World Health Organization

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Using dietary intake modelling to achieve population salt reduction

A guide to developing a country-specific salt reduction model

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Abstract

The amount of sodium (in the form of salt) consumed in Europe exceeds levels recommended by the World Health Organization (WHO). Excess sodium intake causes raised blood pressure and thereby increases the risk of cardiovascular diseases – namely, stroke and coronary heart disease. Many countries in the WHO European Region have initiated national sodium reduction strategies, including reformulation, interpretative front-of-pack labelling, and behaviour change communication. Nevertheless, more concerted action is needed. This policy brief provides guidance for countries on how to identify the specific sources of sodium in the diet and how to calculate their relative contribution to overall sodium intake. Based on this, a theoretical "salt reduction model" can be developed in countries. Such a model can help determine the level of reduction needed in the sodium content of food product categories that are the main contributors to salt intake, including discretionary salt, in order to achieve a significant reduction in population salt intake.

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Executive summary

The amount of sodium (in the form of salt) consumed in Europe exceeds levels recommended by the World Health Organization (WHO). Excess sodium intake causes raised blood pressure and thereby increases the risk of cardiovascular diseases – namely, stroke and coronary heart disease. It is one of the major challenges in Europe in relation to the promotion of healthy diets. A significant proportion of sodium in the diet comes from manufactured foods, such as bread, processed meats and savoury snacks. Yet the high sodium content of certain manufactured products, and the considerable variation in composition within product categories and between countries, indicate that there is significant scope to reduce the amount of sodium added to many manufactured foods. For this reason, WHO and its Member States have agreed a global target to reduce mean population sodium intake by 30% by 2025 for the prevention and control of noncommunicable diseases.

Many countries in the WHO European Region have initiated national sodium reduction strategies, including reformulation, interpretative front-of-pack labelling, and behaviour change communication. These actions align with the policy tools recommended in the WHO European Food and Nutrition Action Plan 2015–2020 to create healthier food environments. Nevertheless, more concerted action is needed. The publication of the WHO guidelines on sodium intake, and the 30% global target, have led to increasing demand from countries for more specific guidance on policies to reduce sodium intake. One recommendation for more fundamental change made by the WHO European Action Plan is to introduce integrated salt reduction programmes that include monitoring of the food supply, stakeholder engagement, and establishment of sodium benchmarks and targets for foods. In this context, this policy brief provides guidance for countries on how to identify the specific sources of sodium in the diet and how to calculate their relative contribution to overall sodium intake. Based on this, a theoretical "salt reduction model" can be developed in countries. Such a model can help determine the level of reduction needed in the sodium content of food product categories that are the main contributors to salt intake, including discretionary salt, in order to achieve a 30% reduction in population salt intake.

This document outlines a five-step approach to developing a salt reduction model.

1. Obtain data on daily food intake and discretionary salt use.

2. Obtain data on the sodium content of foods (food composition data).

3. Calculate current food intake and sodium contribution of different foods and other sources.

4. Identify relevant sodium content targets for manufactured foods.

5. Calculate reductions required in sodium content of manufactured foods and discretionary salt use to achieve a 30% reduction in population salt intake.

Key to an accurate model and its estimations is the data input. It is important that justification for the chosen data source is provided and the methods are transparent. Under each step, guidance is provided on the appropriate data to use and how they should be handled for the purpose of developing the model.

Case studies have been included for two countries, illustrating the process of developing salt models. In order to provide inspiration to countries considering developing a salt reduction model, an overview of existing sodium targets for manufactured foods in selected European countries has also been given, alongside the sodium criteria for labelling and taxation policies.

Background to the salt problem

The World Health Organization (WHO) guideline for sodium intake in adults and children recommends a reduction in sodium intake to less than 2 g/d (grams per day), equivalent to 5 g of salt, for improved health outcomes.[1] For children this figure should be adjusted downwards on the basis of their lower energy requirements relative to adults. Approximately 99% of the world's adult population (in 181 of 187 countries) currently have a mean salt intake above the recommended levels, which causes raised blood pressure and thereby increases the risk of cardiovascular diseases – namely, stroke and coronary heart disease.[2] A meta-analysis of randomized controlled trials demonstrated a dose–response relationship between reduction in sodium consumption and decrease in systolic blood pressure.[3] In addition, another systematic review found that lower sodium intake was also associated with lower risk of stroke and fatal coronary heart disease.[4] Both these reviews contributed to the establishment of the WHO guideline. In 2013, WHO recommended a global target of a 30% reduction in mean population salt intake by 2025 for the prevention and control of noncommunicable diseases. Subsequently, all WHO Member States formally adopted this goal at the 66th World Health Assembly. The goal has since been incorporated in relevant regional strategies, including the WHO European Action Plan for the Prevention and Control of Noncommunicable Diseases 2016–2025 and the WHO European Food and Nutrition Action Plan 2015–2020.[5, 6]

Although the 30% global salt target is challenging, some countries – notably Finland, in the WHO European Region – have demonstrated that reductions of that magnitude are achievable.[7,8] Other countries have achieved important reductions, albeit not yet of the magnitude proposed in the target. In order to achieve the target, the WHO Food and Nutrition Action Plan encourages countries to "develop, extend and evaluate, as a priority, salt reduction strategies to continue progress across food product categories and market segments". It calls on countries to adopt integrated salt reduction programmes that include monitoring of the food supply, stakeholder engagement and establishment of benchmarks and targets. Global policy monitoring reveals that there has been a substantial increase in countries implementing national salt reduction strategies, from 32 in 2010 to 75 in 2014.[10] Almost half (34) of the national salt reduction strategies were in countries in the WHO European Region[10] – partly a result of the common salt reduction framework that had previously been developed at the European Union level.[11] In these countries, almost all strategies comprised initiatives to engage the food industry in lowering the sodium content of processed foods, particularly breads and processed meats. The findings of a more recent survey of country policies conducted by WHO are consistent, showing that most countries in the European Region (76%) report reformulation efforts and more than half (55%) focused on lowering sodium.[12] However, only 30% of countries report having specific salt reduction targets for manufactured foods.

Commercially packaged or processed foods, where sodium is added during food processing, are major sources of sodium for many countries consuming the so-called Western diet.[13,14] Monitoring of the sodium content of packaged foods within and between countries in the WHO European Region, conducted by the Dutch National Institute for Public Health (RIVM) using nutrient data provided by EuroFIR, reveals that there is a wide range of compositions within the same product category, indicating significant scope for improvements towards the "best in class" products (see Fig. 1).[15] Other sources of sodium include discretionary salt added by the consumer during food preparation or cooking, discretionary salt added by the consumer while eating (at the table), and natural sources of sodium in foods. Identification of the specific sources of sodium and their relative contribution in each country's diet is crucial to the design of an effective salt reduction strategy.

Based on this information, a theoretical "salt reduction model" can be developed in countries to determine the level of reduction needed in the sodium content of food product categories that are the main contributors, as well as consumers' discretionary salt intake, in order to achieve a 30% reduction in population salt intake. This salt model can then be used as a guide to where salt reduction efforts should be focused. This was successfully demonstrated in the United Kingdom, where the Food Standards Agency used the UK salt model to engage the food industry in the task of decreasing the sodium content in several product categories to their targeted levels.[16] Reductions in sodium levels of up to 70% were achieved in a range of food categories. This was a substantial part of a multifaceted strategy that by 2011 had resulted in a 15% reduction in mean population salt intake, which contributed to falls in population-wide blood pressure over the same period.[17] This policy brief aims to describe an approach to developing a salt model that can guide countries on which dietary sources of salt can

Fig. 1. Varying sodium content levels in breads and rolls within and between countries in the WHO European Region. Median levels range from 460 to >600 mg/100 g.[15]

Fig. 2. Proposed steps for developing a country-specific salt model

Step 1. Obtain data on daily food intake and discretionary salt use.

Daily food intake

Option A – Direct dietary assessments: 24-hour dietary recall, food frequency questionnaires, weighted or estimated food records.

Option B – Indirect estimates of intake: household expenditure surveys, food sales or food-purchasing data (note: adjustments for food wastage or foods consumed out of home may need to be considered).

Discretionary salt use

Option A – Direct measurement: salt weighing, duplicate collection of salt, questionnaires, etc.

Option B – Indirect: urinary salt excretion minus salt from food.

Step 2. Obtain data on the sodium content of foods.

Option A – Updated and country-specific food composition database (can be compiled from several sources of data, e.g. chemical analyses of sodium content in frequently consumed unlabelled foods or meals, industry-provided data, shop surveys of branded food nutrition labels).

Option B – Use food composition database from neighbouring countries or countries from which most of the food is imported.

Step 3. Calculate current food intake and sodium contribution of different foods and other sources.

A – Categorize foods into small groups, e.g. according to the composition database food product categories.

B – Estimate the mean amount of food consumed per person per day.

C – Estimate the mean sodium content for each food group.

D – Using 3B and 3C, calculate the mean sodium contributed by each food group.

E – Sum the mean sodium from foods with sodium from discretionary and other sources to determine the overall current sodium intake per person per day.

Step 4. Identify relevant sodium content targets for manufactured foods.

A – Identify processed/manufactured foods that are contributors of sodium to the diet.

B – Review sodium targets (mg/100 g) established in other countries for these packaged foods as a starting point.

C – Adjust the sodium content targets as appropriate by checking whether existing products already meet targets; e.g. if < 10% of existing products currently meet targets, then the targets can be increased (easier). For foods without established targets, consult local food experts and examine the existing sodium content range.

Step 5. Calculate reductions required in sodium content of foods & discretionary salt use to achieve 30% target.

A – Using the sodium content targets chosen in Step 4, model the decrease in sodium contributed if the target sodium content was achieved, for each food group.

B – Model a feasible reduction in discretionary salt intake and sodium from other sources.

C – Check that the modelled reductions in sodium contributed by foods, discretionary salt and other sources bring the current mean population sodium intake down by 30%. If not, repeat Step 4C and consider where more ambitious targets would be feasible.

Detailed steps and considerations in developing a salt model

be feasibly reduced in order to efficiently achieve a 30% reduction in population salt intake.

Step 1: Obtain data on daily food intake and discretionary (consumer-controlled) salt use

Key to an accurate model and its estimations is the data input. It is important that the methods for data identification are transparent and justification is provided when choices between data sources have been made.[18, 19] The best available data on food intake and discretionary salt use (salt added by the consumer during food preparation, cooking or eating) for the population of interest (e.g. adults of 18 years and over) should be used.

Detailed food consumption data can be obtained in the following ways:

a. Direct dietary assessment methods (preferred) – 24-hour diet recall, food frequency (and amount) questionnaires, diet history, weighted or unweighted food records, and study-specific dietary questionnaires and duplicate diets.[20–22]

b. Indirect methods for estimating food intake (alternative but not preferred) – household income expenditure or budget surveys, store sales, food-purchasing data or food balance sheets.[23, 24] Based on the method for estimating food consumption chosen, different adjustments or supplementary data may be required to accurately estimate actual and complete food intake. For example, if food intake is derived from household income expenditure surveys, supplementary data on foods consumed outside of the home (restaurants or takeaway meals) are required. If not captured, the edible portion of foods and food wastage also need to be estimated and accounted for.

Information on the amount of discretionary salt used (salt added by the consumer during preparation, cooking and eating) can be obtained in a number of ways:[25]

a. Lithium-labelled salt studies (some are undertaken as part of iodine deficiency studies), where urinary excretion of lithium enables quantification of discretionary salt use.[26, 27]

b. Weighed household salt/salt disappearance studies, where a household's salt container (or salt provided by the study) is weighed at the start and after a specific period of time (e.g. seven days) and the difference in salt is divided by the number of days and household members.[28]

c. Duplicate salt collection studies, where duplicate portions of salt used are collected over a certain time period and the amount is divided by number of days and number of consumers.[29]

d. Discretionary salt intake surveys – specific questionnaires on discretionary salt intake or questions about discretionary salt intake added in diet surveys.

e. Discrepancy between urinary salt excretion and reported dietary intake – subtraction of 24-hour urinary salt excretion from daily salt intake estimated by food consumption surveys or salt attributed to commercially available foods. Note that if dietary surveys capture salt added during cooking or preparation as part of the recipes (check food composition tables), this deduction method calculates discretionary salt intake added by consumers during eating or at the table.

f. Food-grade salt sales data – the total amount is divided by the number of people and days of collection.[30]

Multiple sources of information can be collated to provide a comprehensive understanding of usual daily food intake and discretionary salt use. These sources will need to be justified and any assumptions need to be documented. There are a number of important points to consider when choosing the most relevant data source. These include:

- Representativeness – Are the food intake data representative of what the population of interest would usually eat? Has seasonal or weekday/weekend variation been taken into account? Are the sample demographics and characteristics representative of the population?

- Validity/accuracy of the method – This relates to whether the method appropriately measures actual food intake.[31] Are food portions estimated or weighed? Are brand-specific or product-specific data collected? The approaches adopted to improve accuracy vary for each dietary assessment method. For example, in self-reported food recalls, has adjustment been made for under- or overreporting through consideration of disparities between reported energy intake and estimated energy requirements?[20, 32] Has the multiple-pass technique been used in the 24-hour diet recalls to limit the extent of misreporting? If household income expenditure surveys have been used to estimate food intake, have edible portions, food wastage, homegrown foods, out-of-home dining or foods received as gifts been considered?[33] If packaged food purchasing data or sales data are used, have fresh foods and out-of-home foods been accounted for?

- Reliability/repeatability – This relates to whether the same method gives the same answer when repeated. This can be improved by tailoring the questions for the local population and pre-testing the dietary assessment instruments.[31]

- Up-to-date data – Are the food intake data up to date or have the food supply or dietary patterns changed substantially since the survey? This is to be determined on a case-by-case basis.

Step 2: Obtain data on the sodium content of foods (food composition data)

The next step is to obtain data on the sodium content of foods from national food composition or nutrient databases where available. Where local options are unavailable, nutrient information can be borrowed (with appropriate justification) from neighbouring or similar countries. Ideally, these data would be supplemented with more up-to-date brand- or product-specific sodium content information from the nutrition information panels of local packaged foods.

There are a number of potential sources that can be used to compile data on the sodium content of foods.

- National/regional food composition databases – Many countries in the WHO European Region have national food composition databases. The majority are available online and can be found via the following links: http://www.fao.org/infoods/infoods/tables-and-databases/en or http://www.eurofir.org/food-information/food-composition-databases-2. A more comprehensive list of food composition databases worldwide can be found in the World Nutrient Database for Dietary Studies.[34]

- Branded-food composition data – Several countries collect nutrient information from packaged food nutrition labels – for example, as part of the Global Food Monitoring Group.[35] In addition, since 2008 a number of European Union Member States have used the model pioneered by France as part of their Oqali initiative to monitor the composition of specific food product categories (notably in the context of the EU Joint Action on Nutrition and Physical Activity).[36]

- Shop surveys – If no recent data on the nutrient content of packaged foods are available, shop surveys can be undertaken to gather this information from the main local supermarkets or shops.

- Chemical analysis – The sodium content of common restaurant or takeaway meals or other unlabelled foods can be measured through chemical analysis in laboratories. The WHO Regional Office for Europe's FEEDCities project provides an example of a method that could be adapted for this purpose.[37, 38]

- Industry-provided data – The nutrient content of foods and meals may be collected by market research companies, from food company websites or by direct application to the company itself.

Step 3: Calculate current food intake and sodium contribution of different foods and other sources

Using the data on food and discretionary salt intake combined with the sodium content of foods obtained in Steps 1 and 2, current sodium contributed by the different food groups and discretionary sources can be calculated. Although this method is likely to give a different estimate of sodium intake compared to estimates based on 24-hour urine collection (the gold standard), for the purpose of developing the salt model this method is sufficient to determine the food contributors of sodium, accounting for the amount and frequency of consumption in the population. In this way, the reductions in sodium required, overall and by food category, to achieve a 30% decrease in average salt intake can be calculated.

The calculation can proceed as follows:

a. Categorize foods in the food consumption survey according to the level at which sodium targets can be applied.

   i. If there are no existing sodium targets, categorize foods according to the categorization system used in the food composition database; undertake analysis at the most detailed food group level.

   ii. If existing targets have been established, categorize food groups according to the targets. For example, if there is one target for all types of sliced bread, then white, wholemeal and wholegrain sliced bread can be categorized together. Alternatively, there may be different targets for specific subgroups of food. For example, in the case of processed meats, there may be different targets for sausages, bacon and other cured meats.

b. Estimate the mean amount/weight of food consumed per person per day for each food group determined above (from data obtained in Step 1).[a]

$$\text{Mean amount of food consumed per person per day} = \frac{\text{Sum of amount consumed by all persons (g)}}{\text{No. of persons x no. of days food intake was measured}}$$

   i. For each food group, sum the amount or weight consumed by all individuals and divide this by the number of individuals and the number of days that food

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[a] If food consumption data have been weighted (e.g. so that the sample matches the population, or to account for weekday/weekend or seasonal variation), these data should be used.

intake was collected (e.g. for 24-hour diet recall, divide by 1 day).

c. Estimate the current mean sodium content (mg/100 g) for each food group using data from Step 2.

 i. If sales data are not readily available, a simple mean sodium content of food products in the group can be calculated.

 ii. If available, use the sales-weighted mean sodium content for foods (sodium content of individual branded food products within a group are weighted by their sales volume market share).[39] Calculating the sales-weighted mean sodium content accounts for the top-selling products in the category and therefore more accurately estimates the true mean sodium content of foods consumed by the population. Sales data are difficult to obtain, so only a few countries have been able to calculate the sales-weighted mean sodium content for foods and set targets and monitor changes based on this.[40, 41]

d. Using the mean intake per person per day for each food group (calculated in Step 3b) and the corresponding mean sodium content of the food group, calculate sodium (mg) contributed by each food group.

$$\text{Mean sodium from food (mg/person/day)} = \text{Mean amount of food (g/person/day)} \times \text{Mean sodium content of food (mg/100g)} \div 100$$

 i. Multiply the mean amount of food consumed (g/person per day) calculated in Step 3b by the corresponding mean sodium content of the food (mg/100 g) calculated in Step 3c, and divide by 100.[b]

e. Estimate the mean amount of sodium from discretionary salt intake per day or salt from other sources not included (e.g. packaged food-purchasing surveys may not include foods consumed outside of the home, therefore this information needs to be supplemented with other data on food or sodium intake from restaurants or takeaway meals).

 i. Conversion for discretionary salt to sodium: 1 g of salt = 400 mg of sodium.[c]

f. Sum sodium from all foods and sodium from discretionary salt or other sources to estimate the current total daily sodium intake (see Box 1). To determine the mean

population sodium intake target (30% reduction), multiply the current sodium intake by 0.7 (100 − 30 = 70%).

$$\text{Mean population sodium intake target (30\%)} = \text{Current mean sodium intake} \times (100\% - \% \text{ reduction})$$

Box 1. Calculating the contribution of different dietary sources to sodium intake

It should be noted that the purpose of calculating the current daily sodium intake from dietary intake data is to inform the development of a salt reduction model. This estimate is likely to be different to estimates measured through 24-hour urinary sodium excretion (the gold standard). There are several possible reasons for this difference which will vary in each case. One likely reason is that it is difficult to accurately estimate sodium intake from food consumption data. Possible sources of error in direct or indirect dietary intake surveys include misreporting, self-report bias and inaccuracies in estimating the amount/portion of food consumed.[42, 43] Another reason is the difficulty in measuring discretionary salt added by the consumer, as the way salt is used or consumed varies in different cultures (pickling, dipping, boiling, etc.). If an estimate of 24-hour urinary sodium excretion is available, a comparison should be made, and differences should be acknowledged and explained if possible. However, it should be noted that differences in estimates of absolute daily salt intake do not affect the model, provided that the proportional contributions of sodium from different dietary sources are captured as accurately as possible. The calculated percentage reductions in sodium from foods or discretionary salt required to achieve a 30% decrease in salt intake will remain the same despite different estimates of absolute salt intake. If the two estimates are comparable and estimates from surveys have accounted for all sources of salt intake, a simple correction factor (24-hour urinary sodium divided by sodium calculated from surveys) can be calculated and used to adjust the absolute amount of sodium for each food group.

Step 4: Identify relevant sodium content targets for manufactured foods

a. Identify manufactured, processed or packaged foods that are considered the main sodium contributors that require reformulation.

 i. Depending how dispersed the food sources of sodium in the diet are, you may want to apply a cut-off to determine which foods should be targeted for reformulation (and included in the salt model). For example, previous salt models include food groups that

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[b] It is divided by 100 because the sodium content of food is usually expressed as mg of sodium/100 g of food.

[c] The exact conversion is 1g salt =393.4mg sodium. However, previous publications by WHO and others use the rounded figure of 400mg. For consistency throughout this publication, the authors have chosen to use 400mg.

contribute >500 mg of sodium per day.[44] Alternatively, if sources of sodium are widely dispersed, ensure that the sources of sodium included in the model, when combined, contribute 80% or more of sodium in the diet.

b. Determine mean sodium content targets for manufactured or processed foods.

   i. Use existing local or regional targets if available.

   ii. If no targets exist for the local country, identify existing sodium targets from similar countries (neighbouring countries or countries from which most foods are imported) as a starting point. Some existing sodium content targets (see Table 1) include United Kingdom targets,[45] regional salt reduction targets for selected food groups for the Americas,[46] salt regulation targets for South Africa,[47] and Pacific Islands regional salt targets.[48] Starting with established sodium content targets ensures that they are technologically feasible;[49] however, the targets should be tailored by checking whether existing food products are already meeting the targets. If less than 10% of existing products meet the target, then the sodium content threshold can be increased, so it is more feasible to achieve.[50] If more than approximately 45% of existing products already meet the target, then the sodium content threshold can be lowered (i.e. become stricter). It is recommended that the sodium content distribution is considered and food experts (local food technologists, nutritionists) are consulted in making this decision.

   iii. Where data on the distribution of current sodium content in food products are unavailable to undertake checking (e.g. only mean sodium content is provided), consider whether the target is feasible for the food product in consultation with local food experts.

Where sodium targets are unavailable for certain food products – for example, foods that are unique to the country – obtain local advice on whether sodium is added during the manufacturing process. Then examine the mean, median and interquartile range of sodium content of food products in the food group and consult local food experts to determine a feasible target.

Step 5: Calculate reductions required in sodium content of foods and discretionary salt use to achieve a 30% reduction in population salt intake

a. Using the mean sodium content targets chosen in Step 4, model the decrease in sodium from each manufactured food if the sodium target was achieved using the following steps.

   i. Recalculate the sodium from foods using the target mean sodium content without changing the amount of food consumed.

$$\text{Revised mean sodium from food (mg/person/day)} = \text{Mean amount of food (g/person/day)} \times \text{Target sodium content of food (mg/100g)} \div 100$$

   ii. Calculate the decrease in sodium (mg/person/day) if the foods met their target sodium content, for each food group.

$$\text{Decrease in sodium if target achieved (mg/person/day)} = \text{Sodium from current food (mg/person/day)} - \text{Revised sodium from food if target met (mg/person/day)}$$

[The decrease in sodium if the target sodium content for the food was achieved (mg/person/day) is calculated by the sodium from current food, calculated in Step 3d, minus the revised sodium from food if the target was met, calculated in Step 5a.i.]

   iii. Add up the total decrease in sodium if all processed foods reached their targeted sodium content (Step 5a.ii).

b. Model a feasible reduction in discretionary salt intake or salt from other food sources.

   i. Previous modelling studies have modelled up to a 40% decrease in discretionary salt intake and out-of-home meals.[50, 51] However, this should be determined in consultation with local food experts, based on the current sodium contribution of discretionary salt and foods eaten outside of the home.

   ii. To calculate the revised sodium if reduction in discretionary salt use or other sources of sodium was achieved, multiply the sodium (mg) by 100% minus the targeted percentage reduction.

$$\text{Revised sodium from discretionary salt} = \text{Current sodium from discretionary salt} \times (100\% - \% \text{ reduction})$$

For example, if current sodium from discretionary salt intake was 800 mg/d, modelling a 40% reduction would give a figure of 480 mg/d.

   iii. Calculate the decrease in sodium if the targeted reduction in sodium from discretionary salt or other sources was achieved, as shown in Step 5a.ii.

c. Add together the decrease in sodium from processed or manufactured foods achieving their target sodium content (5a.iii) and the decrease in sodium from discretionary salt

or other sources achieving their target (5b.iii). Check that the modelled decreases bring down the current mean sodium intake by 30% (as calculated in Step 3f). If the modelled mean sodium intake is not lower by 30%, go back to Step 4 and lower the sodium content thresholds (i.e. make them stricter) or set a more ambitious discretionary salt target, within reason.

Two country case studies, illustrating the steps needed to develop a salt reduction model, are presented in the Annex to this brief.

Using the salt model to guide the design of salt reduction strategies

Following development of the salt reduction model, consultations with local food experts, programme leaders and policy-makers are required to interpret and design a salt reduction strategy. It should be highlighted that these are estimations that help understand where changes in sodium content of manufactured foods, discretionary salt use and food consumption should be made to reduce population salt intake by 30% in an efficient and feasible way. As in the United Kingdom, where manufactured foods are major contributors, the salt reduction model could be used in discussions with food manufacturers to encourage gradual voluntary reductions in mean sodium content of processed foods across the food supply.[51] Alternatively, governments may choose to regulate by setting maximum sodium limits.

It should be noted that the targeted sodium contents modelled are intended to be achieved gradually (as in the case of the United Kingdom; see Table 1). Progressive reductions in the sodium content of foods should be implemented with clear timelines, such as a 10–20% reduction, repeated at 1–2-year intervals.[9] Gradual reductions ensure that changes are not detectable by consumers and therefore do not affect product sales or result in compensatory consumption of sodium in other foods.[52] The levels to which sodium content can be reduced in several foods without affecting consumer acceptability have previously been explored in academic reviews.[53, 54] Where countries choose to regulate instead of taking a voluntary approach, the modelled mean target sodium content can be used to inform a maximum sodium limit, such as those legislated in Turkey, Argentina and South Africa; a maximum limit should typically be higher than the mean sodium target, but it can be progressively reduced over time.[47, 55, 56] A relevant example from the WHO European Region is legislation in the Netherlands that applies to salt in bread. The maximum allowed salt content of bread has decreased gradually over the past decade: from 2.5 g per 100 g of dry matter in 2009, to 2.1 g in 2011, to 1.9 g in 2012, and to 1.8 g in 2013. For an average dry matter content of 64%, this limit is equivalent to approximately 1.15 g per 100 g of bread (see Table 1).[57] Countries should also consider the advantages and disadvantages of each type of target (simple average targets, sales-weighted average targets or maximum limits) and determine which is most suitable for their context.[58]

The mean sodium content targets can also be used to inform the sodium content cut-off or criteria for other voluntary or mandatory interventions such as taxation, food procurement policies or guidelines in public institutions and front-of-pack labelling schemes (logos and symbols, traffic light labels, warning labels, etc.).[10] Although these initiatives are intended to help consumers choose lower-salt foods, they can indirectly lead to reformulation of manufactured food products in such a way that they avoid being taxed, excluded from sale in public institutions, or having to carry a negative front-of-pack label. This was successfully demonstrated in Finland when mandatory salt warning labels were introduced for foods containing sodium above certain levels, accompanied by introduction of a "Better choice" logo for products that fell below a certain sodium content (Table 2).[59] It was estimated that the food industry lowered the sodium content of breads, meat products, cheese and ready meals by about 20–25%, contributing to reduction in population salt intake by one third.[8, 60] Israel has also taken steps to introduce warning symbols (or negative front-of-pack labelling) on food packages, with easily identifiable icons. The policy establishes thresholds for sodium (among other nutrients) and is modelled on the system successfully introduced in Chile (Table 2). If the thresholds are exceeded, the food package must bear a warning symbol and the wording "Contains a high amount of [e.g.] sodium". Hungary is currently the only country in the WHO European Region that specifically taxes foods high in salt, setting thresholds for savoury snacks and condiments (Table 2).[61] Implementation of these interventions should all be accompanied by robust monitoring of the sodium content of foods to hold the food industry accountable to voluntary commitments or to check compliance with legislation.

In countries where discretionary salt use is a major contributor of sodium, tailored interventions to encourage consumers to reduce such usage is required. Interventions should be tailored to suit common local practices of discretionary salt use (e.g. dipping salt or salty condiments, pickling foods with salt, adding salt during cooking). Some previously implemented interventions include: replacing regular salt with potassium-enriched salt substitutes; education or campaigns focusing on reducing discretionary salt use; low-salt recipes or substitution with other herbs and spices; provision of measuring spoons

which indicate the recommended maximum daily intake of salt; and warning labels on salt shakers and packages.[62–66]

The accuracy of salt models will vary, mostly depending on the accuracy of their input data. However, it should be acknowledged that these are theoretical models that cannot take account of other influences on dietary intake. Nevertheless, these models should provide guidance on the main sources of salt and therefore the types of intervention that should be implemented to effectively and feasibly lower population salt intake.

Table 1. Examples of sodium content targets from Europe and beyond

Food category	Country	Year target to be met	Year target set	Target (mg sodium/100 g)	Food group description	Notes
Breads	United Kingdom[45, 51]	Salt model average target		350 (average)	Breads and rolls	Other voluntary targets for bread categories include: bread and rolls with additions and morning goods.
		2010	2006	430 (average)		
		2012	2010	400 (average)		
		2017	2012	360 (average) 450 (maximum)		
	South Africa[47, 67]	2016	2013	400 (maximum)	Breads and rolls	This excludes rye bread and breads where high-salt ingredients have been added. These are legislated maximum levels of sodium content.
		2019	2013	380 (maximum)		
	Netherlands[68]	2013	2013	720 (maximum dry matter)	Breads and rolls (dry matter)	For an average dry matter content of 64%, the limit is equivalent to approximately 460 mg sodium/100 g. This is the legislated maximum target.
Processed meats	United Kingdom	Salt model average target		750 (average)	Ham/other cured meats	Other processed meat targets for cooked uncured meat; reformed muscle; comminuted or chopped reformed meat; burger and grill steaks; frankfurters, canned hot dogs, canned burgers; fresh chilled frankfurters; sausages – fresh, chilled or frozen; and cooked sausages.
		2010	2006	1000 (average)		
		2012	2010	700 (average)		
		2017	2012	650 (average)		
	South Africa	2016	2013	950 (maximum)	Processed meats – cured	Other processed meat targets for uncured processed meats and raw or processed meat sausages. These are legislated maximum targets.
		2019	2013	850 (maximum)		
	Argentina[55]	2014/ 2015	2013	1196 (maximum)	Salt-cured cooked products – cooked ham, sausages, mortadella	This is the legislated maximum target.
	Netherlands[69]	2015	2013	1120 (maximum)	Cooked meats	Voluntary targets agreed by the Dutch Meat Products Association.
		2015	2013	945 (maximum)	Cooked composite meats	
Cheese	United Kingdom[45]	Salt model average target		500 (average)	Processed cheese (e.g. slices, strings, etc.)	Other voluntary targets have been set for cheddar and similar hard-pressed, soft white (including cream cheese), cottage, blue cheese (UK produced only) and processed cheese spreads.
		2010	2006	1170 (average)		
		2012	2010	800 (average)		
		2017	2012	680 (average) 800 (maximum)		

Table 1. Contnd.

Food category	Country	Year target to be met	Year target set	Target (mg sodium/100 g)	Food group description	Notes
Savoury snacks	United Kingdom	Salt model average target		550 (average)	Standard potato crisps	All flavours except salt-and-vinegar.
		2010	2006	600 (average)		
		2012	2010	550 (average) 650 (maximum)		
		2017	2012	525 (average) 580 (maximum)		
	South Africa	2016	2013	650 (maximum)	Flavoured potato crisps	These legislated targets apply to all flavours except salt-and-vinegar flavoured potato crisps.
		2019	2013	550 (maximum)		
	Netherlands[70]	2018	2016	480 (maximum)	Potato chips	Voluntary targets agreed by the Association of Bakery and Confectionary Industry.

Table 2. Examples of sodium content thresholds established in labelling and taxation policies

Type of policy	Country	Sodium mg/100 g criteria (conversion based on 1 g salt = 400 mg sodium)	
"High salt content" warning label	Finland[71]	Bread	>440
		Crisp bread	>560
		Cheese	>520
		Sausages	>800
		Cold whole meat cuts	>880
		Breakfast cereals	>560
		Prepared and semi-prepared foods	>480
	Israel	Stage 1 (2020)	>500
		Stage 2 (2021)	>400
"Better choice" label	Finland[72]	Bread	<280
		Crisp bread	<480
		Cheese	<480
		Sausages	<600
		Cold whole meat cuts	<600
		Breakfast cereals	<400
		Prepared and semi-prepared foods	<300
Public Health Product Tax	Hungary[61]	Savoury snacks	>400
		Condiments	>2000

Annex

[A] Case study: Kazakhstan salt reduction model

Step A1: Obtain data on daily food intake and discretionary salt use

- Food intake data were obtained from the 2008 National Nutrition Survey in Kazakhstan residents aged 15 to 59 years.

- Reasons for using these data were:

    - they were the most recent, representative dietary intake data available;

    - food intake was captured using a direct dietary assessment method (24-hour dietary recall) and underreporters were excluded.

- Discretionary salt added during cooking was captured in the 24-hour dietary recall, but not discretionary salt added during eating.

- There were no studies that measured discretionary salt added during eating in Kazakhstan. Based on the difference between 24-hour urinary salt excretion (17.4 g/d, unpublished data from 2015 and 2016) and salt intake estimated from the dietary survey, discretionary salt added by the consumer during eating is likely to be high, at approximately 10 g/d.

- A 2007 study in Kazakh people living in China estimated that discretionary salt added during cooking and eating was approximately 20.9 g/d, based on the salt-weighing approach.[73] However, this measurement is likely to have overestimated discretionary salt consumption, as not all salt used is consumed.

Step A2: Obtain data on the sodium content of foods (food composition data)

- Local food composition data were obtained from local country contacts; missing sodium values for 2.6% of foods were supplemented with values from food industry or nutrition websites.

Step A3: Calculate current food intake and sodium contribution of different foods and other sources

- Foods were categorized according to the local food composition categorization system. There were no existing local sodium targets, so food intake data were analysed at the most detailed level to ensure accuracy. 738 foods were included, which made up 105 submajor food categories or 15 major food categories.

- Mean food intake per individual per day for each food category was calculated by summing the total amount of food consumed for each food category, divided by 3526 individuals and divided by 1 day (24-hour dietary recall).

- Mean food intake per individual per day was multiplied by the mean sodium content of the foods (current mean sodium content of foods was already provided).

- Total mean sodium intake was 2806 mg/d (7.0 g/d of salt); two thirds (1859 mg/d) from foods and one third (947 mg/d) from discretionary salt added during cooking. This does not include discretionary salt added during eating or at the table.

- The target (30% reduction) mean sodium intake was <1964 mg/d.

- Table A below outlines the current mean amount consumed (g/d), mean sodium content (mg/100 g), sodium contributed (mg/d), and percentage sodium contribution for each food group.

Step A4: Identify relevant sodium content targets for manufactured foods

- The 2017 United Kingdom sodium targets were used as a starting point to determine sodium targets.[45] Where available, mean sodium content targets were used instead of maximum targets.

- Local food experts were consulted to provide explanation of locally specific foods and to determine whether sodium was added by manufacturers during processing, by the consumer, or was naturally present in foods.

Step A5: Calculate reductions required in sodium content of foods and discretionary salt use to achieve a 30% reduction in population salt intake

- Reductions in sodium content were simulated in 18 food groups consisting of 109 manufactured food products that had existing sodium levels above the United Kingdom targets and could be reformulated. The target mean sodium content (mg/100 g), percentage reduction in sodium content, and sodium decrease if sodium target was achieved (mg/d) are shown for each food group in Table A below.

- On average, a 27% reduction in the sodium content of these manufactured foods was required, reducing mean sodium intake from 1052 mg/d to 763 mg/d.

- A 40% reduction in discretionary salt use was required, bringing sodium from discretionary salt added during cooking down from 947 mg/d to 568 mg/d.

- A 65% reduction in consumption of sodium-rich mineral waters was modelled, given that sodium was naturally present in high amounts.

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Table A. Kazakhstan model to achieve 30% reduction in salt intake

Food categories	Food group	Current				Modelled reductions		
		Food consumed (g/d)	Current sodium content (mg/100 g)	Current sodium intake (mg/d)	Sodium con-tribution (%)	Target mean sodium content (mg/100 g)	Target mean reduction (%)	Sodium decrease if target met (mg/d)
Reformulation of processed foods above the sodium target								
Breads	Bread and rolls	159.6	482.7	770.3	27.4	360	25.4	195.8
	Bread – yeast-raised (bagels)	2.6	443.0	11.6	0.4	290	34.5	4.0
Meat and fish products	Sausages	6.7	1269.6	85.3	3.0	550	56.7	48.4
	Frankfurters	2.9	805.5	23.2	0.8	600	25.5	5.9
	Cooked uncured meat (whole-muscle chilled, frozen, canned)	0.7	461.5	3.4	0.1	270	41.5	1.4
	Smoked pork	0.1	1609.7	1.4	0.1	1150	28.6	0.4
	Ham	0.1	953.4	1.1	0.04	650	31.8	0.3
	Canned fish	0.4	526.0	2.3	0.1	340	35.4	0.8
Cheese and dairy products	Cheese (hard)	2.3	1027.3	23.7	0.8	700	31.9	7.5
	Cheese (soft blue)	0.0	1900.0	0.5	0.02	800	57.9	0.3
	Cheese (processed)	0.2	1004.3	1.9	0.1	680	32.3	0.6
	Butter	3.4	600.0	20.4	0.7	590	1.7	0.3
	Margarine	0.2	1053.7	1.7	0.1	425	59.7	1.0
	Mayonnaise	4.9	508.1	24.9	0.9	500	1.6	0.4
Vegetable products	Potato (processed)	30.2	253.0	76.4	2.7	185	26.9	20.5
	Canned vegetables	0.2	402.7	0.7	0.02	50	87.6	0.6
Snacks	Crisp bread snacks	0.4	609.9	2.2	0.08	346	43.3	0.9
	Chips (snacks)	0.2	860.0	1.3	0.05	680	20.9	0.3
Sodium reduced through reformulation (mg/d)								289.5
Reduction in consumption or salt added								
	Cooking salt	2.4	39300.0	947.4	33.8		40.0	379.0
	Mineral waters	59.1	229.9	135.8	4.8		65.0	88.2
	Meat dishes	20.4	1118.4	228.5	8.1		30.0	68.6
	Potatoes dishes	49.3	129.9	64.0	2.3		30.0	19.2
Sodium reduced through moderation of consumption (mg/d)								555.0
Total sodium reduction through reformulation and reduced consumption or salt added by consumer (mg/d)								844.5

- An additional eight meat dishes (such as fried chicken, fried meat fat, boiled salted meat and a grilled beef dish) and one potato dish were identified as foods that were usually cooked at home or bought from restaurants/takeaways, as opposed to manufactured/processed foods. A 30% reduction in consumption (when eaten out of the home) or in salt added (when cooked at home) was modelled.

- In total, these modelled reductions decreased mean sodium intake from 2806 to 1962 mg/d; a 30% reduction.

- A limitation was that there were no studies that measured the amount of discretionary salt added during eating in Kazakhstan. It is likely to be a major contributor based on the difference between 24-hour urinary salt estimates and salt intake estimated from the food survey, and in light of the study of Kazakh people in China. For this reason, the required 40% reduction in discretionary salt use also applies to discretionary salt added during eating. Although the absolute amount could not be quantified, this recommended reduction will ensure that a 30% decrease in the overall mean sodium intake is achieved.

[A] Using the salt model to guide the design of salt reduction strategies

- The Kazakhstan salt model demonstrates that a multifaceted approach, targeting both individual and environmental change, is required to lower population salt intake by 30% as recommended by WHO. Given that salt added by consumers is still a major source of sodium in the diet, public awareness campaigns and education are required to encourage consumers to reduce discretionary salt use by 40% and reduce consumption of salty meat dishes and beverages. In particular, education about the sodium content of mineral waters is required, as these are often perceived as healthier beverage options; however, they contain ≥200 mg of sodium per 100 ml. In combination with education, food manufacturers of processed foods across the food supply must gradually lower the sodium content towards the sodium target; this is particularly the case with manufacturers of bread or bakery products and processed meats.

[B] Case study: Turkey salt reduction model

Step B1: Obtain data on daily food intake and discretionary salt use

- Dietary intake information relating to the Turkish population was obtained from two surveys. The primary data source was the 2012 SALTURK II study (n = 464),[74] conducted in rural and urban areas of four provinces: Ankara, Istanbul, Izmir and Konya. The 2010 National Nutrition and Health Survey (n = 8058, for ages 19+), which was nationally representative, was used to cross-check whether food sources of sodium in the diet were comparable.[75]

- Both the SALTURK II study and the National Nutrition and Health Survey used a 24-hour dietary recall method to collect food intake data.

- In addition, the SALTURK II study collected discretionary salt use during eating at the table by pre-estimating the amount of salt (in grams) that was released by one shake of 12 different salt shakers (with a different number and size of holes). The pre-estimated amount of salt released in one normal shake during a meal was calculated by the average amount shaken out by 12 individuals. All participants then self-reported how many times they added salt to each meal.

Step B2: Obtain data on the sodium content of foods (food composition data)

- Both surveys had already calculated the mean sodium content of foods.

- In the SALTURK II study, the sodium content of most foods was obtained from the United States Department of Agriculture (USDA) National Nutrient Database. The mean sodium content of bread in Turkey was estimated by a previous study which chemically analysed (titrimetric method) 100 breads from seven regions and 46 provinces of Turkey.[76]

- In the National Nutrition and Health Survey, the BeBis Nutrient Composition Database was used, which contains nutrient data on Turkish dishes and is supplemented with other data sources, such as Turkomp (a Turkish food composition database developed by the Scientific and Technological Research Council of Turkey), the German Nutrient Database (BLS), the USDA National Nutrient Database, and more.

Step B3: Calculate current food intake and sodium contribution of different foods and other sources

- The current sodium contribution from foods was calculated at high food group levels.[74]

- The total mean sodium intake calculated from the dietary survey was 4721 mg/d (12 g/d of salt): 55% was from processed foods (34% from breads); 30% from discretionary salt added during cooking or food preparation; 11% from discretionary salt added during eating (after cooking); and 4% from foods naturally containing sodium (detailed in Table B).

- The target (30% reduction) mean sodium intake was <3305 mg/d.

- Table B outlines the current mean sodium contributed by each source in mg/d and as a percentage.

Step B4: Identify relevant sodium content targets for manufactured foods

- Bread was the major contributor (34%) among manufactured foods, followed by breakfast foods (cheese, olives, butter, eggs, etc.), which contributed 13%, pickles (3.4%), and meat, poultry and fish products (2.1%).

- The mean sodium content of bread was 716 mg/100 g. The United Kingdom target for mean sodium content of bread is 360 mg/100g – half the current sodium content in Turkey. Sodium content of Turkish breads in the bottom 10th percentile (i.e. with the smallest sodium content) was approximately 510 mg/100g, so 360 mg/100 g is not likely to be a feasible target. Instead, a 40% reduction in the current mean sodium content was modelled on the basis of a meta-analysis which found reductions up to this level did not affect consumer acceptability.[53]

- The 2010 National Nutrition and Health Survey found that mean sodium intake from foods only (excluding discretionary sources) was 2021.5 mg/d, which is slightly lower than the sum of sodium from breads and other processed foods (2596.4 mg/d) estimated in the SALTURK II study. However, despite differences in methodologies, the top food contributors identified in the 2010 survey were consistent with the SALTURK II study, with breads and bakery products contributing the most sodium (46%), followed by olives (22%) and cheese (15%).

Step B5: Calculate reductions required in sodium content of foods and discretionary salt use to achieve a 30% reduction in population salt intake

- Lowering mean sodium content of bread to 430 mg/100 g (40%) reduced sodium contributed by bread from 1613 mg/d to 968 mg/d.

- A 30% reduction in discretionary salt used during food preparation and during eating was required, bringing sodium from discretionary salt down from 1967 mg/d to 1377 mg/d.

- In addition, sodium from processed foods (other than breads) would need to be reduced by 20%. This comprised high-level food groups (breakfast foods contributing 13%; pickles 3%; meat, poultry and fish 2%; others 2%). Data on smaller food groups (e.g. each food item under breakfast foods) were not available, so target sodium content could not be assigned.

- In total, the modelled reductions would bring current mean sodium intake down from 4760 mg/d to 3328 mg/d – a 30% reduction.

- The main limitations of the model were that a more detailed breakdown of sodium contribution by food groups was unavailable for the SALTURK II study and that the sodium content of foods (other than breads) was not derived from local data but borrowed from the USDA National Nutrient Database. It should also be noted that salt intake measured through 24-hour urine collection in the SALTURK II study was 14.8 g/d, so it is likely there is some underreporting in the dietary survey which estimated salt intake of 12 g/d.

[B] Using the salt model to guide the design of salt reduction strategies

- Although the Turkey salt reduction model appears simple, it still provides useful guidance on how to feasibly achieve a 30% reduction in mean salt intake. In contrast to many other countries (e.g. countries consuming a Western diet), the sodium contribution from processed foods in Turkey is less widely dispersed across the food supply. The salt model suggests that the two main food groups currently contributing the most sodium are breads and breakfast foods (olives, cheese, butter, etc.). Strategies to encourage reformulation of these food groups to achieve a lower sodium content is crucial (particularly breads, which have higher mean sodium content than in other countries). Turkey already has maximum sodium limits for these product categories (600mg/100g of dried matter for bread; 3200mg/100g for olives; and 1200–3000mg/100g for cheeses), however this exercise indicates they may need to be further reduced, given their important contribution to sodium intake.[77] Such an approach could be supplemented with improved front of pack labelling and targeted education on reducing consumption of these foods. In addition, strategies to encourage consumers to use 30% less discretionary salt are required, as discretionary salt added by the consumer contributes about 40% of total salt to the diet.

Table B. Turkey model to achieve 30% reduction in salt intake

Sources	Current		Modelled reductions	
	Current sodium intake (mg/d)	Sodium contribution (%)	Target mean reduction (%)	Sodium decrease by meeting target (mg/d)
Salt added to foods during preparation or cooking	1416.2	30	30	424.9
Salt added during eating	550.8	11	30	165.2
Breads	1612.9	34	40	645.2
Processed foods (other than breads)	983.5	21	20	196.7
Breakfast foods (cheese, olives, butter, eggs, etc.)	609.8	13.0		
Pickles	157.4	3.4		
Meat, poultry and fish products	98.4	2.1		
Dried nuts and fruits	39.3	0.8		
Biscuits and crackers	29.5	0.6		
Other (frozen food, ready-to-eat meals)	59.0	1.3		
Sodium naturally present in foods	196.7	4	0	0
Total sodium reduction (mg/d)				1432

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