Chapter

Systematic Reduction of Excessive Salt Intake

Boris Kovač and Urška Blaznik

Abstract

This chapter emphasizes the health outcomes connected with excessive salt consumption and focuses on possibilities to reduce dietary salt intake. The biggest reductions in salt consumption in the population could be achieved by comprehensive strategies involving population-wide policies (regulation, mandatory reformulation and food labelling). Salt reduction policies include the baseline identification of population's salt consumption and major sources of salt in the diet, reformulation of a set number of products available on the market and increased awareness and knowledge on salt reduction at an individual level, creating an environment for salt reduction and the promotion of 'healthy food'. Innovative reformulation by food industry, therefore, has the potential to contribute substantially. Flavours of processed foods could be improved by partially replacing salt with salt substitutes and flavour enhancers. One of the approaches of salt reduction is 'gradual reduction without the consumer's knowledge', which refers to the observation that people in general are unable to differentiate between two substances in which the difference in salt content is low. It is suggested that increased knowledge and appropriate promotion of healthy food and healthy dietary habits, especially in early childhood in kindergartens, schools and at home, are the most promising measures for salt reduction.

Keywords: excessive salt intake, cardiac diseases, products reformulation, salt reduction policies, adequate dietary habits, WHO

1. Introduction

Salt is the primary source of sodium, and high salt intake is associated with hypertension and increased risk of heart diseases and stroke [1–4]. It is well known that high salt intake is the major cause of raised blood pressure and accordingly leads to cardiovascular diseases. Well-conducted cohort studies and few intervention trials showed that a lower salt consumption is connected with lower risk of cardiovascular events [4–6]. Studies [7–9] also suggest a link between excessive salt intake and gastric cancer and type 1 diabetes. A modest reduction in salt intake has a significant effect on blood pressure both in individuals with raised blood pressure and in those with normal blood pressure. These findings provide additional support for a reduction in population salt intake. Furthermore, the meta-analysis [5] shows a dose-response correlation between the reduction in salt intake and the drop in blood pressure. Sodium reduction results in a decrease in blood pressure in normotensives; decrease in hypertension; a significant increase in plasma renin, plasma aldosterone level, plasma adrenaline and plasma noradrenaline; an increase in LDL cholesterol; and an increase in triglyceride [10]. Systematic study and meta-analysis of prospective studies [8, 9] show that dietary salt intake is directly connected with the risk of gastric cancer in prospective population studies—the bigger the consumption of salt, the greater the risk of cancer. An overview study suggested [9] that dietary salt restriction as part of medical nutritional therapy would be useful in patients with type 1 diabetes, while the association between dietary salt intake and health status in patients with type 2 diabetes are confusing. Recently, some studies have shown that high salt intake is correlated with an increased risk for obesity [11, 12]. One of the reasons for this correlation could be the fact that high salt intake stimulates thirst and increases fluid intake and therefore increases the consumption of sugar-containing beverages [13]. The connection between salt intake and obesity may also be partially caused by excessive consumption of processed food that is high in both calories and salt. However, more and more evidence suggest that excessive salt intake is a potential risk factor for obesity regardless of energy intake [11, 13].

It is also recommended to reduce sodium/salt intake in children in order to control blood pressure. These recommendations recognise that salt reduction is compatible with salt iodization, which is considered as a key public health measure for assuring adequate iodine intake in iodine-deficient countries. Sufficient dietary intake of iodine is crucial for preventing iodine-deficiency disorders such as goitre, neurocognitive impairment, hyperthyroidism and hypothyroidism [14, 15]. Iodized salt used for cooking and at the table in households continues to be the major source of iodine in many countries around the world [15]. Dietary salt reduction should be complementary also with the increased level of potassium consumption. Epidemiological studies suggest that for determining the relation between blood pressure and cardiovascular disease risks, the optimal sodium-to-potassium ratio may be more important than individual levels of sodium and potassium [16, 17]. Potassium is commonly found in a variety of unrefined foods, especially fruits and vegetables; food processing reduces the amount of potassium in many food products, and a diet high in processed foods and low in fresh fruits and vegetables is often lacking in potassium. On the other hand, it is important to stress that excessive potassium intake could be reached by consuming some salt replacers. Consumed in excess, potassium may be harmful for some people with kidney problems.

2. Dietary salt reduction policies

Increasing production of processed food, rapid urbanisation, and changing lifestyles are transforming dietary patterns. Highly processed foods are more and more available and are becoming more affordable. People around the world are consuming more energy-dense foods that are high in saturated fats, sugars, and salt. The evidence supporting global actions for a moderate reduction in salt consumption in order to prevent cardiovascular diseases are strong as recently demonstrated in a scientific statement from the European Salt Action Network (E.S.A.N.) by Cappucio et al. [18].

The overall goal of the global salt reduction push is a 30% relative reduction in average population salt intake towards the World Health Organisation (WHO)—recommended level which is less than 5 g per day for adults [19]. This is the only a nutrition-specific target and a core component of the Global Action Plan for the prevention and control of noncommunicable diseases 2013–2020 [20], which aims to achieve a 25% reduction in premature mortality from avoidable noncommunicable diseases (NCDs) by 2025.

The number of countries that are taking action on salt reduction is increasing, but further action is critical to reduce the health consequences of consuming too much salt, particularly in low- and middle-income countries where the risk of

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death from high blood pressure is more than double that in high-income countries [21]. The WHO has been promoting the use of the SHAKE tools to assist Member states technically [22]. Strategies for salt reduction will differ in each setting, but it is likely that the main element of the strategy will be a combination of actions targeting consumers, industry, and government in addition to strong leadership and political commitment [23].

Important elements in interventions to reduce salt intake in the population, set out by the SHAKE package [22], are:

- government policies—including appropriate fiscal policies and regulations to ensure that food manufacturers and retailers produce healthier foods or make healthy products available and affordable;

- working with the private sector to improve the availability and accessibility of low salt products;

- consumer awareness and empowerment of populations through social marketing and mobilisation to raise awareness of the need to reduce salt intake consumption;

- creating an enabling environment for salt reduction through local policy interventions and the promotion of 'healthy food' settings such as schools, workplaces, communities and cities; and

- monitoring of population salt intake, sources of salt in the diet and consumer knowledge, attitudes and behaviours relating to salt to inform policy decisions.

Recent systematic review of salt reduction interventions by Hyseni et al. [24] introduced 'effectiveness hierarchy' of interventions (**Figure 1**) that suggested the biggest reductions in salt consumption in the population could be achieved by comprehensive strategies involving 'upstream' population-wide policies (regulation, mandatory reformulation and food labelling). This is particularly emphasized in middle-to-low income countries, as this is the only way to successfully change the food environment and thereby achieve a reduced salt intake in the population [25, 26]. 'Downstream' individually-based interventions appeared relatively weak

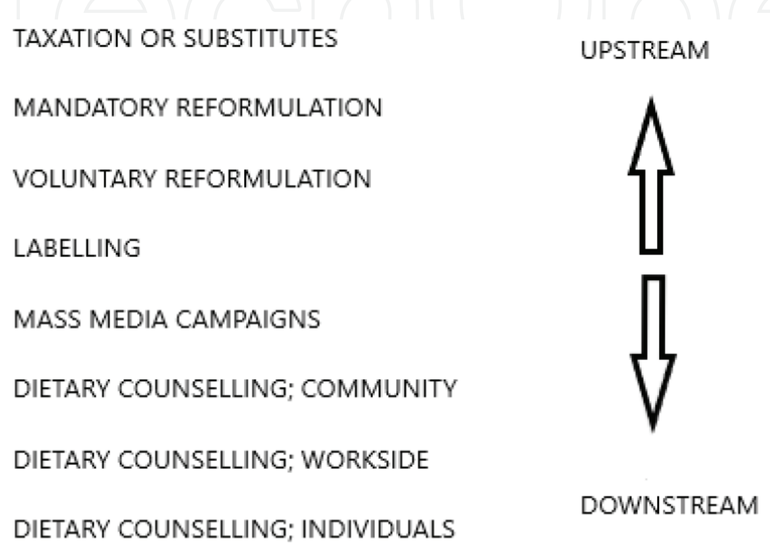

Figure 1.
Interventions classified on the upstream/downstream continuum; adapted from [24].

(e.g. dietary counselling for individuals, media campaigns in isolation). Effects of population-wide policies size from 4 g/day in Finland in Japan, 3 g/day in Turkey and 1.3 g/day in the UK. It has been estimated that mandatory reformulation alone could achieve only a reduction of approximately 1.4 g/day.

Different countries are currently at different stages in the development and/or implementation of salt reduction initiatives. In the United Kingdom, the Scientific Advisory Committee on Nutrition published its Salt and Health report already in 2003, which recommended that salt intake should be reduced to no more than 6 g/day for adults. Government in 2006, challenging the food industry to reduce salt in everyday foods, first introduced salt targets. Salt reduction has been ongoing for more than a decade, and many food categories have shown much improvement, with some products like breakfast cereals now 40% less salty than a decade ago [27]. EU salt reduction activities within E.S.A.N. consider development and alignment of product-specific targets, expanding methods of monitoring food composition, modelling the health impact of efforts and enhancing the knowledge about consumer attitudes, knowledge and behaviours [28]. In the USA, salt reduction work spans across federal, state, and local government agencies. Voluntary efforts by the food industry have been unsuccessful in lowering overall salt intake; further changes in the food supply are needed to bring salt intake within recommended levels [29]. The Australian Federal Government launched Food and Health Dialogue (FHD) in 2010. The focus of the FHD has been on voluntary reformulation of foods, primarily through salt reduction targets [30]. Later in 2015, the Victorian Salt Reduction Partnership (VicSalt Partnership) started bringing together health and research organisations to develop an action plan for salt reduction interventions at a state level [31]. In conclusion, salt reduction activities are currently being implemented through a variety of different programs, but additional efforts and more robust national monitoring mechanisms are required to ensure that countries would achieve the proposed 30% reduction in salt intake within the next decade.

More than 75% of dietary salt comes from the processed foods [32]. Some of the highest contributors of salt to our diets include condiments including table salt, followed by cereals and cereal products (including bread and some types of pizza), meat and meat products (including processed meat such as bacon, ham and sausages) and dairy products (including cheese) [33–35]. Product reformulation by food industry has, therefore, the potential to contribute substantially. However, in order to reduce intakes successfully, consumers need to be encouraged to reduce their salt intake by making healthier food choices and limiting salt used in cooking and added at the table [36–38].

Consumer food selection can be guided by effective and accurate labelling and marketing of food. In salt reduction, the purpose of labelling is to lead food selection towards healthier choices that contain less salt. Nutrition labelling, particularly front-of-pack labelling, may also encourage reformulation of food products. There are a variety of both voluntary and mandatory nutrition labelling systems in use around the world, most commonly applied to pre-packaged food and beverage products. While nutrient declarations (including salt) have to be displayed on all pre-packaged foods, 'front-of-pack' labelling can be used as an additional tool by displaying easily understood information about the nutrient quality of food products (nutrition claims) [39]. Consumers are appealed in salt reduction campaigns to regularly check front-of-pack labels for salt content or scan the barcode using free food scanner apps.

Salt should be seen in the crowded nutrition space, particularly in view of the current consumer concerns around other nutrients, like sugar. Using targeted messaging to highlight the harmful impact of salt on health outcomes was identified as a motivator for behavioural change. For example, the UK government used the message 'Salt Kills' in the first stage of their campaign [37]. In Finland, high-salt warning labels were placed on high salt foods from 1993, resulting in both a decrease in salt intake and reformulation of foods to reduce salt [40]. With reducing salt in the food products, the maintaining consumer acceptance of the products is a challenge. Consumer's perception of salt-reduced foods is of crucial importance for their market success.

Choosing products with lower salt content is one of the possibilities; there are still improvements in eating habits at home. Salt consumption can be reduced by not adding salt during the preparation of food, not having a saltshaker on the table and limiting the consumption of salty snacks.

The knowledge, attitudes and behaviours related to dietary salt intake in high-income countries are low. The same is true for the middle- and low-income countries [41, 42]. Consumers are aware of the health outcomes of a high salt intake, but the fundamental knowledge regarding recommended dietary intake, sources in food and the relationship between salt and sodium is lacking. If in countries with higher income we note that knowledge and more healthy behaviour increase with increasing education, some studies from countries with medium or low income these correlations are not noticed. Their awareness is low regardless of the level of education [42, 43]. Raising awareness of the health impact of salt consumption and the major sources of salt in diets will help to influence consumer behaviour. Strategies that are targeted at behavioural change can then be used to empower people to improve their diets and increase demand for lower-salt food products [44, 45].

Education and communication strategies can lead to changes in social norms relating to salt consumption, increased demand for healthier and lower-salt products, and improvements in overall health for individuals and communities. Economic evaluations clearly show that health education strategies are found to be cost-effective in low- and middle-income countries [46]. Improved health literacy might influence nutritional habits and well-being. However, empirical research on this topic is limited and connection between food and health literacy and diet still needs to be established [47].

Traditionally, dietary recommendations have been set at the average population level. To affect behaviours relating to salt reduction, mass media campaigns are widely used. Typical campaigns place messages not only in media with large audiences such as television or radio, but also on billboards, posters, magazines and newspapers. However, current research is increasingly showing that the risks, benefits and nutritional requirements strongly vary between different population groups depending on their characteristics. Salt reduction campaigns should therefore use innovative social platforms such as the internet, mobile phones, and personal digital assistants to deliver messages to individual's social network [47]. Salt reduction campaigns, designed as mass media or at the individual level, should be properly planned and preferably be multiyear programmes rather than one-off initiatives.

Individuals, who already have elevated blood pressure, and any of the cardiovascular diseases, are advised to decrease salt intake from food [10], so they can follow all salt reduction strategies. A special sub-group of people who have a disease or who are taking medication that can lead to hyponatremia or acute build-up of body water or need a controlled diet may have specific links between sodium intake and health outcomes, and therefore, they require physician-supervised diet [15].

3. Possibilities of salt reduction in food products by reformulation

The experiences of the countries that have introduced salt intake reduction measures in the diet of the population show that it is necessary to systematically and gradually reduce the consumption of salt. Salt (NaCl) affects different properties of food: flavour, preservation and texture. All this happens to different extents depending on the type of food product. Reduction of salt in food products is relatively simple if the salt is used only for a sensory aspect. As some salt is needed in foods for functional reasons, engagement with the food industry is an essential first step to understanding the feasibility of reductions in specific foods as well as to encourage reformulation efforts [22]. Lack of salt in a food product can lead for example to unstable meat emulsion products or bread that stales quickly and has frail texture and lighter crust colour. One of the strategies when dealing with texture issues with low salt content is to find solutions that have ionic strength similar as salt. Salt reduction, therefore, means balancing between taste and side effects. When preparing, for example, meat products, salt is not added only to make food tasteful, the salt also extends the shelf life of dried products. NaCl is used as an essential ingredient in processed meat because of its antimicrobial effect, the ability to enrich the flavour of the product and its functional ability to dissolve myofibrillar proteins, which increases the adhesion and cohesiveness of meat particles in processed meat products [48]. The antimicrobial effect of salt is based on its ability to reduce water activity. Inhibition of the growth of microorganisms is in correlation with the amount of salt present in the aqueous phase of food. Adding sodium ions to the meat causes water loss through the semipermeable membrane of bacteria. Water loss is an osmotic shock that can cause bacterial cell death or cause serious injury, resulting in a significant reduction in bacterial activity [48]. Salt can also affect oxygen solubility, reduce enzymatic activity, or consume energy to exclude sodium ions from cells, which can reduce the growth rate of microorganisms [48].

However, taste and microbial stabilisation are not the only reasons for use of high levels of sodium/salt in food. The level of salt is generally kept high due to the additional practical roles it provides. The presence of salt in meat products solubilises meat proteins, activates extraction of proteins, enhances hydration, water holding capacity and formation of heat-stable emulsions. Salt increases cooking yield and juiciness of the product [49, 50]. The consequences of salt reduction could affect shelf life and quality of processed meat products.

Current approaches of salt intake reduction include decreasing of salt content by stealth, using salt alternatives or using flavour enhancers. Reduction by stealth consists of a step-by-step salt reduction over a longer period of time. The major outcome is that modification in saltiness is not detected by consumers. The result should be acceptable saltiness of the product without apparent organoleptic changes determined by consumers [51, 52]. This strategy shows some weaknesses: it is time-consuming and, in addition, to reach everybody, it needs to be applied on a wide scale. All producers should be uncompromisingly involved in the project, otherwise success would not be reached. It is not realistic to expect the industry to do it voluntarily. The producers should be encouraged by a well-prepared regulation that would gradually limit the amount of salt in products [22]. Although a step-by-step approach to a less salty taste in the initial reduction phase would have to work, in general, only a limited amount of salt could be reduced so that the product would not have an unpleasant taste. An atypical taste is a sufficient reason for not purchasing a product. Only when consumers are informed in terms of salt-reduced product, they can actually indicate a preference for a product that has a significantly lower salt level. Results of many studies show that salt perception is very important for consumer acceptability and a reduction in levels is hard to achieve without using salt replacers [53, 54].

A useful strategy to improve the palatability of reduced salt foods relies on the use of common salt replacing ingredients (salt substitutes). Among several options, potassium chloride (KCl) has proved to be an optimal nutritional ingredient for this purpose [55]. It provides similar properties as common salt (NaCl).

Calcium and magnesium salts have many side effects; calcium chloride ($CaCl_2$) is salty but with many off-tastes bitter, tastes of $MgSO_4$ are usually perceived only at high levels; $CaCl_2$ can cause irritations on the tongue. Bidlas and Lambert's study results confirmed that in any foods, including cheese, bread, and meat, compared to NaCl, KCl calculated on a molar basis has an equivalent antimicrobial effect [56]. KCl has several unwanted side effects, the most important of which are relatively unnatural taints: bitterness, acridity and metallic taste [55, 56]. Commercially available substitutes are usually mixtures of salts containing sodium chloride, potassium chloride and magnesium sulphate. Not many studies [57, 58] have showed that partial substitution of NaCl by salt mixtures resulted in no negative effects on technological and sensory properties. Study on ground beef patties with the potassium chloride, magnesium sulphate and l-lysine hydrochloride salt mixture [57] did not find significant differences in taste compared to those with sodium chloride. However, the results of Gou et al. [59] are opposite. They evaluated the effect of substitution of sodium chloride with potassium chloride, potassium lactate and glycine on texture, flavour and colour of fermented sausages and dry-cured pork loins. Results confirmed that even partial substitution of sodium chloride with potassium chloride has generally negative effect on sensory properties and texture of a product.

Grummer et al. [60] have analysed the use of mineral salt replacers to reduce the sodium content in cheese; mixtures of NaCl or sea salt with KCl, modified KCl, $MgCl_2$, or $CaCl_2$ were used. Both calcium and magnesium chloride resulted in considerable off-flavours (bitter, metallic, unclean and soapy flavours), while potassium chloride did not result in any side effects.

We can conclude that side effects of alternative recipes are in correlation with nature of the basic material and concentration of salt substitutes. Consumed in excess, potassium may be harmful for some people. Many persons with kidney problems are unable to excrete excessive potassium, which could result in a risky situation what we already pointed in introduction. Persons taking cardiac, kidney or liver medications better check with their personal doctor before using salt substitutes instead of sodium.

Flavour enhancers are another category of ingredients used to replace the flavouring properties of salt. The most frequently used flavour enhancers are yeast extracts, yeast and vegetable protein hydrolysates, glutamic acid, monosodium glutamate and various nucleotides. Sausages and similar processed meat products are items in which lower-sodium content options have been successful. When flavour enhancers are used, structural functions of salt-soluble proteins need to be partially replaced by the addition of gums, soy or milk proteins and starches [61, 62]. Yeast extracts can be successfully added to any type of food. Functionally, they are used to cover any unwanted bitterness that addition of potassium chloride may have [62]. Hydrolysed vegetable and yeast proteins are flavour enhancers containing high levels of glutamate that also help initiate the umami taste. Partial replacement of salt with monosodium glutamate ($<1.0\%$) did not result in negative sensorial properties of pork patties, although some studies [63] found high deterioration in quality, such as high cooking loss. Some of L-arginyl dipeptides were recently identified as salt flavour enhancers, in consequence, a possibility to reduce dietary salt intake without compromising palatability is raising [63].

Using spice blends and herbs is a promising alternative to improve the quality of reduced salt food products. By giving a spicy flavour and different aroma, these blends can also suppress or diminish negative effects caused by the use of potassium chloride and other replacers. In general, the alternative is easy to apply in industry, restaurants or at food preparation at home.

4. Development of adequate dietary habits in early childhood

Children's eating habits are established in the preschool period. This process is affected by family eating habits as well as preschool nutrition in kindergartens where children usually spend most of the day and consume most of their daily meals. Both, genetic predisposition and learned experience from environment influence children's preferences to salt. The review study [64] states that although the liking of salty food starts as unlearned response in early infancy, this liking soon develops as a result of repeated exposure to salty food. Generally speaking, a low exposure to salty food in infancy is associated with low preference for salty food [64]. No study suggested that decreasing the exposure to salt during infancy is associated with an increased liking of desire for salty foods.

Concern for the quality of food and children eating habits in preschool is, therefore, extremely important for the development and formation of eating habits later in life [64, 65]. Children learn about food through the direct experience of eating and by observing the eating behaviours of others.

Many authors tried to determine whether children find a food product with reduced salt content different enough to assess it as worse than the product with normal salt content [65]. Whether a food is liked or disliked is an important determinant of food intake, especially among children. Salt contributes to the taste of foods and makes them more enjoyable. Salt level has generally a positive impact on the intake of the target foods [66, 67]. Research found that 4-month-old infants identified and selected salted and not plain water, which indicates their salt taste perception mechanism. Six-month-old infants who were fed salty starchy table food retained their tendency towards salty foods later in childhood [68]. Results of the research showed that children aged 4 or more prefer salty foods to unsalted ones. Various studies have shown that after consuming food with reduced salt content for a certain period of time (up to 12 weeks), the preferred level of salt in food is lowered to such a level that foods with high salt content become unpleasant for the subjects [69]. Results of recent research provide evidence that promoting responsive feeding practices can alter the development of eating behaviour, sleep patterns and early self-regulatory skills, as well as reduce the early obesity risk [70]. In a study conducted by Kovač [65], the response of kindergarten children to less salty bread and the role of teachers and teacher assistants in the introduction of novelties into children's nutrition were studied. The purpose of the study was to identify the possibility of unnoticed reduction in salt content of bread as a basic food in the diet of preschool children. The children were not previously told to pay attention to the saltiness of the product. They evaluated the product as a whole. Using emotional faces, the children explained what they thought of the bread they ate. Despite the limitations of the hedonic evaluation, the results gave essential answer—children like bread with reduced salt content. Results demonstrated that 30% reduction in salt was not registered, while a 50% reduction in the salt content, compared to the original recipe, although noted, was not disruptive. These findings partially correspond to the results of Girgis et al. [71] whose results showed that a 25% salt reduction could be made without being noticed. However, the results of the study indicate that children also accept breads with a 50% reduction in the salt content, compared to the original recipe, although the results of some previous studies suggest that children prefer salty foods to unsalted ones [65]. Children did not associate those breads as 'less salty'.

When children go outside their familiar environment, they are influenced by role models. Children look up to different role models in order to help shape their behaviour in school, their relationships, and also making decisions concerning the food. The effectiveness of a child's role model in food preferences depends on the relationship between the child and the role model. For many young children, the most important role models are their parents and caregivers, older people or celebrities. Children also look up to other relatives, teachers and peers. Peers in kindergarten play an important role in shaping children's eating habits [65]. The results of survey [65] and its qualitative answers indicate that educational personnel have a significant impact on children's preference for a specific product or specific taste.

We can conclude that the environment young children live in, in particular, the persons with whom they are in close contact, is also important when formulating eating habits and influencing children's acceptance of reduced salt taste.

5. Conclusions

High salt intake is the major cause of raised blood pressure and accordingly leads to cardiovascular diseases. The overall goal of the global salt reduction push is a 30% relative reduction in average population salt intake towards the WHO-recommended level that is less than 5 g per day for adults.

The availability and accessibility of low-salt products is a very important part of salt reduction measures. Current approaches of reformulation include decreasing of salt by stealth, using salt substitutes, or using flavour enhancers. The most preferred option, especially when preparing food, is the use of fresh or dried spices to flavour the dishes. Consumer awareness of the need to reduce salt intake consumption should be enhanced by effective and accurate labelling and marketing of food. Creation of an enabling environment for salt reduction and promotion of healthy food and healthy dietary habits are the most promising measures especially in early childhood; at home, in kindergartens and schools. Such an approach could represent a basis for creating healthy dietary habits, which will be of particular importance for their whole life. WHO has stated that reducing salt intake has been identified as one of the most cost-effective measures countries can take to improve population health outcomes. Salt reduction measures will generate an extra year of healthy life for a cost that falls below the average annual income or gross domestic product per person. An estimated 2.5 million deaths could be prevented each year if global salt consumption were reduced to the recommended level [20].

Conflict of interest

The authors declare that no conflict of interests exist.

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