S, He FJ, MacGregor GA. Salt: the dying echoes of the food industry. Am J Hypertens. 2014;27(2):279–81 https://academic.oup.com/ajh/article/27/2/279/161804.
27. Cappuccio FP, Capewell S. Facts, issues, and controversies in salt reduction for the prevention of cardiovascular disease. Functional Food Reviews. 2015;7(1):41–61.
28. Webster J, Waqanivalu T, Arcand J, Trieu K, Cappuccio FP, Appel LJ, et al. Understanding the science that supports population-wide salt reduction programs. J Clin Hypertens. 2017;19(6):569–76. https://doi.org/10.1111/jch.12994 https://onlinelibrary.wiley.com/doi/full/10.1111/jch.12994.
29. Cappuccio FP. Pro: Reducing salt intake at population level: is it really a public health priority? Nephrol Dial Transplant. 2016;31(9):1392–6. https://doi.org/10.1093/ndt/gfw279 https://academic.oup.com/ndt/article/31/9/1392/1752250.
30. He FJ, Appel LJ, Cappuccio FP, de Wardener HE, MacGregor GA. Does reducing salt intake increase cardiovascular mortality? Kidney Int. 2011;80(7):696–8. https://doi.org/10.1038/ki.2011.246 https://www.kidney-international.org/article/S0085-2538(15)55129-6/fulltext.
31. Cappuccio FP, Campbell NR. Population dietary salt reduction and the risk of cardiovascular disease: a commentary on recent evidence. J Clin Hypertens. 2017;19(1):4–5. https://doi.org/10.1111/jch.12917 https://onlinelibrary.wiley.com/doi/full/10.1111/jch.12917.
32. Cook NR, He FJ, MacGregor GA, Graudal N. Sodium and health—concordance and controversy. BMJ. 2020;369:m2440. https://doi.org/10.1136/bmj.m2440 https://www.bmj.com/content/369/bmj.m2440.
33. Brownell KD, Warner KE. The perils of ignoring history: Big Tobacco played dirty and millions died. How similar is Big Food? Milbank Q. 2009;87(1):259–94 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2879177/.
34.•• He FJ, Campbell NRC, Ma Y, MacGregor GA, Cogswell ME, Cook NR. Errors in estimating usual sodium intake by the Kawasaki formula alter its relationship with mortality: implications for public health. Int J Epidemiol. 2018;47:1784–95. https://doi.org/10.1093/ije/dyy114 **This study demonstrates that a spurious J-curve relationship between dietary sodium and total mortality is created when a common but inappropriate method is used**.
35. He FJ, Ma Y, Campbell NRC, MacGregor GA, Cogswell ME, Cook NR. Formulas to estimate dietary sodium intake from spot urine alter sodium-mortality relationship. Hypertension. 2019;74(3):572–80. https://doi.org/10.1161/HYPERTENSIONAHA.119.13117 https://www.ahajournals.org/doi/10.1161/HYPERTENSIONAHA.119.13117.
36. McLean RM, Farmer VL, Nettleton A, Cameron CM, Cook NR, Woodward M, et al. Twenty-Four-Hour Diet recall and Diet records compared with 24-hour urinary excretion to predict an individual's sodium consumption: a systematic review. J Clin Hypertens. 2018;20(10):1360–76. https://doi.org/10.1111/jch.13391 https://onlinelibrary.wiley.com/doi/full/10.1111/jch.13391.
37. McLean RM, Farmer VL, Nettleton A, Cameron CM, Cook NR, Campbell NRC. Assessment of dietary sodium intake using a food frequency questionnaire and 24-hour urinary sodium excretion: a systematic literature review. J Clin Hypertens. 2017;19(12):1214–30. https://doi.org/10.1111/jch.13148 https://onlinelibrary.wiley.com/doi/10.1111/jch.13148.
38. Ji C, Sykes L, Paul C, Dary O, Legetic B, Campbell NRC, et al. Systematic review of studies comparing 24-hour and spot urine collections for estimating population salt intake. Rev Panam Salud Publica. 2012;32(4):307–15 https://scielosp.org/article/rpsp/2012.v32n4/307-315/en/.
39. Ji C, Miller MA, Venezia A, Strazzullo P, Cappuccio FP. Comparisons of spot vs 24-h urine samples for estimating population salt intake: validation study in two independent samples of adults in Britain and Italy. Nutr Metab Cardiovasc Dis. 2014;24(2):140–7 https://www.sciencedirect.com/science/article/abs/pii/S0939475313001609.
40. Olde Engberink RHG, Hoek TC, Noordenne ND, Born BH, Peters-Sengers H, Vogt L. Use of a single baseline versus multiyear 24-hour urine collection for estimation of long-term sodium intake and associated cardiovascular and renal risk. Circulation. 2017;136. doi: https://doi.org/10.1161/CIRCULATIONAHA.117.029028. https://www.ahajournals.org/doi/10.1161/CIRCULATIONAHA.117.029028
41. Cobb LK, Anderson CA, Elliott P, Hu FB, Liu K, Neaton JD. Methodological issues in cohort studies that relate sodium intake to cardiovascular disease outcomes: a science advisory from the American Heart Association. Circulation. 2014;129:1173–86. https://doi.org/10.1161/CIR.0000000000000015 https://www.ahajournals.org/doi/full/10.1161/cir.0000000000000015.
42. Johnson C, Raj TS, Trieu K, Arcand J, Wong MM, McLean R, et al. The science of salt: a systematic review of quality clinical salt outcome studies June 2014 to May 2015. J Clin Hypertens. 2016;18(9):832–9 https://onlinelibrary.wiley.com/doi/full/10.1111/jch.12877.
43. Lucko A, Doktorchik CTA, Campbell NRC. Impact of quality of research on patient outcomes in the Institute of Medicine 2013 report on dietary sodium. J Clin Hypertens. 2018;20:345–50 https://onlinelibrary.wiley.com/doi/pdf/10.1111/jch.13168.
44. Tan M, He FJ, MacGregor GA. Salt and cardiovascular disease in PURE: a large sample size cannot make up for erroneous estimations. J Ren-Angio-Aldo Syst. 2018;19(4):1470320318810015. https://doi.org/10.1177/1470320318810015 https://journals.sagepub.com/doi/10.1177/1470320318810015.
45. Oparil S. Low sodium intake — Cardiovascular health benefit or risk? NEJM. 2014;371(7):677–9. https://doi.org/10.1056/NEJMe1407695 https://www.nejm.org/doi/full/10.1056/nejme1407695.
46. Campbell NRC. More on dissidents and dietary sodium. Int J Epidemiol. 2018;48:670–3. https://doi.org/10.1093/ije/dyy003 https://academic.oup.com/ije/article/47/2/670/4903005.
47. Chinthapalli K. Dethroning the king of condiments: what is the link between salt, hypertension, and mortality? BMJ. 2013;347:f7192 https://www.bmj.com/content/347/bmj.f7192.
48. Logan AG. Dietary sodium intake and its relation to human health: a summary of the evidence. J Am Coll Nutr. 2006;25(3):4F–169F https://www.tandfonline.com/doi/abs/10.1080/07315724.2006.10719528.
49. Alderman MH. Evidence relating dietary sodium to cardiovascular disease. J Am Coll Nutr. 2006;25(3 Suppl):256S–61S https://www.tandfonline.com/doi/abs/10.1080/07315724.2006.10719575?journalCode=uacn20.
50. Franco V, Oparil S. Salt sensitivity, a determinant of blood pressure, cardiovascular disease and survival. J Am Coll Nutr. 2006;25(3 Suppl):247S–55S https://www.tandfonline.com/doi/abs/10.1080/07315724.2006.10719574.
51. Conflict of Interest Disclosures Associated with JACN Volume 25, Number 3(S), June 2006. J Am Coll Nutr. 2006;25(6):550-. doi: 10.1080/07315724.2006.10719571. https://www.tandfonline.com/doi/abs/10.1080/07315724.2006.10719571
52. Nestle M. Food politics: how the food industry infuences nutrition and health. Berkeley, CA: University of California Press; 2007.

https://www.foodpolitics.com/food-politics-how-the-food-industry-influences-nutrition-and-health/

53. Bes-Rastrollo M, Schulze MB, Ruiz-Canela M, Martinez-Gonzalez MA. Financial conflicts of interest and reporting bias regarding the association between sugar-sweetened beverages and weight gain: a systematic review of systematic reviews. PLoSMed. 2013;10(12): e1001578 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3876974/.
54. O'Donnell MJ, Yusuf S, Mente A, Gao P, Mann JF, Teo K, et al. Urinary sodium and potassium excretion and risk of cardiovascular events. JAMA. 2011;306(20):2229–38 https://jamanetwork.com/journals/jama/fullarticle/1105553.
55. Mente A, O'Donnell M, Rangarajan S, Dagenais G, Lear S, McQueen M, et al. Associations of urinary sodium excretion with cardiovascular events in individuals with and without hypertension: a pooled analysis of data from four studies. Lancet. 2016;388(10043):465–75 https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(16)30467-6/fulltext.
56. Alderman M, Sealey J, Cohen H, Madhavan S, Laragh J. Urinary sodium excretion and myocardial infarction in hypertensive patients: a prospective cohort study. Am J Clin Nutr. 1997;65(2 Suppl):682S–6S https://academic.oup.com/ajcn/article/65/2/682S/4655398.
57. Marschner IC, Simes RJ, Keech A. Biases in the identification of risk factor thresholds and J-curves. Am J Epidemiol. 2007;166(7): 824–31. https://doi.org/10.1093/aje/kwm145 https://academic.oup.com/aje/article/166/7/824/94722.
58. Cohen HW, Hailpern SM, Alderman MH. Sodium intake and mortality follow-up in the Third National Health and Nutrition Examination Survey (NHANES III). J Gen Intern Med. 2008;23(9):1297–302 https://link.springer.com/article/10.1007/s11606-008-0645-6.
59. He J, Ogden LG, Vupputuri S, Bazzano LA, Loria C, Whelton PK. Dietary sodium intake and subsequent risk of cardiovascular disease in overweight adults. JAMA. 1999;282(21):2027–34 https://jamanetwork.com/journals/jama/fullarticle/192154.
60. Yang Q, Liu T, Kuklina EV, Flanders WD, Hong Y, Gillespie C, et al. Sodium and potassium intake and mortality among US adults: prospective data from the Third National Health and Nutrition Examination Survey. Arch Intern Med. 2011;171(13):1183–91 https://jamanetwork.com/journals/jamainternalmedicine/fullarticle/1106080.
61. Dinicolantonio JJ, Pasquale PD, Taylor RS, Hackam DG. Low sodium versus normal sodium diets in systolic heart failure: systematic review and meta-analysis. Heart. 2013 Mar 12. https://doi.org/10.1136/heartjnl-2012-302337 https://pubmed.ncbi.nlm.nih.gov/22914535/.
62. Cook NR, Appel LJ, Whelton PK. Lower levels of sodium intake and reduced cardiovascular risk. Circulation. 2014;129:981–9. https://doi.org/10.1161/CIRCULATIONAHA.113.006032 https://www.ahajournals.org/doi/10.1161/CIRCULATIONAHA.113.006032.
63.•• Mente A, O'Donnell M, Yusuf S. Sodium and health: another challenge to the current dogma. Eur Heart J. 2021. doi:10.1093/eurheartj/ehaa1093. https://pubmed.ncbi.nlm.nih.gov/33484121/. **This commentary demonstrates a failure of peer review to ensure an accurate provision and interpretation of evidence**
64. Santos JA, Tekle D, Rosewarne E, Flexner N, Cobb L, Al-Jawaldeh A et al. A systematic review of salt reduction initiatives around the world: a midterm evaluation of progress towards the 2025 global non-communicable diseases salt reduction target. Advances in Nutrition. 2021. doi:https://doi.org/10.1093/advances/nmab008. https://academic.oup.com/advances/advance-article/doi/10.1093/advances/nmab008/6159028
65. He FJ, Tan M, Ma Y, MacGregor GA. Salt reduction to prevent hypertension and cardiovascular disease: JACC state-of-the-art review. J Am Coll Cardiol. 2020;75(6):6632–47. https://doi.org/10.1016/j.jacc.2019.11.055 https://www.sciencedirect.com/science/article/pii/S0735109719386929?via%3Dihub.
66.• He FJ, Brinsden HC, MacGregor GA. Salt reduction in the United Kingdom: a successful experiment in public health. J Hum Hypertens. 2014;28(6):345-52. https://www.nature.com/articles/jhh2013105. **An updated review of the dietary sodium and health issues.**
67. Mancia G, Oparil S, Whelton PK, McKee M, Dominiczak A, Luft FC, et al. The technical report on sodium intake and cardiovascular disease in low- and middle-income countries by the joint working group of the World Heart Federation, the European Society of Hypertension and the European Public Health Association. Eur Heart J. 2017:ehw549. https://doi.org/10.1093/eurheartj/ehw549. https://academic.oup.com/eurheartj/article/38/10/712/2932130.
68. McIntrye L. Post-Truth. London, United Kingdom: The MIT Press; 2018. https://mitpress.mit.edu/books/post-truth
69. Alderman MH, Madhavan S, Ooi WL, Cohen H, Sealey JE, Laragh JH. Association of the renin-sodium profile with the risk of myocardial infarction in patients with hypertension. NEJM. 1991;324(16):1098–104 https://www.nejm.org/doi/full/10.1056/NEJM199104183241605.
70. Graudal N, Hubeck-Graudal T, Jurgens G, Taylor RS. Dose-response relation between dietary sodium and blood pressure: a meta-regression analysis of 133 randomized controlled trials. Am J Clin Nutr. 2019;109:1273–8 https://academic.oup.com/ajcn/article/109/5/1273/5480600.
71. Graudal NA, Galloe AM, Garred P. Effects of sodium restriction on blood pressure, renin, aldosterone, catecholamines, cholesterols, and triglyceride: a meta-analysis. JAMA. 1998;279(17):1383–91 https://jamanetwork.com/journals/jama/article-abstract/187486.
72. Tsirimiagkou C, Karatzi K, Argyris A, Chalkidou F, Tzelefa V, Sfikakis PP, Yannakoulia M, Protogerou AD Levels of dietary sodium intake: diverging associations with arterial stiffness and atheromatosis. Hellenic J Cardiol. 2021. doi:https://doi.org/10.1016/j.hjc.2021.02.005.
73. Mente A, O'Donnell MJ, Dagenais G, Wielgosz A, Lear SA, McQueen MJ, et al. Validation and comparison of three formulae to estimate sodium and potassium excretion from a single morning fasting urine compared to 24-h measures in 11 countries. J Hypertens. 2014;32(5):1005–14 https://journals.lww.com/jhypertension/pages/articleviewer.aspx?year=2014&issue=09000&article=00034&type=Fulltext.
74. McCarron DA, Geerling JC, Kazaks AG, Stern JS. Can dietary sodium intake be modified by public policy? Clin J Am Soc Nephrol. 2009;4(11):1878–82 https://cjasn.asnjournals.org/content/4/11/1878.
75. Alderman MH. Presidential Address: 21st Scientific Meeting of the International Society of Hypertension: dietary sodium and cardiovascular disease: the 'J'-shaped relation. J Hypertens. 2007;25(5): 903–7 https://warwick.ac.uk/fac/sci/med/staff/cappuccio/who/whl_video/presidential_address__21st_scientific_meeting_of.11.pdf.
76. Garduno-Diaz SD, Aksnes B, Alvim Leite M. The normalization of conflicts of interest in the USA and their potential impact on public health nutrition. In: Nutrition W, editor.2017. p. 123-7. https://worldnutritionjournal.org/index.php/wn/article/view/24
77. Mozaffarian D. Conflict of interest and the role of the food industry in nutrition research. JAMA. 2017;317(17):1755–6. https://doi.org/

10.1001/jama.2017.3456 https://jamanetwork.com/journals/jama/article-abstract/2623631.

78. Stuckler D, Nestle M. Big food, food systems, and global health. PLoSMed. 2012;9(6):e1001242 https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1001242.

79. Stuckler D, McKee M, Ebrahim S, Basu S. Manufacturing epidemics: the role of global producers in increased consumption of unhealthy commodities including processed foods, alcohol, and tobacco. PLoSMed. 2012;9(6):e1001235 https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1001235.

80. Liu X, Bai Y, Li S, O'Donnell M, Mente A, Yin L, et al. Associations of estimated 24-h urinary sodium excretion with mortality and cardiovascular events in Chinese adults: a prospective cohort study. J Hypertens. 2021;39:484–93. https://doi.org/10.1097/hjh.0000000000002647 https://journals.lww.com/jhypertension/Fulltext/2021/03000/Associations_of_estimated_24_h_urinary_sodium.15.aspx.