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Population reduction in salt intake for the prevention of cardiovascular disease: the "Four Imperatives"

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Abstract

Salt consumption is now much greater than needed for survival. High salt intake increases blood pressure in both animals and humans. Conversely, a reduction in salt intake causes a dose-dependent reduction in blood pressure in men and women of all ages and ethnic groups, and in patients already on medication. The risk of strokes and heart attacks rises with increasing blood pressure, and a reduction of blood pressure with drugs reduces the risk. However, most events occur in individuals with 'normal' blood pressure levels. Non-pharmacological prevention is therefore the only option to reduce such events in the population at large. Reduction in population salt intake reduces the number of vascular events. It is one of the most important public health measures to reduce the global cardiovascular burden. Salt reduction policies are feasible and effective (*preventive imperative*), cost-saving (*economic imperative*), powerful, rapid, equitable (*political imperative*) and life-saving (*moral imperative*). The World Health Organization recommends reducing salt consumption by 30% globally by 2025, aiming to reduce salt consumption to less than 5g per day, eventually.

***Keywords**:* salt, sodium, population, reduction, blood pressure, CVD, policy, WHO.

Introduction

Sodium is a cation mainly consumed as a component of sodium chloride (or Salt). One gram of sodium is contained in 2.5 g of salt. Salt can be found in nature in a variety of appearances, textures, colours, odours, and it is not always the 'white stuff' we often find on our table. However, in all its natural forms it contains >97% sodium chloride [1].

What is "normal" salt consumption? We should make a distinction between what is 'normal' and what is 'usual' salt consumption. No-one has 'normal' salt consumption, if we intend to refer to the salt our human ancestors were eating regularly. In modern times very few humans now live that condition, and some have been studied in great details. The Yanomamo Indians, a tribe living like our ancestors in the Amazon jungle between Venezuela and Brazil, live on an evolutionary diet with less than 1g of salt per day, little fat, no refined carbohydrates and plenty of potassium and fiber from fruit and vegetables. Hypertension is rare, there is no rise in BP with age and vascular disease in uncommon. Their male adults average blood pressure is 96/61 mmHg and their average serum cholesterol 3.1 mmol/L (~125 mg/dL) [2]. In modern times our salt intake has increased several folds and our potassium intake has decreased because most of the salt we eat today (>75%) derives from salt added to food during the food manufacturing processes rather than from natural sources. Only about 12% is natural and another 11% is added by us when we cook or at the table before eating our food [3].

The "preventive' imperative

One of the priorities worldwide is to reduce the burden of cardiovascular disease (CVD), which is the first killer in the world with coronary heart disease and stroke. One of the priorities to achieve that goal is to reduce population salt consumption by at least 30% by 2025, with a long-term target to reach no more than 5g of salt per day **[4].** What is the evidence to justify this public health measure?

Observational studies indicate that high salt intake is associated with high blood pressure. The association is not a proof that eating more salt causes the blood pressure to rise, and more importantly, does not prove that if one reduces the amount of salt consumed, one will reduce blood pressure. In one of the first randomized placebo-controlled trials on the effect of salt reduction in humans, people with mild hypertension (i.e. clinically defined high blood pressure) were randomised to three different levels of salt intake, ~3, ~6 and ~10 grams of salt per day, each to be sustained for a month. Adherence to the level of salt consumption was monitored with 24h urine collections. Systolic and diastolic blood pressure were taken to monitor the response. The blood pressure fell alongside a reduction in salt intake, suggesting a powerful, dose-dependent natural way of lowering blood pressure in people with high blood pressure without the use of drugs **[5]**. The effect was sustained if the salt reduction was maintained, which in the trial was up to one year.

Many have suggested that not all people respond in the same way to a reduction in salt consumption, due to their individual ‘salt sensitivity’, with some even showing a rise in blood pressure when reducing salt consumption. The range of the blood pressure response to salt reduction follows a normal (Gaussian) distribution **[6].** The distribution shifts to the left when reducing salt intake and on the right when increasing it, with an average response that moves in the same direction, lower on low salt than on high salt. However, ‘within’ an individual this response is variable from time to time so that it is not possible to categorically classify an individual as salt-sensitive or salt-resistant. In other words, none of the methods used to classify people are sufficiently reproducible within an individual and over time to characterize ‘salt-sensitivity’ as dichotomous. Therefore, there is limited scope in the clinical setting to attempt to identify individuals for a targeted approach. On the other hand, there are some characteristics that predict a greater response to salt reduction, as older age, African ancestry, overweight, higher blood pressure, presence of type 2 diabetes **[2]**.

Since the publication of the few early placebo-controlled trials, more than 100 clinical trials have been carried out and many meta-analyses published. Their results, irrespective of different inclusion or exclusion criteria, showed a consistent message: reducing salt intake lowers both systolic and diastolic blood pressure **[7].** The effect of reducing salt intake on blood pressure is dose-dependent: the more you reduce salt, the more the blood pressure falls (Fig. 1a).

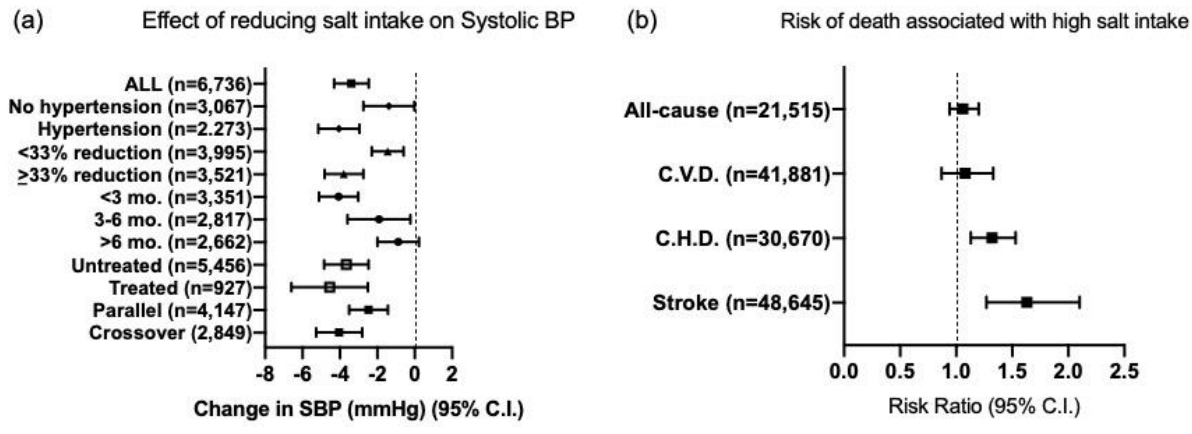

Figure 1: Meta-analysis of [a] randomised clinical trials on the effect of reducing salt intake on systolic blood pressure and [b] of prospective population studies on the risk of all-cause and cause-specific mortality associated with a high salt intake (Modified from **[7]**).

The blood pressure effect of salt is reflected in a detrimental effect on CVD outcomes **[7]**. Meta-analyses of prospective population studies have suggested that a high salt consumption is associated with adverse vascular outcomes. In particular, a difference in ~5g of salt per day (like going from 10g to 5g per day) was associated with a 23% difference in the incidence of fatal and non-fatal strokes in one case **[8]** and 63% in a subsequent update **[7]** (Fig. 1b). In further prospective studies, the relationship between salt consumption, measured by multiple 24h urine sodium determinations, and both CVD outcomes and all-cause mortality proved to be graded and linear across the range of salt consumption seen in most populations **[9-10]**. Finally, in randomized clinical trials where it was possible to measure the effect of a period of salt reduction on vital CVD outcomes, there was a statistically significant 20% reduction in total CVD events **[11].**

There have been claims of a J-shaped curve between salt intake and CVD mortality, with suggestions that moderate salt reduction could be harmful. These claims are based on flawed methodologies leading to erroneous results **[12]**. In brief, 24h urinary sodium excretion has been for decades taken as the gold standard biomarker of daily salt consumption to be used to assess both individuals' and populations' average salt intake. The method of collecting 24h urines is no doubt more demanding for patients, clinicians, researchers, patients and healthy participants than administering or responding to a dietary questionnaire. However, it has been successfully used for decades in both clinical and epidemiological research. Searching for easier alternative methods to assess daily salt consumption have been proposed and tested. Amongst them is the application of mathematical equations to 'predict' daily excretion from the sodium output in a single 'spot' urine collection. These methods, whilst now widely used, provide biased estimates when results are compared to the use of 24h urine collections. The consequences for the assessment of both individuals' salt intake and average populations' salt intake are far reaching **[13-14]**. An example of the bias introduced when using 'spot' urine collections to derive usual salt consumption, compared to the use of 24h collections and the consequences when using these estimates in prospective population studies is illustrated in Fig.2.

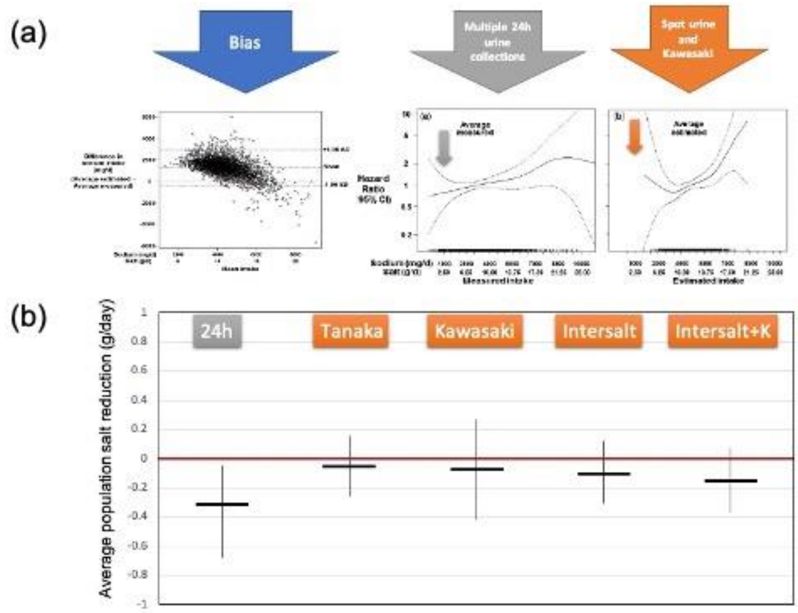

Figure 2: Common flaws in assessing salt consumption and biased interpretations of results: [a] bias detected during the validation and comparison of the Kawasaki formula to estimate 24h urinary sodium excretion from a single morning spot urine sample in 1,083 participants from 11 countries the PURE Study (re-drawn **[15]**) and head-to-head comparison of the estimate of relationships with salt intake and mortality by using the two methods (re-drawn from **[12]**); [b] head-to-head comparisons of an evaluation of effectiveness in a 2-year salt reduction programme in China using 24h urinary sodium excretion or 'spot' urine collections with various formulas to estimate sodium excretion (hence intake) (re-drawn from **[16]**).

There is a large overestimation at low levels of intake and an underestimation at higher intakes (Fig. 2a, left) **[12].** This bias leads to a spurious J-shaped association with mortality (Fig. 2a, right) which is not present when using 24h urine collections (Fig. 2a, middle) **[12].** Furthermore, the use of a spot urine collection would not have the same power to detect small but important changes in average sodium excretion over time in repeated population surveys **[13-14].** This is clearly shown in the China Salt Substitution Study, in which both 24h and 'spot' urine collections have been used to monitor the effectiveness of a population intervention programme **[16].** The use of 'spot' urines would fail to detect important effects of salt reduction strategies compared to the use of 24h urines (Fig. 2b). This would have negative implications in supporting further actions to strengthen public health policies **[13-14].**

Salt reduction is a *preventive imperative* since [a] salt intake is higher than needed, [b] its reduction causes a dose-dependent reduction in BP, [c] it is associated with lower vascular events, [d] it is feasible and effective.

The 'economic' imperative

The applications of policies to reduce salt intake across the entire population is an effective and cost-saving public health measure. Several studies have assessed the health effects and the healthcare-related costs of reducing population salt intake. They have demonstrated that a reduction in salt intake is cost saving for the healthcare systems **[17]**. Obviously, the economic benefits due to reduced healthcare as well as social costs will vary across countries. For instance, in high-income countries like the US, estimated savings of a population salt reduction of 1g per day would be between $10-24b per year **[18]**, whereas in Finland the same reduction would save €146m over 20 years **[19].**

The strategies of government supported policies to reduce salt consumption in populations mainly include "soft" regulations like targeted industry agreements, government monitoring and public education. Globally, a 10% reduction in salt consumption over 10 years is estimated to avert ~5.8 million DALYs/year attributable to CVD, for an average weighted cost of International $ 1.13 per capita over 10 years, making the strategies affordable everywhere **[20]**. From this and other evidence there is an *economic imperative* in reducing salt intake. In every country studied, [a] there would be a significant return on investment, [b] it would be cheaper than using medications, [c] if 'harder' strategies were used (like mandating food reformulation from industry) it would even be cost-saving.

The "political" imperative

The components of the strategy being adopted by the World Health Organization (WHO) and most national health organization to reduce the population consumption of salt over the next few years to achieve a reduction in salt intake towards the final targets of no more than 5g per day is often defined as the "three-pillar approach" strategy based on communication, reformulation and monitoring **[21]** (Fig. 3).

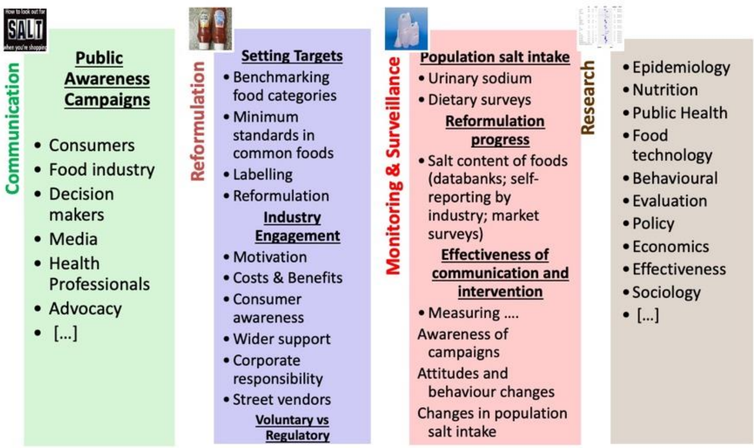

Figure 3: Components of a 'three pillar approach' strategy for the implementation of a population salt reduction based on Communication, Reformulation and Monitoring & Surveillance underpinned by continuous Research (adapted from **[21]**).

These three pillars are supported by continuous research to provide new evidence to support further actions. *Communication* involves mainly public awareness campaigns directed at consumers, food industry, decision makers, media and health professionals. *Reformulation* aims at improving the quality of food by reducing the salt content of commercially available food via setting targets of salt content of benchmark food categories in collaboration with industry in the first instance (using a voluntary approach) or, if not achieved, by regulatory actions. *Monitoring* aims at measuring salt consumption in populations with repeated surveys to demonstrate the effective impact of the policies and at measuring the salt content of reformulated food categories to demonstrate the effectiveness of the reformulation activities **[21]**.

The effectiveness of this programme, measured by the amount of salt reduction achieved, becomes greater and cheaper the more upstream measures are implemented, like the involvement of the industry with either voluntary or mandatory food reformulation with reduced salt content **[22]**.

As many other dietary factors associated with cheap, unhealthy, junk food, also for salt we detect an association between high salt consumption and low socio-economic status. This evidence has been seen in Great Britain **[23]** as well as Italy **[24]**. The evidence is consistent whether we define socio-economic status using occupational parameters or educational attainment. In addition, in Britain over 10 years, salt reduction was spread across all social classes, leaving the inequality untapped **[25]**. One of the reasons whereby social inequalities in salt consumption were not reduced or abolished is, in part, attributable to the fact that in Britain there were no mandatory measures for reformulating. Indeed, using different modelling scenarios, the socio-economic gap can only be significantly reduced if mandatory reformulation is considered **[26]**.

There is a *political imperative* to reduce salt consumption. The effect is [a] rapidly achieved (rapid), [b] with substantial health benefits (powerful), [c] it could help reduce social inequalities (equitable).

The "moral" imperative

Salt consumption greater than 5g per day (or sodium >2g per day) currently is responsible for more than 1.65 million deaths from CVD. This is about 10% of all CVD deaths. More than 80% of these deaths are occurring in low-and-middle-income countries, those with the greatest burden of disease and the least resources **[27]**. The *moral imperative* is therefore justified by a simple statement: population salt reduction saves lives.

Why controversy?

The important shift in the public health debate from 'whether' salt reduces the risk to 'how' to best lower salt intake to reduce CVD has not occurred without obstinate opposition from organizations concerned primarily with the profits deriving from population high salt intake and less with public health benefits and risks **[28]**. Among them, the food and beverage industry has been particularly obstructive either directly or through their public relation campaigns. Their strategies have sadly included biasing research findings by co-opting health professionals, researchers and policy-makers who would create uncertainty using poor science and 'pseudo' controversies **[28-31]**.

To fully understand why the food and beverage industry would be so opposed to a global reduction in salt consumption one needs two be aware of two main concepts: (1) salt is a cheap commodity. In 2009, >27m tons of salt were sold in the US alone with a revenue of $2b. Of those, only 1.5m tons were food grade salt sale fetching >$320m (Source: Salt Institute). The use of salt in food manufacturing generates substantial profits for the food and beverage industry. This is a globalized business transcending borders. Most globally marketed food and beverages products are owned by only 10 large multinationals (Fig. 4).

Figure 4: Who owns what in the globalized food and beverage industry.

They collectively feed daily several hundred million people in >200 countries, generating a combined annual revenue of >$422b, as estimated in 2012 (Source: IFBA); (2) given the large profits involved, let us briefly consider why controversies on the role of salt on health may result more beneficial to the food and beverage industry than to the public health agenda. This "cycle of profit scheme" (Fig. 5) briefly illustrates how salt in foods generates profit.

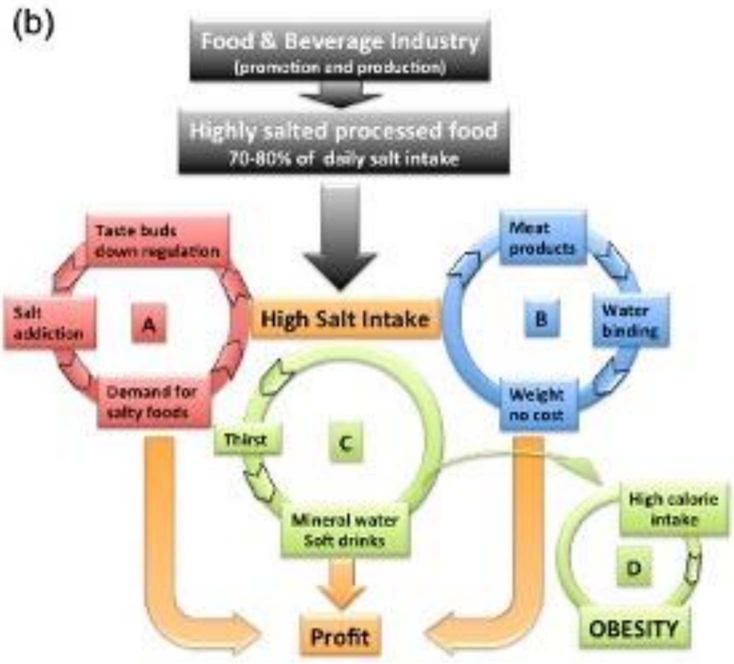

Figure 5: The cycle of profit generated by adding salt to food in production, manufacturing and processing.

(A) it increases *palatability* and *taste addiction*, making bad food edible and increasing demand by downregulating taste buds; (B) through its *hygroscopic properties*, it increases the water content of meat products with increase in weight at no extra costs; (C) it generates *thirst*, it increases drinking, including high-energy sugary as well as alcoholic drinks; (D) this latter effect is contributes to *obesity*, both in adults and in children and adolescents. In adults, reducing salt intake by half (eg: from ~10 g/d to the WHO recommended 5 g/d), would reduce fluid intake by ~350 mL/d per person. This is equivalent to a can of soft drink per person per day **[32]**. In children, a difference in 1 g/d in salt intake is associated with a difference of 100ml and 27 g/d in total fluid and sugar-sweetened soft drink consumption, respectively **[33]**. If salt intake in children in the United Kingdom was reduced by half (mean decrease: 3 g/d), there would be an average reduction of ~2.3 sugar-sweetened soft drinks per week per child (26), causing a significant loss of profit for the industry globally.

Conclusions

Salt consumption is much higher than needed. A reduction in salt consumption causes a dose-dependent reduction in blood pressure. Lower salt intake is associated with lower morbidity and mortality from cardiovascular disease. A population salt reduction programme is feasible and effective (*preventive imperative*), cost-saving in all settings (*economic imperative*), powerful, rapid, equitable (*political imperative*) and life-saving (*moral imperative*). The World Health Organization (WHO) recommends a population-wide reduction in salt consumption as the second most cost-effective public health measure (after tobacco control) for the prevention of cardiovascular disease, the commonest cause of morbidity, disability and death globally. The WHO objective is for a 30% reduction by 2025, aiming for a long-term salt intake not greater than <5g per day.

Declarations

Conflict of Interest

The Author declares that there is no conflict of interest.

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