World Health Organization

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Sodium intake for adults and children

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[1] This publication is a World Health Organization (WHO) guideline. A WHO guideline is any document, whatever its title, containing WHO recommendations about health interventions, whether they be clinical, public health or policy interventions. A recommendation provides information about what policy-makers, health-care providers or patients should do. It implies a choice between different interventions that have an impact on health and that have ramifications for the use of resources. All publications containing WHO recommendations are approved by the WHO Guidelines Review Committee.

Contents

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Abbreviations and acronyms

AUB	American University of Beirut
CDC	Centers for Disease Control and Prevention
CI	confidence interval
FAO	Food and Agriculture Organization of the United Nations
FSANZ	Food Standards Australia New Zealand
GRADE	Grading of Recommendations Assessment, Development and Evaluation
HDL	high-density lipoprotein
IAEA	International Atomic Energy Agency
KFDA	Korea Food and Drug Administration
KHIDI	Korea Health Industry Development Institute
LDL	low-density lipoprotein
MD	mean difference
NCD	noncommunicable disease
NUGAG	Nutrition Guidance Expert Advisory Group
NZFSA	New Zealand Food Safety Academy
PICO	population, intervention, control and outcomes
RCT	randomized-controlled trial
RR	risk ratio
UN	United Nations
UNU	United Nations University
USA	United States of America
WASH	World Action on Salt and Health
WHO	World Health Organization

Symbols

>	greater than
<	less than
≥	equal to or greater than
≤	equal to or less than

Executive summary

Background

Noncommunicable diseases (NCDs) are the main contributor to mortality and morbidity globally (*1, 2*), and interventions to reduce the burden of NCDs are highly cost-effective (*3*). Elevated sodium intake has been associated with a number of NCDs (including hypertension, cardiovascular disease and stroke), and decreasing sodium intake may reduce blood pressure and the risk of associated NCDs (*4, 5*). Recent data on sodium intake show that populations around the world are consuming much more sodium than is physiologically necessary (*6*). In many cases, they are consuming much more than the current World Health Organization (WHO) recommendation on sodium consumption for adults, which is 2 g sodium/day (equivalent to 5 g salt/day) (*7*).

Since the publication of the previous WHO guideline on sodium intake (*7*), an appreciable amount of scientific evidence concerning sodium intake, hypertension and risk of cardiovascular disease has been published. Member States and international partners therefore requested WHO to review the current guideline on sodium intake for adults, and to also generate a guideline on sodium intake for children.

Objective

The objective of this guideline is to provide recommendations on the consumption of sodium to reduce NCDs in most adults and children. The recommendations in this guideline can be used by those developing programmes and policies to assess current sodium intake levels relative to a benchmark. If necessary, the recommendations can also be used to develop measures to decrease sodium intake through public health interventions such as food and product labelling, consumer education, and the establishment of food-based dietary guidelines.

Methods

WHO developed the present evidence-informed guideline using the procedures outlined in the WHO Handbook for guideline development (*8*). The steps in this process included:

- identification of priority questions and outcomes;
- retrieval of the evidence;
- assessment and synthesis of the evidence;
- formulation of recommendations;
- identification of research gaps;
- planning for dissemination, implementation, impact evaluation and updating of the guideline.

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) methodology (*9*) was followed, to prepare evidence profiles related to preselected topics, based on recent systematic reviews of the scientific literature. An international, multidisciplinary group of experts participated in three WHO technical consultations. The first was held in Geneva, Switzerland on 14–18 March 2011; the second in Seoul, the Republic of Korea on 29 November – 2 December 2011; and the third in Geneva, Switzerland on 27–30 March 2012. At these meetings, the group of experts reviewed and discussed the evidence, drafted recommendations, and reached consensus on the strength of the recommendations. The group took into consideration desirable and undesirable effects of the recommendation, the quality of the available evidence, values and preferences related to the recommendation in different settings, and the cost of options available to public health officials and programme managers in different settings. All guideline group members completed a declaration of interests form before each meeting. An External Expert and Stakeholder Panel was involved throughout the process.

The evidence

Reducing sodium intake significantly reduced systolic and diastolic blood pressure in adults and children. The reduction in blood pressure was detected across a wide range of intake levels, and was independent of baseline sodium intake. Reducing sodium intake to <2 g/day was more beneficial for blood pressure than reducing sodium intake but still consuming >2 g/day. Reducing sodium intake had no significant adverse effect on blood lipids, catecholamine levels or renal function. Higher sodium intake was associated with higher risk of incident stroke, fatal stroke and fatal coronary heart disease. There was no association between sodium intake and all-cause mortality, incident cardiovascular disease and non-fatal coronary heart disease. However, the strong positive relationship between blood pressure and these outcomes provides indirect evidence that reducing sodium intake can improve these outcomes through a beneficial effect on blood pressure. Based on the entire body of evidence, WHO generated the following recommendations for sodium intake in adults and children.

Recommendations

- WHO recommends a reduction in sodium intake to reduce blood pressure and risk of cardiovascular disease, stroke and coronary heart disease in adults (*strong recommendation*[1]). WHO recommends a reduction to <2 g/day sodium (5 g/day salt) in adults (*strong recommendation*).

- WHO recommends a reduction in sodium intake to control[2] blood pressure in children (*strong recommendation*). The recommended maximum level of intake of 2 g/day sodium in adults should be adjusted downward based on the energy requirements of children relative to those of adults.

[1] A strong recommendation is one for which the guideline development group is confident that the desirable effects of adherence outweigh the undesirable effects.

[2] "Control" for this recommendation refers to the prevention of a deleterious rise in blood pressure with age.

These recommendations apply to all individuals, with or without hypertension (including pregnant and lactating women), except for individuals with illnesses or taking drug therapy that may lead to hyponatraemia or acute build-up of body water, or require physician-supervised diets (e.g. patients with heart failure and those with type I diabetes). In these subpopulations, there may be a particular relationship between sodium intake and the health outcomes of interest (*10, 11*). Hence, these subpopulations were not considered in the review of the evidence and generation of the guideline.

These recommendations complement the WHO guideline on potassium intake, and should be used in conjunction with that and other nutrient guidelines and recommendations to guide the development of public health nutrition programmes and policies. Addressing the optimal ratio of sodium to potassium was outside the scope of this guideline; however, if an individual consumes the amount of sodium recommended in this guideline and the amount of potassium recommended in the WHO guideline on potassium intake, the ratio of sodium to potassium would be approximately one to one, which is considered beneficial for health (*12*).

These recommendations recognize that salt reduction and salt iodization are compatible. Monitoring of salt intake and salt iodization at country level is needed to adjust salt iodization over time as necessary, depending on observed salt intake in the population, to ensure that individuals consuming the recommended amount of sodium continue to consume sufficient iodine.

These recommendations were based on the totality of evidence regarding the relationship between sodium intake and blood pressure, all-cause mortality, cardiovascular disease, stroke and coronary heart disease, as well as potential adverse effects on blood lipids, catecholamine levels and renal function. The evidence regarding the relationship between sodium intake and blood pressure was of high quality, whereas the evidence regarding sodium intake and all-cause mortality, cardiovascular disease, stroke and coronary heart disease was of lower quality. Therefore, these recommendations should be reviewed when more evidence on the relationship between sodium intake and all-cause mortality and cardiovascular disease outcomes becomes available.

The successful implementation of these recommendations would have an important public health impact through reductions in morbidity and mortality, improvement in the quality of life of millions of people, and substantial reductions in health-care costs (*1, 3, 13*).

Introduction

Scope and purpose

The objective of this guideline is to provide recommendations on the consumption of sodium for most adults and children. It is important to establish nutrient guidelines so that nutrition interventions can be developed in a logical, systematic, and scientific manner taking into account the best available evidence. The recommendations in this guideline can be used by programme and policy planners to assess current sodium intake levels relative to a benchmark and develop measures to decrease sodium intake, where necessary, through public health interventions including, but not limited to, food and product labelling, consumer education, and the establishment of Food-Based Dietary Guidelines (FBDG). This guideline does not provide guidance on specific food intake because such dietary guidelines should be based on the overall dietary goals, which take into consideration all required nutrients. It should be used in conjunction with the guideline on potassium intake and other nutrient guidelines to guide public health nutrition programme and policy development.

This guideline provides a global, evidence-informed recommendation on sodium intake for:

- adults (≥16 years of age) for the reduction of blood pressure and risk of cardiovascular disease, stroke and coronary heart disease;
- children (2–15 years of age) for the control of blood pressure.

The guideline does not provide recommendations for individuals with illnesses or taking drug therapy that may lead to hyponatraemia or acute build-up of body water, or require physician-supervised diets (e.g. patients with heart failure and those with type I diabetes). These special subpopulations were not considered in the review of the evidence and generation of the guideline because, in these subpopulations, there may be a particular relationship between sodium intake and the health outcomes of interest (*10, 11*).

The guideline will help Member States and their partners to make informed decisions on the appropriate nutrition actions to reduce noncommunicable diseases (NCDs). It is intended for a wide audience, including policy-makers and their expert advisers, and technical and programme staff in organizations involved in the design, implementation and scaling-up of nutrition actions for public health.

This document presents the key recommendations and a summary of the supporting evidence. Further details of the evidence base are provided in Annex 1 and other documents listed in the references.

Background

NCDs are the leading cause of death globally, killing more people each year than all other causes combined (*14*). The major NCDs currently account for approximately 60% of all deaths and 43% of disease burden globally, and these levels are expected to continue to rise (*2, 15*). In 2008, 29 million NCD-related deaths (almost 80%) occurred in low and middle-income countries. In those countries, 29% of NCD-related deaths were in people under 60 years of age; in contrast, in high-income countries, only 13% of such deaths were premature. In 2005, cardiovascular disease itself accounted for 30% of all deaths: the equivalent of infectious disease, nutritional deficiency, and maternal and perinatal conditions combined (*2*).

Hypertension is considered a major risk for cardiovascular disease, especially heart attack and stroke. Suboptimal systolic blood pressure (>115 mmHg) is estimated to contribute to 49% of all coronary heart disease and 62% of all stroke (*13*). Thus, the burden of morbidity and mortality from hypertension and related NCDs is currently one of the most urgent public health problems globally. Although NCDs disproportionately affect adults, they and their risk factors are now being detected more frequently in paediatric populations. Diet-related NCDs are chronic, and take years and decades to manifest; thus, delaying the onset of these diseases could improve lives and result in substantial cost savings (*3*). Blood pressure during childhood has a significant association with blood pressure during adulthood, meaning that children with increased blood pressure are at high risk for hypertension and its related morbidities as adults (*16*). Additionally, elevated blood pressure in childhood contributes to cardiovascular disease pathology during childhood itself (*17*). Thus, addressing, during childhood, the problem of elevated blood pressure and other risk factors for NCDs that could manifest later in life is crucial to combat NCDs.

Sodium is the principal cation in extracellular fluid in the body, and is an essential nutrient necessary for maintenance of plasma volume, acid–base balance, transmission of nerve impulses and normal cell function. In healthy individuals, nearly 100% of ingested sodium is absorbed during digestion, and urinary excretion is the primary mechanism for maintaining sodium balance (*18*). Even in hot, humid climates, there are only minimal loses through faeces and sweat. Acclimation to heat occurs rapidly; thus, within a few days of exposure to hot and humid conditions, individuals lose only small amounts of sodium through sweat (*19, 20*). Under conditions of extreme heat and intense physical activity that result in high sweat production, sodium losses in sweat are increased and appreciable; nonetheless, most individuals can replace the necessary sodium through food consumption, without dietary alterations, supplements or specially formulated products (*19-21*).

Sodium and chloride are the chemical components of common table salt; however, sodium can be found in other forms, and the primary contributors to dietary sodium consumption depend on the cultural context and dietary habits of a population (*22*). Sodium is found naturally in a variety of foods, such as milk, meat and shellfish (Annex 2). It is often found in high amounts in processed foods such as breads, crackers, processed meats and snack foods (*23-26*). High amounts of sodium are also found in many condiments (e.g. soy and fish sauces) (*23*). Thus, a diet high in processed foods and low in fresh fruits and vegetables is often high in sodium (*24, 26*). Although the minimum intake level necessary for proper bodily function is not well defined, it is estimated to be as little as 200–500 mg/day (*18, 27*). Data from around the world suggest that the population average sodium consumption is well above the minimal physiological needs, and in many countries is above the value recommended by the 2002 Joint World Health Organization/Food and Agriculture Organization of the United Nations (WHO/FAO) Expert Consultation (*12*) of 2 g sodium/day (equivalent to 5 g salt/day) (*22*).

Increased sodium consumption is associated with increased blood pressure, whereas lower sodium consumption appears to decrease blood pressure in adults (*12, 28-30*). A number of recent high-quality systematic reviews of randomized-controlled trials (RCTs) have concluded that decreased sodium intake relative to usual or higher intake results in lowered blood pressure in adults with or without hypertension (*30-33*). A review concerning advice to reduce sodium consumption concluded that intensive behaviour-change interventions targeting decreasing sodium

intake successfully reduced blood pressure in adults with or without hypertension (*34*). However, the reductions in sodium intake and in blood pressure were modest, and the authors concluded that environmental changes (e.g. reduction of sodium in processed foods) would facilitate a greater reduction in sodium consumption and, therefore, have a greater impact on blood pressure.

Increased sodium has also been associated with cardiovascular diseases (*7, 35*), although the evidence is less clear than that for blood pressure. A recent systematic review of RCTs that reported cardiovascular disease and stroke found no relationship between sodium intake and cardiovascular disease. However, few RCTs reported cardiovascular disease outcomes; hence, there was insufficient evidence to substantiate a relationship between sodium intake and these outcomes (*36*). Numerous observational cohort studies have explored the relationship between sodium intake and cardiovascular disease. Most of these studies have reported a direct relationship between sodium intake and cardiovascular disease, stroke or coronary heart disease. However, others have reported no relationship, an inverse relationship or even a J-shaped relationship (i.e. increased risk at both the lowest and the highest sodium intake levels). A recent meta-analysis of 13 cohort studies of a duration of 4 years or more, which did not include the most recently published observational cohort studies (*37, 38*), concluded that there was a direct relationship between increased sodium consumption and subsequent risk of cardiovascular disease and stroke (*35*).

There is little disagreement that decreased sodium intake decreases blood pressure, but there is some concern that it might also lead to adverse effects in health. Decreased sodium intake results in reduced blood volume and thus activates the renin–angiotensin–aldosterone and sympathetic nervous systems (indicated by increased adrenaline and noradrenaline), which help to control blood volume (*39*). Likewise, a reduction in blood volume without a concurrent reduction in blood lipids can lead to an increased concentration of lipids in the blood. A recent systematic review reported an increase in renin, aldosterone, adrenaline and noradrenaline, total cholesterol and triglyceride with reduced sodium (*33*). However, the changes in blood lipids and catecholamine levels were transient and no longer present after 4 weeks of reduced sodium intake (*33*). Although the changes in renin and aldosterone levels persisted with longer term reduced sodium intake, the importance of these changes is uncertain (*40, 41*). An increased risk of cardiovascular morbidity and mortality with increased renin or aldosterone level has been reported (*42, 43*), but the evidence is not conclusive (*44, 45*). Unlike blood pressure, a change in these hormones is not currently recognized as a reliable biomarker for future risk (*41, 46*).

Justification

Much of the human and social impact caused each year by NCD-related morbidity and mortality could be averted through interventions that are well understood, cost effective and feasible (*14*). Decreased sodium intake in the population is a cost-effective public health intervention that could potentially reduce the burden of NCD morbidity and mortality (*3*). Because of the ever-increasing importance of NCDs on health-care costs and burden of disease (*2, 3, 15*), Members States requested WHO to update its guideline on sodium intake for adults and to develop a guideline on sodium intake for children, to inform public policy.

Before a guideline can be generated, benefits and potential harms should be assessed. Some researchers have reported that reducing sodium intake to levels even below those currently recommended by WHO would lead to even greater health benefits (*30*). Conversely, others have questioned the importance of the modest reduction in blood pressure caused by decreased sodium intake in individuals without hypertension (*33*). Additionally, two recently published cohort studies have proposed that reducing sodium intake to <2 g/day may be associated with increased risk of cardiovascular disease and stroke (*37, 38*). The continued debate over the effect of sodium consumption and health outcomes, and the recent research that is continuously adding to the evidence base in the scientific literature, warrant a complete systematic review of all available epidemiological evidence considering sodium and blood pressure, all-cause mortality, cardiovascular disease, stroke, coronary heart disease and potential adverse effects (e.g. changes in blood lipids, catecholamine levels and renal function).

Guideline development process

This guideline was developed in accordance with the WHO evidence-informed guideline development procedures outlined in the *WHO Handbook for guideline development* (*8*).

Advisory groups

Development of this guideline was undertaken by the WHO Department of Nutrition for Health and Development[1], in partnership with the Department of Research Policy and Cooperation and members of the WHO Secretariat (Annex 3). The work was guided by the WHO Steering Committee for Nutrition Guideline Development (Annex 4), which also provided overall supervision of the guideline development process. The WHO Secretariat and the Steering Committee included representatives from all departments of WHO with an interest in the provision of scientific advice on nutrition. Two additional groups were formed: an advisory guideline group and an external expert and stakeholder panel, as outlined below.

Advisory guideline group

The WHO Nutrition Guidance Expert Advisory Group (NUGAG) Subgroup on Diet and Health was convened to support the development of this guideline (Annex 5). This group included experts who had previously participated in various WHO expert advisory panels, as well as others identified through open calls for specialists. In forming this group, WHO took into consideration the need for a balanced gender mix, expertise from multiple disciplinary areas and representation from all WHO regions. Efforts were made to include subject-matter experts; statistical, systematic review, program evaluation and Grading of Recommendations Assessment, Development and Evaluation (GRADE) methodologists; and representatives of potential stakeholders (e.g. programme managers and other health professionals involved in the health-care process). There were no representatives of commercial organizations, because such individuals are prohibited from being members of any WHO guideline group. External resource persons, including subject matter experts and systematic review and GRADE methodologists, were invited to the NUGAG meetings as observers to provide technical input. These individuals did not participate in the decision-making processes. NUGAG's role was to advise WHO on the choice of outcomes important for decision-making and the interpretation of the evidence.

Panel

The External Expert and Stakeholder Panel was formed during the planning stages of guideline development. The panel was consulted on the scope of the guideline, and on the specific research questions to be addressed and outcomes to be investigated in the systematic reviews of the literature. The panel was later asked to review and provide feedback on the completed draft guideline (Annex 6). During the consultations on both the scoping of the guidelines and the draft guideline documents, there was an

[1] The Department of Research Policy and Cooperation has since been reorganized and the nutrition guideline development work is being carried out in close collaboration with the Department of Knowledge Management and Sharing.

open call for all interested parties to join the External Expert and Stakeholder Panel. The panel comprises individuals who responded to direct solicitation for contributions based on their known expertise and interest in the subject matter, or to the WHO open call for public comment executed through the electronic mailing lists of the WHO Department of Nutrition for Health and Development, and that of the Codex Alimentarius Commission, and through the posting of the call for public comment on the WHO and United Nations (UN) Standing Committee of Nutrition websites.

Scoping of the guideline, evidence appraisal and decision-making

WHO developed an initial set of questions to be addressed in the guideline. The questions were based on the needs of Member States and international partners for policy and programme guidance. They were also influenced by the request of the Codex Committee of Nutrition and Foods for Special Dietary Uses. The population, intervention, control and outcomes (PICO) format was used in generating the questions (Annex 7). The PICO questions were first discussed and reviewed by the WHO Secretariat and the WHO Steering Committee for Nutrition Guideline Development and were then made available for public comment from 1 to 28 February 2011. Feedback was received from 16 individuals or organizational stakeholders, and the questions were adapted accordingly.

The draft set of PICO questions was presented to the NUGAG Subgroup on Diet and Health during its meeting on 14–18 March 2011. During that meeting, the guideline topic was introduced and the scope of the guideline to be generated finalized. The PICO questions were discussed and outcomes and populations were ranked in importance by NUGAG members. The prioritization of the PICO questions defined the scope of the evidence to be used in informing the guideline development. Subsequent to the meeting, WHO reviewed the scientific literature and conducted new systematic reviews and meta-analyses to address the PICO questions. WHO was supported in the execution of these reviews by external experts with subject-matter expertise, and expertise in systematic reviews and the GRADE methodology.

A follow-up meeting of the NUGAG Subgroup on Diet and Health was held from 29 November to 2 December 2011. WHO presented the systematic reviews of evidence, and a draft recommendation that had been prepared before the meeting. This draft recommendation included:

- a summary of the evidence from the systematic reviews;
- draft GRADE evidence profiles assessing the quality of the body of evidence;
- potential research gaps, concerns and opportunities for feasible implementation of the recommendations in diverse cultural contexts;
- appropriate references.

The NUGAG Subgroup on Diet and Health discussed the evidence and the GRADE assessment of the quality of evidence, and advised WHO on the interpretation of

the results. The subgroup also discussed the draft recommendation and, through consensus, reached an agreement on that recommendation.

The systematic reviews and the GRADE evidence profiles for each of the critical outcomes were used for drafting the guideline. Classification of the strength of each recommendation included consideration of the desirable and undesirable effects of the recommendation, the overall quality of the evidence, values and preferences related to the recommendation in different settings, and the cost of options available to public health authorities in implementing the recommendation in different settings (Annex 8). The classification was discussed among the NUGAG members, invited external resource persons and the members of the WHO Secretariat present at the meeting. The final wording of the recommendations and their strength were based on the consensus of members of the WHO Secretariat present and the NUGAG members only. There were no strong disagreements among the NUGAG members.

From 1 to 29 February 2012, a draft of this guideline was made available for public comment. Participants in the External Expert and Stakeholder Panel were consulted, and other interested parties were invited to comment, as outlined above. More than 165 comments were received from 30 individuals and representatives of stakeholder groups. WHO reviewed the comments and made appropriate updates to the guideline. The guideline was then presented for finalization to the NUGAG Subgroup on Diet and Health at their meeting on 27–30 March 2012. The finalized guideline was submitted for clearance by WHO before publication.

Management of conflicts of interest

According to the rules in the WHO *Basic documents* (*47*), all experts participating in WHO meetings must declare any interest relevant to the meeting before participating. The declaration of interest forms for all guideline group members were reviewed by WHO when finalizing the composition of the NUGAG Subgroup on Diet and Health. All NUGAG members, external experts and other special invitees participating in each of the NUGAG meetings submitted a declaration of interests form, together with their curriculum vitae. In addition, each participant verbally declared interests at the beginning of each meeting. The procedures for management of interests strictly followed the WHO *Guidelines for declaration of interests for WHO experts* (*48*). The potential interests declared by members of the NUGAG Subgroup on Diet and Health and external expert and resource persons are summarized in Annex 9.

Summary of evidence

Evidence base

This guideline is based on a review of the epidemiologic literature, including three new systematic reviews conducted by WHO (*49-51*). One review included a reanalysis of data of a fourth systematic review (*36*), to explore data needed for the evidence base for this guideline (*49*). Specific health outcomes considered were:

- in adults – blood pressure, all-cause mortality, cardiovascular disease, stroke, coronary heart disease, renal function, blood lipids, catecholamine levels and other potential adverse effects;
- in children – blood pressure, blood lipids, catecholamine levels and other potential adverse effects.

The specific research questions guiding these systematic reviews were:

- What is the effect of decreased sodium intake compared with higher sodium intake on health outcomes in adults and children?
- Compared with higher sodium intake, what is the effect on health outcomes in adults and children of decreased sodium intake to:
  - less than 2 g/day;
  - 1.2–2 g /day;
  - less than 1.2 g/day?

Evidence was considered conclusive of either a benefit or a harm from decreased sodium intake if the point estimate suggested a benefit or harm and the 95%CI did not overlap a threshold of relevance. That is to say, if the real value were the high or the low 95%CI and that value was still of clinical relevance, the evidence was considered conclusive. If the point estimate were near the null value and the 95%CI did not overlap a threshold of relevance (e.g. if the real value were the high or the low 95%CI value and that value was not of clinical relevance) the evidence was considered conclusive of no effect. In such cases, the point estimates were considered precise.

Conversely, evidence was considered inconclusive if the point estimate suggested a benefit or a harm but the 95%CI crossed a threshold of relevance (e.g. if the real value were the high or the low 95%CI value and that value was not of clinical relevance). In such cases, the point estimates were considered imprecise.

Adults

Blood pressure in adults

The systematic review to explore the relationship of sodium and blood pressure and potential adverse effects identified 37 RCTs that reported systolic or diastolic blood pressure, renal function, blood lipid concentration or plasma or urinary catecholamine level (*49*). The studies were undertaken in Australia, Europe, North America and New Zealand, and covered a variety of countries, climates and cultural contexts. Twenty-four studies were undertaken in individuals with hypertension (defined as a blood pressure ≥140/90 mmHg (*52*)), five in individuals without hypertension, and eight in a mixed group of individuals with or without hypertension. No studies reported results for women separate from men, two studies were conducted in men, and 35 studies were conducted in a mixed group of men and women.

All studies measured 24-hour urinary sodium excretion to estimate sodium intake, which was assumed to be equivalent to excretion (*18*). The higher sodium intake ranged from 2.07 to 4.77 g/day (mean 3.79 ±0.61 g/day). The reduced sodium intake ranged from 1.13 to 3.34 g/day (mean of 2.04 ±0.54 g/day). The mean decrease in sodium from higher intake was 1.74 ±0.58 g/day or 44.7%. All studies were of a duration of 4 weeks or more. The meta-analysis of 36 studies with 49 comparisons found that decreased sodium intake resulted in a decrease in resting systolic blood pressure of 3.39 mmHg (95% confidence interval [CI]: 2.46, 4.31) (quality of evidence high[1]) and a decrease in resting diastolic blood pressure of 1.54 mmHg (95%CI: 0.98, 2.11) (quality of evidence high). The meta-analysis of six studies with six comparisons with results on ambulatory blood pressure reported that decreased sodium intake resulted in a decrease in ambulatory systolic blood pressure of 5.51 mmHg (95%CI: 3.16, 7.87) (quality of evidence high), and a decrease in ambulatory diastolic blood pressure of 2.94 mmHg (95%CI: 1.51, 4.36) (quality of evidence moderate). These results are consistent with five previous systematic reviews that reported a decrease in blood pressure with reduced sodium intake in adults (*30-34*).

WHO conducted a meta-analysis of data that directly addressed the question of whether a consumption of sodium of <2 g/day is more beneficial than a consumption of >2 g/day. Two studies with three comparisons randomly assigned participants to multiple intervention arms of varying levels of sodium intake, with one arm consuming reduced sodium at a level <2 g/day, one arm consuming reduced sodium but >2 g/day and one arm consuming higher sodium. The average intake was 1.4 g/day for the lowest consumption group, 2.29 g/day for the middle consumption group and 3.64 g/day for the higher group. A meta-analysis comparing the lowest (<2 g/day) to the middle (>2 g/day) consumption groups found that reducing sodium intake to <2 g/day compared to reducing intake but still consuming >2 g/day resulted in a decrease in resting systolic blood pressure of 3.47 mmHg (95%CI: 0.76, 6.18) (quality of evidence high), and a decrease in resting diastolic blood pressure of 1.81 mmHg (95%CI: 0.54, 3.08) (quality of evidence high). Only one study directly compared an intake <1.2 g/day to a reduced intake to a level >1.2 g/day. The findings suggested a benefit with a decrease of 8.00 mmHg (95%CI: –1.73, 17.73) (quality of evidence moderate) but were inconclusive.

All-cause mortality, cardiovascular disease, stroke, and coronary heart disease in adults

WHO conducted a systematic review of the literature for epidemiological evidence on the relationship between sodium intake and all-cause mortality, cardiovascular disease, stroke and coronary heart disease. There were two recent systematic reviews with all-cause mortality, cardiovascular disease, stroke or coronary heart disease as outcomes (*35, 36*): one included RCTs and the other cohort studies. The data from the review of RCTs were re-analysed to remove the study in an acutely ill population (*49*). The meta-analysis of data of two RCTs with two comparisons was inconclusive (risk ratio [RR] 0.84[1]; 95% CI: 0.57, 1.23) (quality of evidence moderate). The authors concluded that there was insufficient power to detect a statistically significant effect because of the limited number of events, even on synthesis of data.

[1] Based on the grades of evidence set by the GRADE Working Group: **high quality**, we are very confident that the true effect lies close to that of the estimate of the effect; **moderate quality**, we have moderate confidence in the effect estimate; the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different; **low quality**, our confidence in the effect estimate is limited; the true effect may be substantially different from the estimate of the effect; **very low quality**, we have very little confidence in the effect estimate; the true effect is likely to be substantially different from the estimate of the effect.

WHO then conducted another systematic review of cohort studies to update the previously identified systematic review (*35, 50*). This review included 15 prospective cohort studies with 167,656 participants that reported the relationship of sodium intake to subsequent all-cause mortality, cardiovascular disease, stroke or coronary heart disease in adults. Studies were conducted in Europe, Japan and the United States of America (USA). Sodium intake was measured through urinary sodium excretion or dietary records. Studies calculated RRs or hazard ratios for the risk of all-cause mortality, cardiovascular disease, stroke or coronary heart disease among groups, based on estimated sodium consumption level. For the meta-analyses, the reference group was always the group consuming the lowest amount of sodium per day, and the comparison group was generally the group consuming the highest amount of sodium per day. One study reported the RR for a one standard deviation increase in consumption level (1.9 g/day), and this value was used in the meta-analyses. Populations had wide ranges of sodium intake, with some consuming as little as 1.4 g/day in the lowest group and 2.6 g/day in the highest group, and others consuming as much as 4 g/day in the lowest group and 6.6 g/day in the highest group. The follow-up period ranged from to 3.8 to 22 years.

The meta-analysis of seven studies with 10 comparisons meeting the inclusion criteria that reported all-cause mortality was inconclusive (RR 1.06 [2]; 95% CI: 0.94, 1.20) (quality of evidence very low).

The meta-analysis of 10 cohort studies with 14 comparisons reporting stroke was supportive of a benefit of reduced sodium intake on subsequent risk of stroke (RR 1.24; 95% CI: 1.08, 1.43) (quality of evidence very low). Increased sodium intake was also associated with increased risk of fatal stroke events (RR 1.63; 95%CI: 1.27,2.10) (quality of evidence low). The meta-analyses of sodium intake and cardiovascular disease or coronary heart disease were inconclusive (cardiovascular disease RR 1.12; 95%CI: 0.93,1.34 and coronary heart disease RR 1.04; 95%CI: 0.86,1.24) (quality of evidence very low). The meta-analysis of sodium intake and coronary heart disease mortality detected an increased risk of fatal coronary heart disease events with higher sodium intake (RR 1.32; 95%CI: 1.13,1.53) (quality of evidence very low). The meta-analysis of nine cohort studies with 13 comparisons was inconclusive regarding the relationship of higher sodium consumption and cardiovascular disease (RR 1.12; 95% CI: 0.93, 1.34) (quality of evidence very low). The meta-analysis of six cohort studies with nine comparisons reporting on sodium intake and subsequent risk of coronary heart disease was inconclusive (RR 1.04; 95% CI: 0.86, 1.24) (quality of evidence very low).

There is a well-established relationship between increasing blood pressure and increasing risk of cardiovascular diseases, especially coronary heart disease and stroke (13, 53). Blood pressure is therefore considered a reliable biomarker for estimating risk of cardiovascular disease (*46, 54*). Recognizing the limitations of any biomarker, it was nonetheless determined that blood pressure could be a suitable proxy indicator for risk of cardiovascular disease, coronary heart disease and stroke. Thus, in addition to the direct evidence from cohort studies, the data from the RCTs compiled in the systematic review of the effect of reduced sodium on blood pressure in adults (*49*) were used as part of the evidence base to consider the effect of reduced sodium on cardiovascular disease, stroke and coronary heart disease.

[1] In the analyses of data from RCTs, an RR <1 signifies decreased risk with decreased sodium intake, whereas RR >1 signifies increased risk with decreased sodium intake.

[2] In the analyses of data from cohort studies, RR >1 signifies increased risk with increased sodium intake

Potential adverse effects in adults

Some researchers have reported that reduced sodium could potentially have adverse effects on blood lipid concentrations (i.e. increase total cholesterol, low-density lipoprotein [LDL] cholesterol and triglyceride, and decrease high-density lipoprotein [HDL] cholesterol), catecholamine levels or renal function. To address the potential for decreased sodium to have such adverse effects, WHO included studies reporting these outcomes in the systematic review of RCTs (*49*). Fifteen studies reported on total cholesterol, LDL, HDL or triglyceride concentration; all had a duration of 1–2 months. The meta-analysis of 11 trials with 15 comparisons reporting total cholesterol concentration reported a nonsignificant increase in total cholesterol of 0.02 mmol/L (95%CI: –0.03, 0.07) (quality of evidence high). Consistent with no effect of reduced sodium intake on total cholesterol levels, four additional studies did not provide numerical data, but reported that there was no statistically significant difference in total cholesterol levels between reduced sodium and usual or higher sodium groups. The meta-analysis of nine studies with 11 comparisons reporting HDL concentration was consistent with a slight, but not physiologically important, decrease in HDL with reduced sodium intake versus usual intake of 0.01 mmol/L (95% CI: 0.00, 0.03) (quality of evidence moderate). The meta-analysis of six studies with eight comparisons reporting LDL concentration reported a nonsignificant increase in LDL of 0.03 mmol/L (95% CI: –0.02, 0.08) (quality of evidence high). The meta-analysis of eight studies with 10 comparisons reporting total triglyceride concentration reported a nonsignificant decrease in triglyceride concentration of 0.04 mmol/L (95% CI: –0.01, 0.09) (quality of evidence high). The results showed little or no adverse effect of reduced sodium on blood lipid concentrations. The meta-analysis of seven studies with seven comparisons reporting catecholamine levels showed that reduced sodium intake resulted in a nonsignificant increase in plasma noradrenaline of 8.23 pg/mL (95% CI: –27.84, 44.29) (quality of evidence high). The meta-analysis of four studies with four comparisons reporting plasma adrenaline also reported a nonsignificant increase 6.90 pg/mL (95% CI: –2.17, 15.96) with decreased sodium (quality of evidence high). These results were consistent with the previous systematic review in the literature reporting the effects of reduced sodium on blood lipids and catecholamine levels when only studies of 4 weeks duration or longer were considered (*33*).

Five studies reporting on the effect of sodium intake on indicators of renal function (urinary protein excretion, urinary albumin excretion and urinary albumin:creatinine ratio) met the inclusion criteria for the systematic review. The meta-analysis of one study with three comparisons reporting urinary protein excretion reported a decrease of 76.6 µmol/L (95%CI: 0.97, 154.2) in urinary protein excretion (quality of evidence high). Consistent with a beneficial effect of reduced sodium on renal function, one other study, which could not be combined in the meta-analysis due to the form of the results, reported a reduction in urinary protein excretion with reduced sodium. Additionally, three studies reported urinary albumin excretion, but could not be combined in a meta-analysis due to the highly skewed distribution of this variable. The results were consistent with a beneficial effect of reduced sodium on renal function. One study with 169 participants having a reduced sodium intake and 169 a usual sodium intake reported a significant reduction in urinary albumin levels with reduced sodium intake. One study with 46 participants having a reduced sodium intake and 46 a usual sodium intake reported a non-significant decrease in urinary albumin with reduced sodium.

One study with 17 participants having a reduced sodium intake and 17 a usual sodium intake reported no change. Also consistent with a beneficial effect of reduced sodium on renal function, two studies reported a reduced urinary albumin:creatinine ratio with reduced sodium intake. The results suggest that reduced sodium does not have an adverse effect on renal function and may potentially have a beneficial effect.

Children

Blood pressure in children

WHO conducted a systematic review of the literature on sodium intake and blood pressure in children. Two previous reviews of the literature were identified (55, 56); these reviews were more than 5 years old and included a wide range of ages and types of studies. Therefore, WHO conducted an original systematic review and meta-analysis of controlled trials including only trials with children 2–15 years of age. WHO identified and included nine controlled trials that tested the effect of reduced sodium on blood pressure in children, and one cohort study that explored the relationship between sodium intake and change in blood pressure over time (51). The studies were conducted in Australia, Europe and the USA. The controlled trials included children 5–15 years of age. The children in the cohort study were 5–17 years at baseline and were followed for 7 years.

The meta-analysis of nine controlled trials with 14 comparisons testing systolic blood pressure found that decreased sodium resulted in a decrease in resting systolic blood pressure of 0.84 mmHg (95%CI: 0.25, 1.43) (quality of evidence moderate). The meta-analysis of eight controlled trials with 12 comparisons measuring resting diastolic blood pressure found that decreased sodium resulted in a decrease in resting diastolic blood pressure of 0.87 mmHg (95%CI: 0.14, 1.60) (quality of evidence moderate). The cohort study reported a slightly higher (not significant) difference in the rate of increase in blood pressure over time in the group consuming the highest amount of sodium compared to the lowest group.

Although there were a number of high-quality controlled trials testing the effect of reduced sodium intake on blood pressure in children, the data from the systematic review conducted in adults (*49*) were also used as part of the evidence base for the recommendation for children. Renal function is fully developed in early childhood; thus, it was considered acceptable to use information from adults to infer the effect of sodium intake on blood pressure in children. The evidence from studies conducted in adults was downgraded from high to moderate in quality because of indirectness (i.e. the use of a proxy population for the target population).

Potential adverse effects in children

WHO conducted a systematic review of the literature of potential adverse effects such as changes in blood lipids and catecholamine levels in children. The review identified no studies that measured the effect of reduced sodium on blood lipids or catecholamine levels in children. The data from the systematic review in adults (*49*) were used as the evidence base for the effect of reduced sodium on blood lipids, catecholamine levels and other potential adverse effects in children. The evidence was downgraded from high to moderate quality because of indirectness.

Final considerations of the evidence

In the systematic review of RCTs, WHO grouped the studies by blood pressure status at baseline, to explore the potential need for separate guidelines based on blood pressure status. The meta-analysis of the six studies with seven comparisons in individuals with normal blood pressure found that reduced sodium intake reduced systolic blood pressure by 1.38 mmHg (95%CI: 0.02, 2.74) (quality of evidence moderate). The meta analysis of 24 studies with 31 comparisons in individuals with hypertension found that reduced sodium intake reduced systolic blood pressure by 4.06 mmHg (95%CI: 2.96, 5.15) (quality of evidence high). The meta analysis of eight studies with 13 comparisons in mixed populations of individuals both with or without hypertension found that reduced sodium intake reduced systolic blood pressure by 3.41 mmHg (95%CI: 1.69, 5.13) (quality of evidence high). Although the reduction in blood pressure was statistically significantly less in individuals without hypertension, it was still evident. The effect of sodium reduction on blood pressure in individuals without high blood pressure is relatively small. Nevertheless, the high prevalence of hypertension in adult populations globally (*2*), and the clear benefit of reduced sodium in individuals with high blood pressure and in populations of individuals with and without high blood pressure, means that reducing sodium intake is likely to be broadly beneficial to populations around the world.

The body of evidence suggests that reducing sodium is beneficial for most individuals, regardless of current sodium consumption level. In the set of RCTs, the intake in the higher sodium group ranged from 2.07 to 4.77 g/day (mean 3.79 ±0.61 g/day), and the reduced sodium intake ranged from 1.13 to 3.34 g/day (mean 2.04 ±0.54 g/day). The overall effect estimate of reducing sodium on blood pressure was significant across this broad range of baseline intake. Furthermore, WHO grouped studies based on baseline sodium intake level, and found a significant decrease in systolic blood pressure in all subgroups. In the four studies with a baseline sodium intake of <3 g/day, the decrease was 1.79 mmHg (95%CI: 0.07, 3.52); in the studies with a baseline sodium intake of 3.0–3.5 g/day, the decrease was 2.97 mmHg (95%CI: 1.21, 4.73); in the studies with a baseline sodium intake of 3.5–4.0 g/day, the decrease was 3.07 mmHg (95%CI: 1.43, 4.71); in the studies with a baseline sodium intake of 4.0–4.5 g/day, the decrease was 3.91 mmHg (95%CI: 1.72,6.10); and in the studies with a baseline sodium intake of >4.5 g/day, the decrease was 5.74 mmHg (95%CI: 3.03, 8.45). The test of subgroup differences suggested no difference in the change in systolic blood pressure by subgroup (P=0.17).

This guideline is based on a review of the literature and on three new systematic reviews. The new meta-analyses found that reduced sodium intake decreased resting and ambulatory systolic and diastolic blood pressure in individuals with or without hypertension. These results are consistent with five previous systematic reviews that reported a decrease in blood pressure with reduced sodium in adults both with or without hypertension (*30-34*). Although a meta-analysis of two RCTs was inconclusive regarding the effect of decreased sodium on risk of cardiovascular disease, stroke and coronary heart disease, the systematic review and meta-analysis of cohort studies found a significant direct association between sodium intake and stroke. These results are consistent with the previous review and meta-analysis that the current review updated, which found a significant direct association between sodium and risk of both stroke and cardiovascular disease (*35*).

The results from the new systematic review and meta-analyses regarding cardiovascular disease and coronary heart disease did not find a significant positive relationship between sodium and those outcomes; nonetheless, there was no adverse effect of decreased sodium intake on risk of cardiovascular disease or coronary heart disease. There was no indication from the RCTs of a duration of 4 weeks or more that reduced sodium intake had any adverse effects on blood lipids and catecholamine levels. These results were consistent with a previous systematic review when only the studies in that review of 4 weeks or more were considered (*33*). There was also no indication of an adverse effect of reduced sodium on renal function, and the results were even suggestive of a beneficial effect. A systematic review and meta-analyses also showed that reduced sodium intake decreases systolic and diastolic blood pressure in children. These results were consistent with two previous systematic reviews of the literature in children (*55, 56*).

Finally, the modest reduction in resting systolic blood pressure (3.39 mmHg) and in diastolic blood pressure (1.54 mmHg) would have important public health benefits. Elevated blood pressure is the leading risk factor for mortality, accounting for almost 13% of deaths globally (*1*). In the USA, a decrease of 2 mmHg in diastolic blood pressure in the population could result in an estimated 17% decrease in the prevalence of hypertension, 6% decrease in risk of coronary heart disease and 15% decrease in risk of stroke. It could also prevent an estimated 67,000 coronary heart disease events and 34,000 stroke events every year (*57*). In the United Kingdom, researchers estimate that a 5 mmHg reduction in systolic blood pressure could reduce the prevalence of hypertension by 50% (*58*). Additionally, the relationship between blood pressure and risk of vascular mortality is positive, strong and linear down to a systolic blood pressure of 115 mmHg, below which there is no evidence (*53*). Thus, almost all reduction in blood pressure is beneficial for health, and modest population-wide reductions in blood pressure result in important reductions in mortality, substantial health benefits and meaningful savings in health-care costs (*1, 3, 13*).

Recommendations and remarks

Recommendations

- WHO recommends a reduction in sodium intake to reduce blood pressure and risk of cardiovascular disease, stroke and coronary heart disease in adults (*strong recommendation* [1]). WHO recommends a reduction to <2 g/day sodium (5 g/day salt) in adults (*strong recommendation*).
- WHO recommends a reduction in sodium intake to control[2] blood pressure in children (strong recommendation). The recommended maximum level of intake of 2 g/day sodium in adults should be adjusted downward based on the energy requirements of children relative to those of adults.

Remarks

- These recommendations apply to all individuals, with or without hypertension (including pregnant or lactating women), except for individuals with illnesses or taking drug therapy that may lead to hyponatraemia or acute build-up of body water, or require physician-supervised diets (e.g. patients with heart failure and those with type I diabetes). In these subpopulations, there may be a particular relationship between sodium intake and the health outcomes of interest (*10, 11*). Hence, these subpopulations were not considered in the review of the evidence and generation of the guideline.
- For this recommendation, "adults" includes individuals ≥16 years of age.
- For this recommendation, "children" includes individuals 2–15 years of age inclusive.
- The recommendation for children does not address the recommended period of exclusive breastfeeding (0–6 months) or the period of complementary feeding with continued breastfeeding (6–24 months).
- These recommendations were based on the totality of evidence regarding the relationship between sodium intake and blood pressure, all-cause mortality, cardiovascular disease, stroke and coronary heart disease, as well as potential adverse effects on blood lipids, catecholamine levels and renal function. The evidence regarding the relationship between sodium intake and blood pressure was of high quality, whereas the evidence regarding sodium intake and all-cause mortality, cardiovascular disease, stroke and coronary heart disease was of lower quality. Therefore, these recommendations should be reviewed when more evidence on the relationship between sodium intake and all-cause mortality and cardiovascular disease outcomes becomes available.

[1] A strong recommendation is one for which the guideline development group is confident that the desirable effects of adherence outweigh the undesirable effects. The recommendation can be either in favour of or against an intervention. Implications of a strong recommendation are as follows: for patients, most people in their situation would desire the recommended course of action, only a small proportion would not; for clinicians, most patients should receive the recommended course of action, and adherence to this recommendation is a reasonable measure of good-quality care; for policy-makers, the recommendation can be adopted as a policy in most situations.

[2] "Control" for this recommendation refers to the prevention of a deleterious rise in blood pressure with age

- These recommendations recognize that salt reduction and salt iodization are compatible. Monitoring of salt intake and salt iodization at country level is needed so that salt iodization can be adjusted over time, depending on observed salt intake in the population, so that individuals consuming the recommended amount of sodium will continue to consume sufficient iodine.
- These recommendations complement the WHO guideline on potassium consumption and should not be interpreted to replace or supersede that guideline. Public health interventions should aim to reduce sodium intake and simultaneously increase potassium intake through foods.
- These recommendations do not address the optimal sodium to potassium ratio; however, if this guideline and the WHO guideline on potassium intake are achieved, the molar ratio of sodium to potassium would be approximately one to one.
- The recommended intake level in children is lower than that of adults when children's energy requirements are less than adults. The adjustment of recommended sodium intake based on energy requirements is recommended because of the positive association between energy requirements and sodium intake. Each country should determine the energy requirements of various age categories of the paediatric population relative to adults approximately 20–50 years of age, to lower the recommended maximum intake value of 2 g/day. If country-specific data are not available, data from another country with similar population demographics and dietary habits can be used to make this adjustment.

Translation and implementation

This nutrient guideline on sodium can aid the logical, systematic, and scientific development of nutrition interventions taking into account the best available scientific evidence. This guideline should be used in conjunction with potassium and other nutrient guidelines to guide public health nutrition programmes and policies.

The recommendations in this guideline can be used by programme and policy planners to assess current sodium intake relative to a benchmark and develop measures to decrease sodium intake, where necessary, through public health interventions including, but not limited to, food and product labelling and consumer education. Additionally, this guideline can be translated at the country-level into culturally and contextually specific FBDGs that take into account locally available food and dietary customs.

Providing overall dietary guidance is outside the scope of this guideline because such dietary guidance should be based on overall dietary goals, which consider all required nutrients. It is recognized that it is feasible to achieve this recommendation while respecting national dietary customs because a wide variety of fresh foods are naturally low in sodium (Annex 2). Additionally incremental sodium reduction in processed foods is feasible without consumer complaint.

Research gaps and future initiatives

Implications for future research

- Further high-quality RCTs testing the effect of reducing sodium to <1.2 g/day on blood pressure and adverse effects (e.g. changes in blood lipids and catecholamine levels in adults) are warranted to increase the evidence base.
- Further high-quality RCTs testing the effect of sodium reduction on blood pressure and adverse effects (e.g. changes in blood lipids and catecholamine levels in children) are warranted to increase the evidence base.
- Further high-quality RCTs with multiple intervention arms directly testing the effect of multiple levels of sodium on health outcomes are warranted to strengthen the evidence base for the target sodium intake level.
- Further high-quality RCTs with all-cause mortality, cardiovascular disease, stroke and coronary heart disease as outcomes are warranted to strengthen the evidence base on the effect of sodium intake on these patient-relevant outcomes.

Dissemination

The current guideline will be disseminated through:

- electronic media such as slide presentations;
- mailing lists of the WHO Department of Nutrition for Health and Development and the UN Standing Committee on Nutrition;
- the web site of the WHO Department of Nutrition for Health and Development.

A summary of this guideline will also be available in all six UN languages through the WHO Department of Nutrition for Health and Development's electronic Library of Evidence for Nutrition Actions. The library displays WHO guidelines related to nutrition, and complementary documents such as systematic reviews and other evidence informing the guidelines, biological and behavioural rationales for the effectiveness of a guideline, and other relevant resources produced by Member States and global partners.

Updating the guideline

The recommendations in this guideline will be reviewed by the end of 2017. If new information is available by that date, a guideline review group will be convened to evaluate the new evidence and revise the recommendation. However, if a large amount of new evidence becomes available before that date, a guideline review group may be convened earlier. The Department of Nutrition for Health and Development at the WHO Headquarters in Geneva, together with partners in other departments within the WHO Secretariat, will be responsible for coordinating the updating of the guideline, following the formal *WHO Handbook for guideline development* (*8*) procedures. When the guideline is due for review, WHO will welcome suggestions for additional questions that could be addressed in the guideline.

Annex 1 GRADE summary of findings tables

What is the effect of decreased sodium intake relative to higher intake in adults (≥16 years of age)?

Outcomes	Effect (95 % CI)	Number of participants (studies)	Quality of the evidence (GRADE)	Comments
Cardiovascular disease [1] (directly assessed; RR greater than 1 indicates increased risk with increased sodium intake)	**RR: 1,12** (0.93 to 1.34)	46 483 (9 studies)	⊕⊖⊖⊖ **very low**	Data from cohort studies begin with a GRADE of low. Downgraded due to imprecision because 95%CI crossed threshold of relevance of benefit or harm.
Cardiovascular disease [1] (directly assessed; RR less than 1 indicates decreased risk with decreased sodium intake)	**RR: 0.84** (0.57, 1.23)	720 (2 studies)	⊕⊕⊕⊖ **moderate**	Data from randomized-controlled trials. Only two studies. Downgraded due to imprecision because 95%CI crossed threshold of relevance of benefit or harm.
Stroke (directly assessed: RR greater than 1 indicates increase risk with increased sodium intake)	**RR: 1.24** (1.08 to 1.43)	72 878 (10 studies)	⊕⊖⊖⊖ **very low**	Data from cohort studies begin with a GRADE of low. Downgraded due to inconsistency.
Coronary heart disease (directly assessed: RR greater than 1 indicates increased risk with increased sodium intake)	**RR: 1,04** (0.86 to 1.24)	37 343 (6 studies)	⊕⊖⊖⊖ **very low**	Data from cohort studies begin with a GRADE of low. Downgraded due to imprecision because 95%CI crossed threshold of relevance of benefit or harm.
All cause mortality (directly assessed: RR greater than 1 indicates increased risk with increased sodium intake)	**RR: 1,06** (0.94 to 1.20)	21 515 (7 studies)	⊕⊖⊖⊖ **very low**	Data from cohort studies begin with a GRADE of low. Downgraded due to inconsistency.
Resting systolic blood pressure [2] (follow-up 1-36 months; units mmHg; better indicated by lower values)	**MD 3.39 lower** [3] (4.31 to 2.46 lower)	6 736 (36 studies)	⊕⊕⊕⊕ **high**	Evidence suggests a dose response with greater benefit to blood pressure as sodium intake decreases

CI, Confidence interval; RR, Risk ratio; MD, Mean difference.

GRADE Working Group grades of evidence:

High quality: We are very confident that the true effect lies close to that of the estimate of the effect.

Moderate quality: We have moderate confidence in the effect estimate. The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Low quality: Our confidence in the effect estimate is limited. The true effect may be substantially different from the estimate of the effect.

Very low quality: We have very little confidence in the effect estimate. The true effect is likely to be substantially different from the estimate of the effect.

[1] Composite cardiovascular disease as reported by original study authors. This variable included some or all of the following: fatal and non-fatal stroke, coronary heart disease, myocardial infarction, and/or congestive cardiac failure, or episode of coronary revascularization, bypass grafting, and/or angioplasty.

[2] Additional evidence from a meta-analysis of 36 randomized-controlled trials (RCTs) with 49 comparisons reporting resting diastolic blood pressure is supportive of a benefit of decreased sodium on blood pressure (MD 1.54 mmHg lower (2.11 to 0.98 lower)) (quality of evidence high), and a meta-analysis of six RCTs with six comparisons reporting ambulatory systolic and diastolic blood pressure is supportive of a benefit of decreased sodium on blood pressure (systolic MD 5.51 mmHg lower (7.87 to 3.16 lower); diastolic MD 2.94 mmHg lower (4.36 to 1.51 lower) (quality of evidence high).

[3] A MD described as 'lower' signifies a reduction in the outcome in the decreased sodium versus the higher sodium group.

For details on studies included in the reviews, see references (*49, 50*).

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What is the effect of decreased sodium intake relative to higher intake in adults (≥16 years of age)?

Outcomes	Effect (95 % CI)	Number of participants (studies)	Quality of the evidence (GRADE)	Comments
Total cholesterol [4] 95%CI(follow-up 1 - 2 months; units mmol/L; Better indicated by lower values)	**MD 0.02 higher** (0.03 lower to 0.07 higher)	2 339 (11 studies)	⊕⊕⊕⊕ **high**	Not downgraded due to imprecision because did not cross threshold of relevance of benefit or harm.
Plasma noradrenaline [5] (follow-up 1 - 2.5 months; units pg/mL; better indicated by lower values)	**MD 8.23 higher** (27.84 lower to 44.29 higher)	265 (7 studies)	⊕⊕⊕⊕ **high**	Not downgraded due to imprecision because did not cross threshold of relevance of benefit or harm.e
Urinary protein excretion [6] (follow-up mean 1.5 months; units ng/mL filtrate; better indicated by lower values)	**MD 76.6 lower** (154.2 lower to 0.97 higher)	189 (1 study)	⊕⊕⊕⊕ **high**	Only one study with three comparisons included in the meta-analysis to produce effect estimate
Minor side effects [7] (better indicated by lower values)		249 (3 studies)	⊕⊖⊖⊖ **very low**	No quantitative data available

CI, Confidence interval; RR, Risk ratio; MD, Mean difference.
GRADE Working Group grades of evidence:
High quality: We are very confident that the true effect lies close to that of the estimate of the effect.
Moderate quality: We have moderate confidence in the effect estimate. The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low quality: Our confidence in the effect estimate is limited. The true effect may be substantially different from the estimate of the effect.
Very low quality: We have very little confidence in the effect estimate. The true effect is likely to be substantially different from the estimate of the effect.

[4] Consistent with no effect of reduced sodium intake on total cholesterol levels, four additional RCTs qualitatively reported no statistically significant difference between reduced sodium and control groups in total cholesterol levels. A meta-analysis of 9 RCTs with 11 comparisons reporting high-density lipoprotein (HDL) concentration was consistent with a slight decrease in HDL which did not indicate a decrease of biological importance (MD 0.01 mmol/L lower (0.03 lower to 0.00)) (quality of evidence moderate). A meta-analysis of six RCTs with eight comparisons reporting low-density lipoprotein (LDL) concentration was consistent with no effect of low sodium intake on LDL (MD 0.03 mmol/L higher (0.02 lower to 0.08 higher))(quality of evidence high). A meta-analysis of eight RCTs with 10 comparisons reporting total triglyceride concentration was consistent with no effect of low sodium on triglyceride concentration (MD 0.04 mmol/L lower (0.01 lower to 0.09 higher))(quality of evidence high).

[5] A meta-analysis of four RCTS with four comparisons reporting plasma adrenaline is supportive of no effect of reduced sodium on catecholamine levels (MD 6.90 pg/mL higher (2.17 lower to 15.96 higher)) (quality of evidence high).

[6] Consistent with a beneficial effect of reduced sodium on renal function, one study, which could not be combined in the meta-analysis due to the form of results, reported a reduction in urinary protein excretion with reduced sodium. Consistent with a beneficial effect of reduced sodium, one study with 169 low sodium and 169 control participants reported a significant reduction in urinary albumin levels with low sodium intake, one study with 46 low sodium and 46 control participants reported a non-significant decrease in urinary albumin with reduced sodium, and one study with 17 low sodium and 17 control participants reported no change. Consistent with a beneficial effect of reduced sodium, two studies reported reduced urinary albumin:creatinine ratio with low sodium intake.

[7] Minor adverse effects such as headache, edema, dizziness and muscle aches were reported in three studies and there was no difference in reported minor adverse effects between low sodium and control groups.

For details on studies included in the reviews, see references (*49*, *50*).

What is the effect of a decrease in sodium intake to <2 g/day relative to an intake of ≥2 g/day in adults?

Outcomes	Effect (95 % CI)	Number of participants (studies)	Quality of the evidence (GRADE)	Comments
Cardiovascular disease [1] (directly assessed)				There were no studies with cardiovascular disease as an outcome which addressed this question.
Stroke (directly assessed)				There were no studies with cardiovascular disease as an outcome which addressed this question.
Coronary heart disease (directly assessed)				There were no studies with cardiovascular disease as an outcome which addressed this question.
All cause mortality (directly assessed)				There were no studies with cardiovascular disease as an outcome which addressed this question.
Resting systolic blood pressure [2] 1-36 months; units mmHg; better indicated by lower values)	**MD 3.47 lower** [3] (6.18 to 0.76 lower)	820 (2 studies)	⊕⊕⊕⊕ **high**	
Total cholesterol [4] (follow-up 1 - 2 months; units mmol/L; Better indicated by lower values)	**MD 0.05 higher** (0.00 lower to 0.11 higher)	1 560 (1 study)	⊕⊕⊕⊕ **high**	Only one study with three comparisons included in the meta-analysis to produce effect estimate
Plasma noradrenaline (follow-up 1 - 2.5 months; units pg/mL; Better indicated by lower values)	**MD 107 lower** (437 lower to 223 higher)	24 (1 study)	⊕⊕⊕⊕ **high**	Only one study with three comparisons included in the meta-analysis to produce effect estimate
Urinary protein excretion				There were no studies with cardiovascular disease as an outcome which addressed this question.
Minor side effects				There were no studies with cardiovascular disease as an outcome which addressed this question.

CI, Confidence interval; RR, Risk ratio; MD, Mean difference.
GRADE Working Group grades of evidence:
High quality: We are very confident that the true effect lies close to that of the estimate of the effect.
Moderate quality: We have moderate confidence in the effect estimate. The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low quality: Our confidence in the effect estimate is limited. The true effect may be substantially different from the estimate of the effect.
Very low quality: We have very little confidence in the effect estimate. The true effect is likely to be substantially different from the estimate of the effect.

[1] Composite cardiovascular disease as reported by original study authors. This variable included some or all of the following: fatal and non-fatal stroke, coronary heart disease, myocardial infarction, and/or congestive cardiac failure, or episode of coronary revascularization, bypass grafting, and/or angioplasty.

[2] Additional evidence from a meta-analysis of 36 randomized-controlled trials (RCTs) subgrouped by those studies in which the intervention group achieved an absolute intake of <2 g/day compared to those studies in which the intervention group achieved an absolute intake of ≥2 g/day was compatible with a greater reduction in blood pressure when intake was <2g/day (<2 g/day, MD = 3.39 lower (4.69 to 2.09 lower) vs ≥2/day intake, MD = 2.68 lower (3.66 to 1.70 lower)).

[3] A MD described as 'lower' signifies a reduction in the outcome in the decreased sodium versus the higher sodium group.

[4] Additional evidence from a meta-analysis of 12 RCTs with 17 total comparisons subgrouped by those studies in which the intervention group achieved an absolute intake of <2 g/day compared to those studies in which the intervention group achieved an absolute intake of ≥2 g/day was compatible with no differential effect of varying sodium intake levels on total cholesterol (I <2 g/day, mean difference = 0.02 lower (0.03 lower to 0.08 higher) vs ≥2g/day intake, MD = 0.02 lower (0.08 lower to 0.03 higher)). A meta-analysis of results from one RCT with two comparisons is consistent with no differential effect of varying sodium intake levels on high-density lipoprotein (HDL) concentration (MD = 0.00 lower (0.02 lower to 0.01 higher) or low-density lipoprotein (LDL) concentration (MD = 0.04 higher (0.03 lower to 0.12 higher).

For details on studies included in the reviews, see references (*49, 50*).

What is the effect of decreased sodium intake relative to higher intake in children (2–15 years of age)?

Outcomes	Effect (95 % CI)	Number of participants (studies)	Quality of the evidence (GRADE)	Comments
Resting systolic blood pressure [1] (assessed in children, follow-up 1-36 months; units mmHg; better indicated by lower values)	**MD 0.87 lower** [2] (1.47 to 0.26 lower)	1 245 (8 studies)	⨁⨁⨁⨀ **moderate**	2 studies with 4 comparisons were not randomized. Downgraded due to high risk of bias.
Resting systolic blood pressure [1] (assessed in adults, follow-up 1-36 months; units mmHg; better indicated by lower values)	**MD 3.39 lower** [2] (4.31 to 2.46 lower)	6 736 (36 studies)	⨁⨁⨁⨀ **moderate**	Downgraded due to indirectness
Total cholesterol (assessed in children)				No studies assessed this outcome in children
Total cholesterol [3] (assessed in adults; follow-up 1 - 2 months; units mmol/L; Better indicated by lower values)	**MD 0.02 higher** (0.03 lower to 0.07 higher)	2 339 (11 studies)	⨁⨁⨁⨀ **moderate**	Downgraded due to indirectness
Plasma noradrenaline (assessed in children)				No studies assessed this outcome in children
Plasma noradrenaline [3] (assessed in adults; follow-up 1 - 2.5 months; units pg/mL; better indicated by lower values)	**MD 8.23 higher** (27.84 lower to 44.29 higher)	265 (7 studies)	⨁⨁⨁⨀ **moderate**	Downgraded due to indirectness
Minor side effects (assessed in children)				No studies assessed this outcome in children
Minor side effects [3] (assessed in adults)		249 (3 studies)		No quantitative results available

CI, Confidence interval; RR, Risk ratio; MD, Mean difference.
GRADE Working Group grades of evidence:
High quality: We are very confident that the true effect lies close to that of the estimate of the effect.
Moderate quality: We have moderate confidence in the effect estimate. The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low quality: Our confidence in the effect estimate is limited. The true effect may be substantially different from the estimate of the effect.
Very low quality: We have very little confidence in the effect estimate. The true effect is likely to be substantially different from the estimate of the effect.

[1] Additional evidence from a meta-analysis of 7 randomized controlled trials (RCTs) and non-randomized controlled trials with 11 comparisons measuring resting diastolic blood pressure was consistent with a benefit of reduced sodium on blood pressure (MD = 1.67 mmHg lower (3.22 to 0.13 lower))(quality of evidence low). One additional cohort study which could not be combined in meta-analysis was consistent with reduced diastolic blood pressure with reduced sodium intake in girls over time.
[2] A MD described as 'lower' signifies a reduction in the outcome in the decreased sodium versus the higher sodium group.
[3] Results from data collected in adults used as proxy for children.

For details on studies included in the reviews, see reference (*51*).

Annex 2 Examples of sodium content in various foods and food groups

Approximate amount of sodium content in various food groups

Food group	Sodium content mg/100 g
Table salt, baking soda, baking powder	38,000
Bouillon cubes, powdered broths, soups, gravies	20,000
Soy sauce	7,000
Snack foods (e.g. pretzels, cheese puffs, popcorn)	1,500
Bacon	1,500
Sauces and spreads	1,200
Cheese, hard	800
Processed vegetables	600
Butter/margarine	500
Cheese, soft	400
Processed fish	400
Cereals and cereal products (e.g. bread, breakfast cereals, biscuits, cakes, pastries)	250
Fish, raw or frozen	100
Eggs	80
Milk and cream	50
Vegetables, fresh or frozen	10
Fruits, fresh or frozen	5

1000 mg = 43.5 mmol

Note: The information in this table is based on approximate calculations of an average mg of sodium per 100 g food from diverse, iconic foods taken from food composition databases from around the globe. The sodium content varies substantially within the food groups and the table provides a relative comparison of average levels of sodium only. The information provided can be used only for approximate comparisons of food groups, and should not be used to estimate daily intake.
Sources: (*23, 59-62*)

Comparison of the sodium content of an example of foods in unprocessed (i.e. "natural") and processed states

Food item	Description	Sodium content (mg/100 g)
Beef	Topside, roast, lean and fat	48
	Corned beef, canned	950
Bran	Bran, wheat	28
	Bran flakes	1,000
Cheese	Hard cheese, average	620
	Processed	1,320
Chick-peas	Dried, boiled in unsalted water	5
	Canned, re-heated, drained	220
Crab	Boiled	370
	Canned	550
Cod	Cod, in batter, fried in blended oil	100
	Fish fingers, fried in blended oil	350
New potatoes	Raw, boiled in unsalted water	9
	Canned, re-heated, drained	250
Peanuts	Plain	2
	Dry roasted	790
	Roasted and salted	400
Peas	Raw, boiled in unsalted water	Trace
	Canned, re-heated, drained	250
Potato chips	Homemade, fried in blended oil	12
	(French fries) Oven chips, frozen, baked	53
Salmon	Raw, steamed	110
	Canned	570
	Smoked	1,880
Sweet corn	On-the-cob, whole, boiled in unsalted water	1
	Kernels, canned, re-heated, drained	270
Tuna	Raw	47
	Canned in oil, drained	290
	Canned in brine, drained	320

1000 mg = 43.5 mmol
Source: (6)

Annex 3 WHO Secretariat

WHO Headquarters

Dr Francesco Branca
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Department of Nutrition for Health and Development

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Coordinator
Nutrition Policy and Scientific Advice Unit
Department of Nutrition for Health and Development

Dr Nancy Aburto
Scientist
Nutrition Policy and Scientific Advice Unit
Department of Nutrition for Health and Development

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Family and Community Health

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Dr Joao Breda
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Regional Adviser
Nutrition
WHO Regional Office for the Western Pacific
Manila, the Philippines

Annex 4 Members of the WHO Steering Committee for Nutrition Guideline Development 2010 - 2011

WHO Headquarters

Dr Francesco Branca
Director, Nutrition for Health and Development Department

Dr Tikki Pang (Pangestu)
Director, Research Policy and Cooperation

Dr Elizabeth Mason
Director, Child and Adolescent Health and Development
Alternate:
Dr Nigel Rollins
Scientist, Newborn and Child Health and Development

Dr Ala Alwan
Acting Director, Chronic Diseases and Health Promotion
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Technical Officer
Chronic Disease and Health Promotion

Dr Ruediger Krech
Director, Ethics, Equity, Trade and Human Rights
Alternate:
Ms Nicole Valentine
Technical Officer, Ethics, Equity, Trade and Human Rights

Dr Maged Younes
Director, Food Safety, Zoonoses and Foodborne Diseases

Dr Robert D. Newman
Director, Global Malaria Programme
Alternate:
Dr Sergio Spinaci
Associate Director, Global Malaria Programme

Dr Aafje Rietveld
Medical Officer, Global Malaria Programme

Dr Willem Van Lerberghe
Director, Health Policy, Development and Services

Dr Gottfried Otto Hirnschall
Director, HIV/AIDS
Alternate:
Mr Craig Michael McClure
Senior Technical Officer, HTM/HIV

Dr Jean-Marie Okwo-Bele
Director, Immunization, Vaccines and Biologicals

Dr Michael Mbizvo
Director, Reproductive Health and Research

Dr Mario Raviglione
Director, Stop Tuberculosis
Alternate:
Dr Knut Lonnroth
Medical Officer, Stop Tuberculosis

Dr Daniel Eduardo Lopez Acuna
Director, Strategy, Policy and Resource Management

Dr Nevio Zagaria
Acting Director, Emergency Response & Recovery Operations

International Agency for Research on Cancer

Dr Isabelle Romieu
Director, Nutrition Department

Annex 5 Members of the NUGAG Subgroup on Diet and Health and external resource persons 2010 - 2011

Members of the NUGAG Subgroup on Diet and Health

(Note: the areas of expertise of each guideline group member are given in italics)

Professor Pascal Bovet
University Institute of Social and Preventive Medicine,
Lausanne University Hospital
Switzerland
and Ministry of Health
Seychelles
Programme manager, noncommunicable diseases

Professor Michael Clarke
School of Nursing and Midwifery
Trinity College, Ireland
and United Kingdom Cochrane Centre
United Kingdom
Methods, systematic review

Professor John H Cummings
Centre for Oncology and Molecular Medicine
Division of Medical Sciences
University of Dundee
United Kingdom
Carbohydrates, dietary fibre

Professor Ibrahim Elmadfa
Institution of Nutritional Sciences
University of Vienna
Austria
Human nutrition, nutrient requirements, fats and fatty acids, dietary diversity

Professor Nahla Hwalla
Faculty of Agricultural and Food Sciences
American University of Beirut
Lebanon
Dietetics, nutrition, food-based dietary guidelines, diet and health

Associate Professor Rachel Huxley
Division of Epidemiology & Community Health
University of Minnesota
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Epidemiology, physiology, biostatistics, meta-analysis, obesity

Professor Shiriki Kumanyika
Center for Clinical Epidemiology & Biostatistics
University of Pennsylvania School of Medicine
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Human nutrition, epidemiology, obesity, salt/sodium

Professor Mary L'Abbe
Department of Nutritional Sciences
Faculty of Medicine
University of Toronto
Canada
Nutrition science, trans-fatty acids, risk assessment and risk management, diet and health

Professor Duo Li
Department of Food Science and Nutrition
Zhejiang University
China
Nutritional epidemiology, fats and fatty acids

Professor Jim Mann
Department of Medical and Surgical Sciences
University of Otago
New Zealand
Carbohydrates, sugars, diabetes, fats and fatty acids

Professor Carlos Monteiro
Department of Nutrition, School of Public Health
University of Sao Paulo
Brazil
Human nutrition, epidemiology, double-burden of malnutrition

Professor Dariush Mozaffarian
Harvard School of Public Health
Harvard University
USA
Cardiology, epidemiology, diet and health

Professor Srinath Reddy
Public Health Foundation of India
India
Cardiovascular diseases, obesity, noncommunicable diseases

Professor Murray Skeaff
University of Otago
New Zealand
Fats and fatty acids, biomarkers, diet and health, human nutrition

Professor H.H. (Esté) Vorster
Faculty of Health Sciences
North-West University
South Africa
Nutrition physiology, public health nutrition, food-based dietary guidelines

External resource persons

Professor Francesco Cappuccio
University of Warwick
Warwick Medical School
United Kingdom

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School of Public Health
Imperial College London
United Kingdom

Dr Caroline Lee Hooper
School of Medicine, Health Policy and Practice
University of East Anglia
United Kingdom

Dr Sarah Kelly
Institute for Ageing and Health
School of Dental Sciences
University of Newcastle
United Kingdom

Dr Cho-il Kim
Department of Food and Nutrition Industry
Korea Health Industry Development Institute
The Republic of Korea

Dr Joerg Meerpohl
German Cochrane Centre
Institute of Medical Biometry and Medical Informatics
University Medical Center Freiburg
Germany

Professor Paula Moynihan
Institute for Ageing and Health
School of Dental Sciences
University of Newcastle
United Kingdom

Annex 6 External Expert and Stakeholder Panel

Members commenting on priority questions (February 2011)

Comments received from	Affiliation
Eduard Baladia (on behalf of Maria Manera, Julio Basulto and Eduard Baladia)	Spanish Association of Dietitians & Nutritonists, Spain
Gerda Feunekes	Unilever, the Netherlands
Suzanne Harris	International Life Sciences Institute, USA (with offices around the world)
Mark Huffman	Northwestern University Feinberg School of Medicine, USA
Siobhan Jennings	Health Service Executive, Ireland
Erika Ketterer	Heart and Stroke Foundation, South Africa
Anatoliy Khudaiberganov	Ministry of Health, Uzbekistan
Branka Legetic (on behalf of the Pan American Health Organization Expert Group on Salt Reduction)	Pan American Health Organization Expert Group on Salt Reduction, Americas
Graham MacGregor	Consensus Action on Salt and Health, United Kingdom
Bruce Neal	The George Institute for Global Health, Australia
Aileen Robertson	Metropolitan University College Copenhagen, Denmark
Barbara Schneeman	U.S. Food and Drug Administration; U.S. Delegate to the Codex Committee on Nutrition and Foods for Special Dietary Uses and the Codex Committee on Food Labelling, USA
Hans Verhagen	National Institute for Public Health and the Environment (RIVM), the Netherlands
Jacqueline Webster	The George Institute for Global Health, Australia

Members commenting on the draft guidelines (February 2012)

Comments received from	Affiliation
Nebal Aboul Ella	National Nutrition Institute, Egypt
Michael Alderman	The Albert Einstein College of Medicine, USA
Leila Alouane	National Institute of Nutrition and Food Technology, Tunisia
Salmeh Bahmanpour	Shiraz University of Medical Sciences, Iran (Islamic Republic of)
Amber Bastian	Health Promotion Board, Singapore
Wulf Becker	National Food Agency, Sweden
Lucie Bohac	Network for Sustained Elimination of Iodine Deficiency, Canada
Norm Campbell	University of Calgary, Canada
Jalila el Ati	National Institute of Nutrition and Food Technology, Tunisia
Sheila Fleischhacker	Institute of Food Technologists, USA
Gihan Fouad	National Nutrition Institute, Egypt
Isabel Gaertner	German Federation for Food Law and Food Science, Germany
Mark Huffman	Northwestern University Department of Preventive Medicine, USA
Antti Jula	National Institute for Health and Welfare, Finland
Chor San Khoo	ILSI North America, USA
Marzia Lazzerini	WHO Collaborating Center for Maternal and Child Health, IRCCS Burlo Trieste, Italy
Sandrine Lauret	EuSalt (European Salt Producers' Association), Belgium
Graham MacGregor	Wolfson Institute, Queen Mary University of London, United Kingdom

Comments received from	Affiliation
Kathryn McMurry	National Heart, Lung, and Blood Institute, United States of America
Viola Michael	Non Communicable Disease Section, Disease Control Division, Ministry Of Health, Malaysia
Gulsen Saleh	National Nutrition Institute, Egypt
Rusidah Selamat BT	Nutrition Division, Ministry of Health, Malaysia
Letty Shiu	Health Promotion Board, Singapore
Pasquale Strazzullo	Department of Clinical and Experimental Medicine, University of Naples Medical School, Italy
Eman Sultan	National Nutrition Institute, Egypt
Alison Tedstone	Department of Health, England, United Kingdom
Ljiljana Trajkovic Pavlovic	Institute of Public Health of Vojvodina / School of Medicine University of Novi Sad, Republic of Serbia
Jacqueline Webster	The George Institute for Global Health, Australia
Clare Whitton	Health Promotion Board, Singapore
Sahar Zaghloul	National Nutrition Institute, Egypt

Annex 7 Priority questions in the format of population, intervention, control and outcomes (PICO)

Adults

What is the effect of reduced sodium intake compared with higher intake on health outcomes? What is the target level of intake for maximum health benefit?

Participants	Adults (≥16 years of age) with or without hypertension, or a population of adults (some with and some without hypertension), with or without type 2 diabetes, previous cardiovascular disease, previous cancer, etc.
Intervention (or exposure)	Intervention: decreased sodium intake via advice, specific foods, supplements or whole diet provided, and unconfounded by other dietary, weight, lifestyle or pharmaceutical interventions.
Control	Diet with sodium level higher than in the intervention (may be usual intake or specific sodium intake) via advice or specific foods or supplements or whole diet provided.
Specific comparisons	• Reduced sodium intake (any level) versus higher sodium intake (usual sodium intake). • Reduced sodium intake by ≥1/3 of usual or higher intake level versus reduced sodium intake by <1/3 of usual or higher. • Consuming <2 g sodium/day versus consuming ≥2 g sodium/day. • Consuming <1.2 g sodium/day versus consuming ≥1.2 g sodium/day versus consuming 1.2–2.0 g sodium/day.
Outcomes	All-cause mortality, cardiovascular disease, stroke, coronary heart disease, blood pressure, renal function, adverse effects (blood lipids, catecholamine levels and any other adverse events reported by study authors).
Settings	All countries

Children

What is the effect of reduced sodium intake compared with higher intake on health outcomes? What is the target level of intake for maximum health benefit?

Participants	Children or adolescents (2–15 years inclusive), not acutely ill, with or without type 2 diabetes, previous cardiovascular disease, previous cancer, etc.
Intervention (or exposure)	Intervention: decreased sodium intake via advice, specific foods, supplements or whole diet provided, and unconfounded by other dietary, weight, lifestyle or pharmaceutical interventions. Exposure: single baseline or repeated sodium intake measurement
Control	Diet with sodium level higher than in the intervention (may be usual intake or specific sodium intake) via advice or specific foods or supplements or whole diet provided.
Specific comparisons	• Reduced sodium intake (any level) versus higher sodium intake (usual sodium intake) • Reduced sodium intake by ≥1/3 usual or higher intake level versus reduced sodium intake by <1/3 of usual or higher. • Consuming <2 g sodium/day versus consuming ≥2 g sodium/day.
Outcomes	Blood pressure (systolic and/or diastolic), adverse effects (blood lipids, catecholamine levels and any other adverse events reported by study authors)
Settings	All countries

Annex 8 Summary of considerations for determining the strength of the recommendations

Quality of evidence:

- High-quality evidence that decreasing sodium is beneficial for blood pressure in adults.
- High-quality evidence that decreasing sodium has no harmful effect on blood lipids, catecholamine levels, renal function or any minor side effects (e.g. headache and dizziness) in adults.
- Moderate-quality evidence that reduced sodium is consistent with a benefit to renal function in adults.
- Because of the well-established relationship between blood pressure and cardiovascular disease outcomes, the evidence of an effect of sodium on blood pressure was also considered moderate-quality evidence that reduced sodium is beneficial for reducing risk of cardiovascular disease, stroke and coronary heart disease.
- Moderate-quality evidence that reduced sodium is beneficial for controlling blood pressure in children.
- Moderate-quality evidence that reduced sodium has no harmful effect on blood lipids, catecholamine levels or any minor side effects (e.g. headache and dizziness) in children.
- High and moderate-quality evidence that consuming <2 g sodium/day compared with consuming ≥2 g sodium/day is beneficial for reducing blood pressure and risk of cardiovascular disease, stroke and coronary heart disease in adults.
- High-quality evidence that consuming <2 g sodium/day compared with consuming ≥2 g sodium/day has no effect on blood lipids or catecholamine levels; however, recognizing that these data come from a limited number of studies, directly testing the effect of <2 g sodium/day compared with consuming ≥2 g sodium/day on these outcomes.

Values and preferences:

- This recommendation places a high value on reduction of blood pressure, cardiovascular disease, stroke, coronary heart disease and related NCDs.
- NCDs affect countries in all regions and all income levels, thus rendering interventions to reduce the burden of NCDs valuable in all contexts.
- Recognizing that some persons have taste preference for higher sodium foods.
- Recognizing that reformulation of processed foods would be necessary to provide consumers with choices of lower-sodium products that continue to be palatable to the consumer and marketable for producers.

Trade-off between benefits and harm:

- High-quality evidence in adults and moderate-quality evidence in children of benefit of decreasing sodium intake on blood pressure.
- Blood pressure is a good proxy indicator for risk of cardiovascular disease, stroke and coronary heart disease outcomes. Though inconclusive, there was evidence from the meta-analyses of cohort studies measuring cardiovascular disease or coronary heart disease that reduced sodium has potential benefits. The cohort data supported a reduction in risk of stroke with decreased sodium intake.
- High-quality evidence in adults and moderate-quality evidence in children indicates no negative effect on blood lipids or catecholamine levels with decreased sodium intake for 4 weeks or more.

Costs and feasibility:

- Cost–benefit analyses have consistently identified reduced sodium intake as one of the most cost-effective public health interventions available.
- In many countries, this recommendation will require:
  - the cooperation of the food industry to reduce sodium content in processed foods and to make reduced sodium products widely available and accessible, to provide consumer choice;
  - activities to raise consumer awareness;
  - improvements in food labelling.
- Experience in some countries has demonstrated that reduction of sodium content of processed foods is feasible and achievable for food manufacturers working in close cooperation with government agencies, and that these efforts can result in marked reductions in sodium content of products without adverse consumer reaction.
- Additional strategies for the implementation of these recommendations will include public education, health promotion, and behavioural change. These strategies are even more important in contexts where most sodium intake comes from addition in the home.

Annex 9 Management of conflict of interest

NUGAG members

Professor John Cummings, Professor Shiriki Kumanyika and Professor Este Vorster declared that they received support from the local organizers of the third meeting of the Subgroup on Diet and Health; that is, the Korean Food and Drug Administration (KFDA)/Korea Health Industry Development Institute (KHIDI).

It was considered that the declared interests did not constitute any conflict of interest for their roles as members of the NUGAG Subgroup on Diet and Health, nor did they represent any conflict of interest for the work being undertaken by the NUGAG Subgroup on Diet and Health.

Professor Ibrahim Elmadfa declared that he has received research grants from the Ministry of Health, Austria; the European Commission; the European Food Standard Agency; and Nutrisciencia, Switzerland. The grants were received by his university, and funds were mainly used for staff costs for those working in the research projects and fieldwork.

Further information obtained from Professor Elmadfa regarding Nutrisciencia indicated that it is a Liechtenstein for-profit foundation, registered with the Public Registry of the Principality of Liechtenstein under number FL-0002.251.294-8. The purpose of the foundation is to support research, education and science to universities in Germany. It also contributes to charitable and humanitarian organizations. No commercially operating companies are involved in the operation of the foundation, either directly or indirectly. The declared interests were not considered to constitute any conflict of interest for Professor Elmadfa's role as a member of the NUGAG Subgroup on Diet and Health, nor did they represent any conflict of interest for the work being undertaken by the NUGAG Subgroup on Diet and Health.

Professor Nahla Hwalla declared that she has received research support including grants, collaborations, sponsorships and other funding from WHO, the International Atomic Energy Agency (IAEA), the Lebanese National Council for Scientific Research, the UN University (UNU) and Nestle Middle East.

Further information obtained from Professor Hwalla regarding the declared grant received from Nestle Middle East indicated that the grant supports two types of projects at the American University of Beirut (AUB): intervention activities to promote healthy eating in schools, and research activities of three faculty members in the Faculty of Agriculture and Food Sciences, where Professor Hwalla, as the Dean of the Faculty, oversees the implementation of these activities. Professor Hwalla also indicated that there is an agreement between AUB and Nestle Middle East that all intellectual property (including technology, method, know-how or data rights) produced during the course of the projects will belong to AUB. Professor Hwalla's declared interests do not present any conflict of interest for the work of the NUGAG because the funds she received for her own research were from UN agencies (i.e. WHO, IAEA and UNU) and a governmental institution (i.e. the Lebanese National Council for Scientific Research). It was agreed that Professor Hwalla could participate in the March 2011 meeting as a member of the NUGAG Subgroup on Diet and Health, especially since:

- *the interest is not personal;*
- *the amount received is not significant in view of the total budget of the faculty;*
- *funding is going to a programme that was already established before the Nestle contribution and that has governmental support. It was suggested that an appropriate disclosure statement be prepared to indicate her declared interest. Professor Hwalla participated in the March 2011 NUGAG meeting but was not able to attend the November 2011 meeting when the current guideline was developed.*

Professor Mary L'Abbe declared that she received research grants from the Canadian Institutes of Health Research, to evaluate the impact of Canada's sodium reduction policy; the Public Health Agency of Canada, to prepare a report on public food procurement policies related to sodium; and the Beef Information Centre (a non-profit research foundation funded, but administered at arm's length, by the Canadian beef industry), to examine the iron bioavailability of the diets of Canadians. Professor L'Abbe also receives other funding for research in NCD prevention and health promotion. She also declared that she has spoken at the annual meeting of the Canadian Meat Council to explain Canada's Sodium Working Group report recommendations, and the process being used to develop Canada's sodium targets for foods. Her travel expenses were paid by the Canadian Meat Council, but no honorarium was received. Professor L'Abbe appeared as a witness to the Canadian Parliament's Standing Committee on Health, as Chair of Canada's Sodium Working Group, to advocate for action to reduce sodium in Canadian foods and to increase consumer awareness of sodium, and to support research in the sodium field.

The research grant received from the Beef Information Centre was for a study to examine the iron availability of the diets among the Canadian populations; this activity was not related to the area of recommendations being reviewed and updated by the NUGAG Subgroup on Diet and Health. Hence, it was suggested that the declared interest be reported in the process and the meeting report with details, but that no action be taken and Professor L'Abbe be accepted as a member of the NUGAG Subgroup on Diet and Health.

Professor Jim Mann declared that he is employed by a university that has an interest in nutrition as it relates to human health, and receives research grants from New Zealand governmental agencies. He also declared that, as an individual and as advisory committee member, he has provided expert advice relating to nutrition and human health to innumerable national and international bodies including WHO, FAO, the World Cancer Research Fund and the media.

The declared interests were not considered to constitute any conflict of interest for Professor Mann's role as a member of the NUGAG Subgroup on Diet and Health, nor did they represent any conflict of interest for the work being undertaken by that subgroup.

Professor Dariush Mozaffarian declared that he has received a significant number of research grants to study the effects of dietary factors on chronic diseases from the US National Institutes of Health; the Searle Scholar Award from the Searle Funds at the Chicago Community Trust; the Genes and Environment Initiative at the Harvard School of Public Health; the Gates Foundation/WHO Global Burden of Diseases, Injuries and Risk Factors Study; and GlaxoSmith Kline, Sigma-Tau and Pronova for an investigator-initiated, not-for-profit trial of fish oil to prevent post-surgical arrhythmia. He has also received modest honoraria and travel reimbursement for

speaking at scientific conferences and reviewing on topics related to diet and cardiovascular disease, including from the US Food and Drug Administration, International Life Sciences Institute, Aramark, Unilever, SPRIM, Nutrition Impact, WHO, UpToDate, and several universities and scientific organizations. He has no ownership, patents, stocks, advisory board membership or speaking board membership.

The trial of fish oil, for which Professor Mozaffarian received grants from GlaxoSmith Kline, Sigma-Tau and Pronova, is not related to the work of the NUGAG Subgroup on Diet and Health. Given Professor Mozaffarian's honoraria, travel reimbursement and speaking and reviewing engagements, it was agreed that the declared interest in the process be documented in the meeting report and that no action be taken. It was decided he could participate as member of the NUGAG and his participation in the guideline development meetings would be reviewed for each meeting topic in the future.

Professor Murray Skeaff declared various memberships as follows:

- Serving as a member of the Public Health Scientific Advisory Group and the chair of the Food and Nutrition Working Group of the New Zealand National Heart Foundation. These groups advise the Heart Foundation, a nongovernmental organization, about the scientific basis of its public health efforts to reduce the burden of heart disease in New Zealand. He is not an employee of the Heart Foundation and receives no remuneration for work related to the Advisory Group.
- Appointed in 2008 as a Scientific Fellow of Food Standards Australia New Zealand (FSANZ). "The FSANZ Fellows Program aims to establish a network of distinguished scientists and experts from key disciplines in areas relevant to food regulation. The network is intended to promote close collaborative relations between FSANZ staff, the Fellows, and their affiliated institutions to the benefit of all parties." No remuneration is given to Fellows.
- Serving as a member of the New Zealand Food Safety Academy (NZFSA). The NZFSA is a governmental department within the Ministry of Agriculture and Fisheries. From time to time, NZFSA seeks the advice of experts in areas where its staff do not have the required expertise or where it requires confirmation of the advice provided by its staff. NZFSA also establishes expert groups to seek more specific assistance in relation to particular issues, drawing experts from the members of the academy. A $1000 honorarium is paid to Professor Skeaff's university each year.

The declared interests were not considered to constitute any conflict of interest for his role as a member of the NUGAG Subgroup on Diet and Health, nor did they represent any conflict of interest for the work being undertaken by that subgroup.

External experts and resource persons

Professor Francesco Cappuccio declared that he provided expert testimony on salt and cardiovascular disease as part of the Guidance Development group of the National Institute of Health and Clinical Excellence of England in 2009. He is an unpaid member of Consensus Action on Salt and Health (2000–present), the World Action on Salt and Health (WASH) (2003–present), the National Heart Forum (2010–present), the Pan American Health Organization/WHO Salt Group (2009–2011), and the European Salt Action Group (2007–present).

Professor Paul Elliott declared that he is a member of WASH. He also declared that his university is currently receiving research funds for the INTERMAP study from the US National Institutes of Health, and that he received research support for a sodium intake study from the US Centers for Disease Control and Prevention (CDC) in 2010. He declared that he provided an expert opinion related to:

- population sodium intake to the US National Heart, Lung, and Blood Institute National Health and Nutrition Examination Survey Sodium Working Group, Bethesda, USA in January 2011;
- sodium intake measurement methods and efficacy for the Epidemiology & Surveillance Branch of CDC, USA during 2010–2011.

Dr Lee Hooper declared that she has received research funding from Barry Callebaut (to her university) to carry out a systematic review on the effects of chocolate and cocoa on markers of oxidative stress; the review was completed in August 2010. She has also received research funding from Soy Nutrition Institute (to her university) to carry out a systematic review on the effects of soy and isoflavones on hormonal status in women; the review was completed in July 2008.

Dr Sarah Kelly declared the support for her participation at the third meeting of the NUGAG Subgroup on Diet and Health from the local organizers of the third meeting of the Subgroup on Diet and Health; that is, the KFDA/KHIDI.

Dr Cho-il Kim declared that, in 2009, she provided an expert opinion to the KFDA when they were developing a guideline to identify "energy-dense and nutritient-poor" foods according to the Special Act on Food Safety Management for Children. Since 2009, the sale of such food has been prohibited within school premises and in designated stores in the vicinity of schools (referred to as the "Green Food Zone"). Since 2010, television advertisements for such food are prohibited between 5:00 pm and 7:00 pm every day. Dr Kim thought that this information was relevant because the regulations on energy-dense and nutrition-poor foods deal with the fat and sugar content of food, and the meeting of the NUGAG Subgroup on Diet and Health was also reviewing recommendations related to total fat and sugars.

Professor Paula Moynihan declared that she received a research grant (to her university) that included reviewing the intake of sugars in care homes as a small component of a large dietary study from the United Kingdom Food Standard Agency/Department of Health; the study was completed in January 2011. She also declared that her travel costs for the third meeting of the NUGAG Subgroup on Diet and Health were covered by research funds from her university.

External experts and resource persons were involved in the discussions of the evidence, but did not vote at the NUGAG meetings at which the recommendations were formulated. The final wording and determination of the strength of the recommendations were based on the consensus of the NUGAG members only.

Members of the External Expert and Stakeholder Panel were also required to submit a signed declaration of interests form and a current curriculum vitae before commenting on the draft recommendations and guideline document.

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