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Aims and Scope

The journal '*Cardiovascular Diagnosis and Therapy*' (Print ISSN: 2223-3652; Online ISSN: 2223-3660) accepts basic and clinical science submissions related to Cardiovascular Medicine and Surgery. The mission of the journal is the rapid exchange of scientific information between clinicians and scientists worldwide.

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Table of Contents

Preface

Review Article

Original Article

Brief Report

Perspective

Arts and Medicine

Preface

Salt intake reduction efforts: advances and challenges

The articles in this special issue of *Cardiovascular Diagnosis and Therapy* describe the efforts to reduce salt intake in different parts of the world, including South America, Africa, the Middle East, the Far East (China and Mongolia) and Australia, in addition to an overview of the work of the World Hypertension League in this domain. Sharing experiences from diverse regions and countries, these data will contribute to better understanding the challenges and opportunities encountered by the groups working in the field.

The alarming increase in cardiovascular diseases (CVD) in the world has led to numerous calls for preventive measures. One of the cost effective measures, identified as a ‘best-buy’, by the WHO, is salt intake reduction (1). Accordingly, local governmental and non-governmental bodies are working together to develop programs to lower salt intake at the population level by 30% towards the WHO guideline of <5 g/day (2).

The evidence linking salt intake to hypertension and data demonstrating a decrease in blood pressure with salt intake reduction is widely available in the medical literature (3-5). It is based on observational data and also well designed clinical trials. However, ascertaining that salt intake reduction leads to a decrease in hard cardiovascular outcomes (death, stroke, or myocardial infarction) remains a contentious issue. On the one hand, there are members of the scientific community, who continue to demand more rigorous scientific evidence for effectiveness of salt reduction in reducing hard CVD outcomes (6,7). On the other hand, are the majority of pragmatic public health experts who find the existing evidence is strong enough to warrant action and are already advancing. Of note, the latter group is not only supported by the WHO, but also by many other respectable scientific bodies (8-10). These opposing stands were noted by the editorial team during the preparation of this issue, having being raised by several reviewers of the articles presented here. Whilst the impact on blood pressure is undisputed, the question of clinical effectiveness (impact on CVD) of salt reduction is still unanswered in some scientists’ minds and therefore merits continued attention.

On the ground, tremendous progress has been made in relation to the development and implementation of salt reduction strategies. Several regional organizations, such as the World Health Organization Collaborating Centre on Population Salt Reduction at the George Institute in Sydney, the World Hypertension League and the World Action on Salt and Health, have remits to support salt reduction. Previous recent reviews have identified 75 national strategies with programs existing in all regions of the world (11). Most programs include work with the industry to reduce salt in foods, in parallel with initiatives (consumer campaigns and labeling) to influence consumer behavior. Many also include programs to influence food in public institutional settings such as public procurement policies or incorporating nutrition education into school curricula. Establishing targets for salt levels in foods and meals that the food industry had to achieve is a fundamental aspect of many programs. And whilst most programs are voluntary, an increasing number of initiatives such as South Africa, and Argentina, include legislation.

The UK and Finland are examples of national government programs that have already had a significant impact on population salt intake (12,13) (The UK program was initiated in 2003 and in 2012 reported a 15% (1.4 g/day) reduction in salt, and more recently has reported parallel reductions in blood pressure in England estimated to be reducing mortality from stroke or ischemic heart disease by 36% (14). Many other countries are already reporting reductions in salt levels in foods or changes in consumer knowledge, attitudes and behavior which, in time, are expected to result in reductions in salt intake.

The range of articles featured here adds further insights to the growing body of literature on the implementation of salt reduction initiatives. Globally, the brief review from the World Hypertension League highlights how the organization has made advocacy for salt reduction a strategic priority and provides an overview of existing and planned work, including agreed nomenclature for salt, development of fact sheets and the establishment of standards for salt research. From Africa, the review of WHO’s supported interventions shows that, whilst overall progress is slow, countries are in various stages of implementation. South Africa has already established legislation which requires the food industry reduce the salt content of a number of its products, but several other countries are just embarking studies to measure population salt intake.

From the Western Pacific Region, the review from Mongolia shows how the findings from a national stakeholder consultation, baseline monitoring and a series of pilot intervention projects have been used to inform the proposed National

Salt Reduction Strategy from Mongolia (2015-20). It identifies the importance of a strengthened legislative framework and robust monitoring linked to a national stroke surveillance program moving forwards. From China the authors inform us of different policies and community interventions aiming to reduce salt intake and explain regional differences within China. From Australia, we learn about the importance of national NGO and advocacy organizations, and a new State level partnership on salt in Victoria, in encouraging more sustained and comprehensive action to reduce salt.

From the Middle East we observe countries at different stages of implementing salt reduction programs. The majority are targeting salt reduction in bread, which has been identified as one of the major sources of salt intake. The salt content of various types of bread (pita, markouk and others) and commonly consumed cheese products in the area is described in the Lebanese experience. In Kuwait, Qatar and Bahrain local authorities are collaborating with major bakeries to reduce salt in bread products by 10%. This goal has been achieved in Kuwait and ongoing efforts are underway to achieve lower salt levels.

From Latin America, the Brazilian experience describes a setting where one of the largest school meal programs in the world, which reaches up to 42.2 million students, has been modified to promote a healthier more nutritive diet with lower salt content. Interestingly, this is conducted while promoting consumption of products from local farms i.e., strengthening the link between economic success and promotion of healthier diets. A similar large scale intervention aiming to improve the meals of the industry workers is also described. The Argentinian contribution to this issue shows the compliance of the food industry to a national law limiting salt content of their products with more than 84% of products achieving a salt level below the maximum permitted level.

Taken together, the information from these diverse international experiences provides a rich source of inspiration and learning for others working in the field. We anticipate that this focus issue will contribute significantly to the global discussion and exchange of experiences about salt reduction and hypertension control over the next decade.

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Review Article

An overview of salt intake reduction efforts in the Gulf Cooperation Council countries

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Abstract: Globally, morbidity and mortality from non-communicable diseases (NCDs) are increasing steadily and at an alarming rate. High blood pressure is a major risk factor for cardiovascular disease (CVD) and salt reduction is an effective measure to decrease mortality rates. In the Eastern Mediterranean region, current salt intake is high, with an average intake of >12 g per person per day. Reducing the intake of salt has been identified as a priority intervention to reduce NCDs. Countries of the Gulf Cooperation Council (GCC) are showing a willingness to comply with the World Health Organization (WHO) recommendations and an eagerness to reduce the burden of NCDs. However, they face some challenges, including lack of political commitment, lack of experience, and shortage of qualified human resources. Salt intake reduction efforts vary in the GCC region, from achieving 20% salt reduction in bread, to the very early stages of planning.

Keywords: Global disease burden; non-communicable disease (NCD); cardiovascular disease (CVD); risk factor; salt reduction strategies; eastern mediterranean regional office; Gulf Cooperation Council (GCC)

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Introduction

Non-communicable diseases (NCDs) are the leading causes of premature death in the 21st century, and represent a threat to human health and economic growth (1). Currently, 39 million people die each year from NCDs, principally, cardiovascular disease (CVD), cancers, chronic respiratory disease, and diabetes. The main risk factor for the global disease burden is raised blood pressure and is estimated to cause 9.4 million deaths each year. This is more than half the estimated 17 million annual deaths caused by CVD (1,2).

The 2010 World Health Organization's (WHO) global status report on NCDs urged Member States to take immediate actions in reducing salt intake (1). Salt reduction was recommended as one of the top three priority actions to reduce premature mortality from NCDs by 25% by 2025 (3). To achieve this, the WHO recommended a 30% reduction in salt intake by 2025 with an eventual target of 5 g per day for adults and lower levels for children based on calorie intake (1). They also recommended reducing the salt content of food as an effective measure to achieve accelerated results in saving lives, preventing cases of disease, and avoiding costs (2,4). This position has since been endorsed by the 2011 Political Declaration of the UN High-Level Meeting (UN HLM) on NCDs (5) and has led to the development and adoption of the Global Monitoring Framework and Voluntary Global Targets for the Prevention and Control of NCDs. As a result, Member States have agreed upon a global target of a 30% gradual reduction in mean salt intake by 2025 (5,6).

The Gulf Cooperation Council (GCC) includes six countries: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates (UAE). In these countries populations lead a sedentary lifestyle, where high blood pressure (*Figure 1*) and obesity (*Figure 2*) are known to be major contributing risk factors to NCDs (7). Thus, it is not surprising that CVD is the main cause of morbidity and mortality in the Gulf region (8).

The estimated total deaths in GCC countries caused by NCDs range between 65% and 78%, with the highest estimates in Bahrain and Saudi Arabia and the lowest in Oman and Qatar, respectively (7). In the Eastern Mediterranean

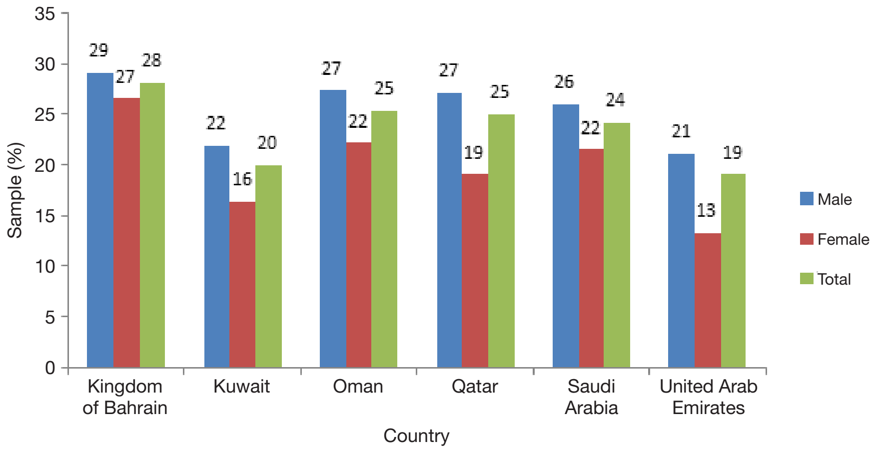

Figure 1 Prevalence of high blood pressure in GCC countries. GCC, Gulf Cooperation Council.

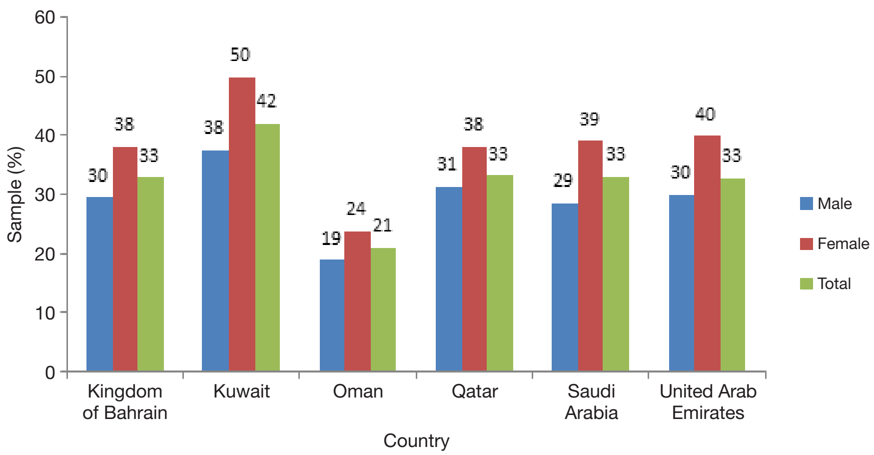

Figure 2 Prevalence of obesity in GCC countries. GCC, Gulf Cooperation Council.

Region (EMR), current salt intake is high, with an estimated average intake of >12 g per person per day in most countries. This is more than double the amount recommended by the WHO. Cereal products, in particular bread, are a popular staple food in GCC countries, and contribute a major part of salt in the diet. When bread (of the same type) was compared between countries in the EMR, a wide variation of salt content was observed (*Table S1*). Therefore, a reduction of the salt level in bread was sought as an effective means to reduce the NCD burden in the region. This article gives an overview of the efforts and initiatives taken by each country in the GCC region to reduce the salt intake and achieve WHO targets.

Salt reduction activities in GCC countries

In 2014, the GCC Executive Board of Health Ministers convened a meeting in Kuwait to discuss reducing the growing burden of NCDs in the region (8). The main risk factors addressed were salt and fat intake reductions to meet the 2025 targets. This meeting urged countries in the region to develop a framework of action with indicators that can be adopted, implemented, monitored and evaluated. The outcome of this meeting was the release of the *Kuwait Declaration for the Control of Non-Communicable Diseases* (8) in which Member States agreed to commit to its recommendations.

Kingdom of Bahrain

Bahrain is an island located near the western shores of the Arabian Gulf with a population of ~1,300,000 people. According to the WHO, CVDs account for 26% of

Table 1 Summary of national projects measuring sodium intake in Kuwait

Study	Sodium intake (mg)	Comments/limitations
Evidence for nutrition transition in Kuwait: over-consumption of macronutrients and obesity	Men: 3,466; women: 2,706 (~8 g salt)	The amount of sodium shown is probably an underestimate because not all foods containing sodium in Kuwait were included in the study
Acrylamide level in baked foods consumed in Kuwait	Adults: 4,000 (10 g salt)	The amount of sodium shown is probably an underestimate because not all foods containing sodium in Kuwait were included in the study

Source: Zaghloul *et al*., 2012 (12); Alomirah *et al*., 2008 (13).

the total deaths in Bahrain (7). The Nutrition Section, Ministry of Health (MOH), is the main governmental body responsible for salt intake reduction activities.

In their efforts to establish baseline data on sodium intake among the Bahraini population, a study was conducted by the Nutrition Section to assess urinary sodium levels. A spot urine test indicated an average of 136 mmol/L, and 122 mmol/L of urinary sodium among children (n=128) and adults (n=64), respectively (9). These results were inaccurate as the sample size was not representative of the population.

In 2014, a pilot study was conducted to determine the salt intake in a sample of 50 Bahraini adults aged 20-40 years, by collecting 24-hour urinary sodium (10). Results showed that only 8% of males and 10% of females were found to have relatively high concentration of urinary sodium. However, further analysis is needed due to the small sample size.

Furthermore, another pilot study was conducted, in collaboration with EMRO, to assess the salt content of bread (10). Twenty samples were collected from different bakeries throughout Bahrain. The average salt content was found to be approximately 90,000 ppm; this was much higher than the WHO recommended levels. The Nutrition Section has proposed an action plan for an annual 10% salt reduction in bread. This is awaiting approval from the MOH.

Approximately 70% of the bread in Bahrain is produced by the Bahrain Flour Mills Company (BFMC), which follows standardized recipes for the different types of bread produced. The smaller proportion of bread sold in the market is produced by privately owned bakers. No data is available on the amount of salt added to the bread. Salt is added to the flour before mixing the dough. The food labelling of bread is only included on bread produced by the BFMC. It includes the calories and macronutrient content but does not indicate the salt content.

A ministerial decree was formulated in 2014 to establish a multisectoral committee, which aims to reduce salt in bread products. The objective of this committee is to set up a strategy with an action plan that includes:

(I) Reducing salt in the bakery products;
(II) Enforcing food labeling to include salt content;
(III) Developing a legislation and monitoring its implementation.

Kuwait

Kuwait lies on the northwestern tip of the Arabian Gulf. The total population is ~4,100,000 million people (11). According to the WHO, CVDs account for 41% of the total deaths. The Food and Nutrition Administration (FNA) part of the Ministry of Health is the main governmental body in charge of overseeing salt reduction activities.

It is critical to determine the amount of salt consumed before any intervention is implemented. Two studies analyzing food consumption in Kuwait (12,13) found the average salt intake to be within 8-10 g per day. This range may be an underestimate as not all food items were included in the studies (*Table 1*).

Data from these studies provided information on the main food sources of salt in the Kuwaiti diet, indicating that salt was mainly added during food preparation at home. This was shown to be the main source of salt intake. They also showed that bread consumption was the second main source of salt (*Figure 3*). Further research is needed to ensure the accuracy of data for future actions. Kuwait is currently at the stage of designing a study to determine salt intake by using the gold standard of assessing 24-hour urinary sodium.

The majority of bread in Kuwait is produced locally by Kuwait Flour Mills and Bakeries Company (KFMBC). This factory accounts for 80% of the total bread production in Kuwait. The factory follows standardized recipes for the

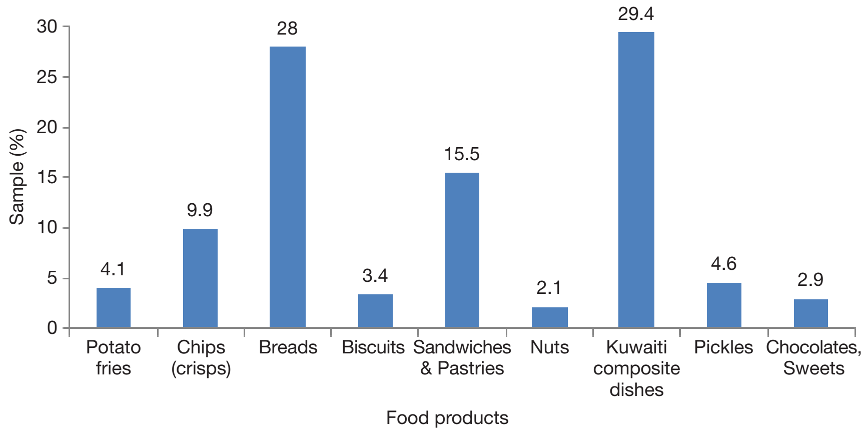

Figure 3 Major sources of salt in Kuwait.

different types of bread produced. Salt is mixed with the flour before water is added to make the dough. The food labelling is included on the bread produced by the company and only includes the calorie and macronutrient content.

The MOH in partnership with KFMBC decided to implement the WHO recommendations regarding reducing salt intake. A 10% reduction of salt in bread was achieved in March 2013. This was followed by another 10% reduction 6 months later, in August of the same year. By October, 2013 almost all types of bread produced by the company, with the exception of one traditional variety, had a 20% salt reduction. An example of the regular monitoring of salt in bread is shown in *Figure S1*.

Kuwait imports more than 95% of consumed food. Processed foods such as breakfast cereals, cheese, chips and meat, account for a significant amount of salt in the Kuwaiti diet. Some of these food items are sometimes highly consumed, for example, chips by children. This was recognized as an opportunity to further engage the private sector. A plan to advocate partnership and engage food companies with health awareness activities was put together. The major aims included:

(I) Introducing salt reduction strategies and its beneficial impact on the health of the population;
(II) Emphasizing the critical role of the private sector in the actions to be taken;
(III) Requesting information on the current level of salt in locally produced and imported foods;
(IV) Working with the private sector on an effective and applicable plan of action for the gradual reduction of salt.

A similar approach with the same aims was taken by meeting with the largest restaurant franchise operators in Kuwait. The objectives of the meeting were to open dialogue with the companies; to highlight the health benefits of salt reduction; and, to emphasize the feasibility with no financial losses. This is currently in progress.

Sultanate of Oman

Oman lies on the southeastern coast of the Arabian Peninsula. Its population size is approximately three million. According to the WHO, CVDs account for 33% of the total deaths (7). The Ministry of Health, Oman, is the main governmental body that oversees salt reduction activities.

The National Nutrition Survey based on the 24-hour dietary recall suggested the average intake of salt between 11-12 g per day (14). In order to reduce the consumption of salt to the levels specified by WHO, initiatives are being planned, though are still in their initial stages. Currently, the MOH is working towards reducing salt levels in commonly consumed foods; mainly focusing on highly salted foods such as bread, cheese, and processed meats.

According to the director of Nutrition, Ministry of Health, there is no standardized recipe for bread of the same kind, thus, the salt content varies within the same bakery chain (*Table S2*).

Future interventions for the reduction of salt include:

(I) Establishing a national taskforce for salt reduction;
(II) Achieving 10% reduction of salt in the bread within 6-8 months, 2014;
(III) Identifying of the main sources of salt in the diet;
(IV) Reviewing and revising national food standards for bread to reflect the recommended minimum levels

of salt content in bread;

(V) Conducting studies to monitor the intake of sodium using the 24-hour urinary assessment;

(VI) Establishing salt standards for compliance by all bakers.

Qatar

Qatar lies on the northeastern coast of the Arabian Peninsula. It has a population size of approximately 2 million people. According to WHO, CVDs account for 24% of total deaths (7). The Supreme Council of Health (SCH) is the main governmental body that oversees salt reduction activities in Qatar.

A national project by the SCH found that the main source of salt in the diet was from bread and other baked products (15). The council, in collaboration with EMRO planned initiatives to reduce salt in bread by 30% (*Table S3*).

The main national bakery (Mesaieed Bakery, or Qbake) was first contacted as it is the main producer of bread. It was requested to send the samples of the commonly consumed bread namely, the brown Arabic bread, small, (70 g × 4 pieces =280 g), white Arabic bread, small, (70 g × 10 pieces =700 g) and brown and white Lebanese bread, large, (140 g × 5 pieces =700 g) to the Central Food Laboratory. The results showed a 10% salt content reduction.

Before implementing another 10% reduction in salt content, the SCH is testing if a 20% salt reduction in different types of bread will have an effect on taste and palatability (to reach 0.90 kg per 100 kg for all bread types). Samples showed a wide range of salt levels between the different bakeries (the results ranged between 0.20% and 1.80% sodium content). Bakeries have been notified to reduce the salt content by 10% and the samples are now being tested to see if this has been achieved. This would establish a baseline for the gradual reduction of the added salt by 30%.

Kingdom of Saudi Arabia (KSA)

Saudi Arabia is the largest Arab state in Western Asia, constituting the bulk of the Arabian Peninsula. It has a population size of approximately 28 million people. Data reported in the WHO NCD country profile showed that CVDs account for 46% of the total deaths in the country (7). The Ministry of Health, is the main governmental body that oversees salt reduction activities.

During the recent Gulf Nutrition Committee Meeting held in Kuwait (February 2015), Saudi Arabia reported that salt intake reduction efforts are in their preliminary stages. Similar to other GCC countries, reduction of the salt content in bread is being targeted. As a result, the MOH proposed to pass a decree aiming to reduce salt by 10% annually until a target of 30% reduction is achieved. Bakeries in the country were contacted and several workshops were held to introduce this initiative. The MOH expressed challenges of reducing salt in the popular traditional breads as it is often added according to the baker's preference. Therefore, while initial steps are underway, coverage and monitoring of implementation will remain a challenge.

The United Arab Emirates (UAE)

The UAE is located on the southeast end of the Arabian Peninsula, and has a total population of approximately nine million people (7). According to the WHO, CVDs account for 30% of the total deaths in the UAE. The Ministry of Health, UAE is the main governmental body in charge of overseeing salt reduction activities.

The MOH is in its initial stages of implementing its salt intake reduction strategy. Currently it is identifying the main producers of bread to review the current situation regarding bread production, distribution, and the use of standardized recipes. The aim is to set a plan of action for the gradual reduction of salt in bread.

Conclusions

Countries of the GCC are showing willingness to comply with the WHO recommendations to reduce salt intake so as to reach the overall goal of reducing the burden of NCDs. However, there are challenges faced, including lack of political commitment, inexperience and shortage of qualified human resources. They are at the early stages of salt intake reduction. The efforts in the GCC countries range from the 20-30% salt reduction strategy in bread, to building partnerships with the private sector, to the very early stages of planning.

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Table S1 Content of salt in bread highly consumed in Eastern Mediterranean region

Countries	Type of bread	No. of samples	Sodium content in wet basis (ppm)	Salt content in g/1,000 g	Salt content in g/100 g	Daily intake of salt in grams from bread (300 g/d/p)	Estimated daily salt intake g/d/p	Percentage of bread contribution to total salt intake
Bahrain	Sliced bread	5	2,631.9	6.58	0.66	–	–	–
	Arabic bread	5	2,634.9	6.59	0.66	–	–	–
	Flat bread	10	5,260.7	13.15	1.32	–	–	–
	Average		3,509.2	8.77	0.88	2.6	13.5	19.5
Oman	Sliced bread (white)	5	3,662.2	9.16	0.92	–	–	–
	Samoon bread	4	4,701.9	11.75	1.18	–	–	–
	Lebanani flat bread	6	2,312.5	5.78	0.58	–	–	–
	Average		3,558.9	8.90	0.89	2.7	9.5	28.1
Egypt	Baladi refined bread	5	1,582.5	3.96	0.40	–	–	–
	Baladi ordinary	5	2,010.1	5.03	0.50	–	–	–
	Average		1,796.3	4.49	0.45	1.3	9.2	14.6
Kuwait	Flat Arabic thin bread (brown)	3	3,319.4	8.30	0.83	–	–	–
	Flat thin Arabic bread	4	3,330.6	8.33	0.83	–	–	–
	Flat Arabic bread	4	6,087.5	15.22	1.52	–	–	–
	Flat Arabic bread (brown)	2	4,516.5	11.29	1.13	–	–	–
	Average		4,313.5	10.78	1.08	3.2	9.7	33.4
Tunisia	French bread	10	4,881.7	12.20	1.22	2.4	11.1	22.0
Qatar	Arabic bread (small)	5	2,714.1	6.79	0.68	–	–	–
	Arabic bread (large)	5	1,677.3	4.19	0.42	–	–	–
	Arabic bread (brown)	5	1,790.0	4.48	0.45	–	–	–
	Lebanese bread	5	1,680.0	4.20	0.42	–	–	–
	Lebanese bread (brown)	5	2,468.3	6.17	0.62	–	–	–
	Average		2,065.9	5.16	0.52	1.5	10.5	14.8
Jordan	White bread (small)	4	1,114.6	2.79	0.28	–	–	–
	White bread (large)	8	2,256.3	5.64	0.56	–	–	–
	Average		1,685.5	4.21	0.42	1.3	10.3	12.3
Morrocco	Morocco bread (round, thick)				1.47	5.88	10.9	53.9
UAE	Rqaq bread		6,052.49	15.1	1.51	–	–	–
	Rqaq bread		5,901.32	14.8	1.48	–	–	–
	Samoon bread		2,695.52	6.7	0.67	–	–	–
	Samoon bread		2,619.6	6.5	0.65	–	–	–
	Toast bread		3,145.14	7.9	0.79	–	–	–
	Toast bread		3,145.45	7.9	0.79	–	–	–
	Lebnani bread		1,960.99	4.9	0.49	–	–	–
	Lebnani bread		1,914.76	4.8	0.48	–	–	–
	Average		3,429.4	8.6	0.86	2.6	9.2	28.0
Lebanon	Arabic bread (white)		2,190	5.5	0.55	1.6	9	18.3

KUWAIT FLOUR MILLS & BAKERIES CO.
QUALITY CONTROL DEPARTMENT
BAKERIES LABORATORY

DATE: 29/10/2014
TO: MANAGER OF QC AND LABS DEPT
FROM: HEAD OF BAKERIES LABORATORY

SUBJECT : SALT REDUCTION IN THICK ARABIC BREAD WHITE

Referred to objective of salt reduction in **Thick White Arabic Bread** bakeries lab has started gradual decrease in salt amount since Feb 2013. The salt amount has been reduced to 20 % approximately in current formulation as compared to previous formulation. Now the salt and sodium contents in one piece of thick white Arabic bread as per analysis done on 19/10/2014 are as under:

The salt amount in Thick White Arabic Bread : 939.8 mg per piece
The Sodium content in Thick White Arabic Bread : 370 mg per piece

Summary of calculation and analysis results conducted in our labs are detailed below

A- CALCULATION

PARAMETERS	PREVIOUS RECIPE	RECENT RECIPE	REDUCTION IN SALT	
			amount	%
Salt % added in dough	1.263	1.013		19.8
Salt in bread - mg	1199	962	237 mg	19.8
Sodium in bread - mg	472	378.7	93.3 mg	19.8

B- ANALYSIS RESULTS

Parameters	Analysis Results	calculation
Sodium content per bread	370 mg / piece	378.7 mg/piece
Salt contents per bread	939.8 mg/ piece	962 mg/piece

Notes :

Sodium Daily intake recommended by FDA = not more than 2300 mg/day
1 piece of thick white Arabic bread provides sodium : 370 mg = 16.1 % of DV

Best regards,

NADIAH A BOURESLI
HEAD OF BAKERIES LAB

Figure S1 Kuwait.

Table S2 Food chemistry analysis

NO	COA NO.	Sample details	Salt content (%)	Ash (%)	Comparison with EMR research (Oman)-averages
1	F141130008	Dhahabi Lebanese brown bread	0.19	1.10	
2	F141130009	Dhahabi Lebanese white bread	0.13	0.70	
3	F141130010	Dhahabi white sliced bread	1.01	1.62	0.92
4	F141130011	Dhahabi buns bread	1.03	1.69	
5	F141130012	Dhahabi samoon rolls bread	1.06	1.67	
6	F141130013	Switt modern Oman bakery Lebanese white bread	0.06	0.55	0.58
7	F141130014	Switt modern Oman bakery Lebanese brown bread	0.04	0.93	
8	F141130015	Switt modern Oman bakery sliced milk bread	0.78	1.88	
9	F141130016	Carrefour mini roll bread	0.63	1.26	
10	F141130017	Carrefour Arabic bread	0.27	0.76	
11	F141119004	Al Emarates bakeries-Arabic bread	0.15	0.76	
12	F141119005	Al Emarates bakeries-Arabic brown bread	0.27	1.2	
13	F141119006	Al Emarates bakeries-samoon bread	0.38	0.94	1.18
14	F141119007	Al Emarates bakeries-buns bread	0.38	0.95	
15	F141119008	Sohar Beach bakery-buns bread	0.87	1.52	
16	F141119009	Sohar Beach bakery-samoon bread	0.93	1.59	
17	F141119010	Sohar Beach bakery-Arabic bread	0.54	1.13	

Table S3 GCC salt reduction plan and action for bread

Country	Plan		Decree number and date	Starting date for implementation of decree	Salt level (g/100 g)			Summary of the plan#
	M*	V**			At starting point	Current	Target	
Qatar	Decrease salt levels in all bakeries around Qatar by 30%	Decreasing salt levels further according to bakery preference	Agreement for commencing salt reduction plan 30th May 2013 (agreement attached) Official letter sent to Qatar Central Laboratory 26th March 2014 (letter attached)	28 July 2013 (Qbake) 3 April 2014 (major national bakeries)	Qbake Lebanese bread (white) =0.650 White big Arabic bread =0.630 White small Arabic bread =0.810 Brown Arabic bread =0.800 Other bakeries (mean) White Arabic bread =0.756 Brown Arabic bread =0.740 White Lebanese bread =0.575 Brown Lebanese bread =1.115 White sliced bread =1.190 Brown sliced bread =1.218 White dinner rolls =0.987 White burger buns =1.110 White hotdog buns =1.004 Brown hotdog buns =1.225 Rotti =1.15	Lebanese bread (white) =0.490 White big Arabic bread =0.540 White small Arabic bread =0.600 Brown Arabic bread =0.690 White Arabic bread =0.615 Brown Arabic bread =0.690 White Lebanese bread =0.355 Brown Lebanese bread =0.690 White sliced bread =0.865 Brown sliced bread = pending White dinner rolls = pending White burger buns = pending White hotdog buns = Pending Brown hotdog buns = pending Rotti = pending	Decrease salt levels in all bakeries around Qatar by 30%	The initiative has started in collaboration with the WHO EMRO in response to studies done that showed the main source of sodium in an average person's diet comes from bread and baked products In order to ensure positive results and collaboration by local bakeries, they were contacted individually and attended two meetings each, where it was agreed to send original bread samples to the SCH Central Food Laboratory, then further to reduce the added amount of salt by 30% in three phases (I) The main national bakery (Mesaieed Bakery-or Qbake) was contacted by the SCH and according to request, the following was done ● Control samples were sent to the SCH Central Food Laboratory that included the original recipes, samples sent were brown and white Arabic bread (small) and brown and white Lebanese bread (large). The above bread types are the most commonly sold types of bread ● The recipes for all four bread types mentioned above had the salt added decreased by 10%, and currently in process for decreasing further 10% ● Currently testing to see the applicability for decreasing sodium levels in all types of bread produced by the bakery by more than 20% for some (to reach 0.90 kg per 100 kg for all bread types) (II) Local bakeries around the state of Qatar have been contacted by the SCH and original samples (recipes) by all have been sent to the Central Food Laboratory for testing ● Original samples sent showed a wide range of sodium levels between the different bakeries (the results ranged between 0.20% and 1.80% sodium content) ● Bakeries have been notified with results on salt content and have now reduced salt content added to recipes by 10% - currently testing

*, mandatory; **, voluntary; #, summary of the plan may include (I) bread types included in salt reduction; (II) time frame for gradual reduction; (III) the percentage of daily bread consumption. GCC, Gulf Cooperation Council; SCH, Supreme Council of Health.

Review Article

Sodium intake reduction efforts in Lebanon

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Abstract: Sodium intake reduction efforts in Lebanon are quite recent and have just started to take effect on the national level. Starting out from an academic institution, the Lebanese Action on Sodium and Health (LASH) campaign was established to counter the increasing prevalence of hypertension and associated adverse health effects. The campaign's strategy was based on four pillars: research, health communication, advocacy, and monitoring. The LASH group set out with determining: baseline sodium intake of the population, main sources of sodium intake, and the knowledge, attitudes, and behaviors (KAB) of the population as a situation analysis that prompts for action. This gave LASH tangible evidence of the magnitude of the problem and the need for the government, the food industry, and the consumers, to be mobilized to take part in devising a solution. Currently, Lebanon is at a stage of technically working to reduce the sodium content in the major sources of sodium, namely local bread and bread-like products. The next steps will include implementation of a plan for monitoring industry compliance, while studying other food targets, including dairy products and processed meat. Meanwhile, the health communication plan is ongoing and the Salt Awareness Week is celebrated every year with media appearances of LASH researchers to raise the issue to the public eye.

Keywords: Sodium chloride; dietary; salt intake reduction; Lebanon; public health; prevention; dietary intervention

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Introduction

Cardiovascular diseases (CVDs) represent the majority of all-cause mortality in Lebanon (60%) in persons aged 50 years and older, who represent 22% of the Lebanese population (approximately 4.467 million) (1,2). CVD, mainly stroke, resulted in 2,072 deaths in 2002 and represent 10% of total deaths according to WHO 2011 estimates (3). Hypertension is a major underlying risk factor for CVD with a prevalence of 29% (4).

Several studies have estimated the morbidity and mortality attributable to excessive salt intake worldwide. Mozaffarian *et al*. [2014] showed that excessive dietary sodium intake was responsible for 1.65 million CVD deaths worldwide in 2010. The overwhelming majority of the deaths (84%) occurred in low- and middle-income countries (5). From a preventive point of view, He *et al*. showed that 35,000 annual stroke and ischemic heart disease deaths could be prevented in the UK alone, and 2.5 million cases worldwide, if the salt intake was reduced to a maximum of 6 g/person/day (6). In Lebanon, no studies are published about the contribution of excess salt intake to morbidity and mortality; however, based on the globally collected evidence we chose to adhere the WHO recommendations to work on reducing sodium intake (7).

Public health efforts in Lebanon

To plan and implement sodium intake reduction in Lebanon, a group of researchers and public health specialists

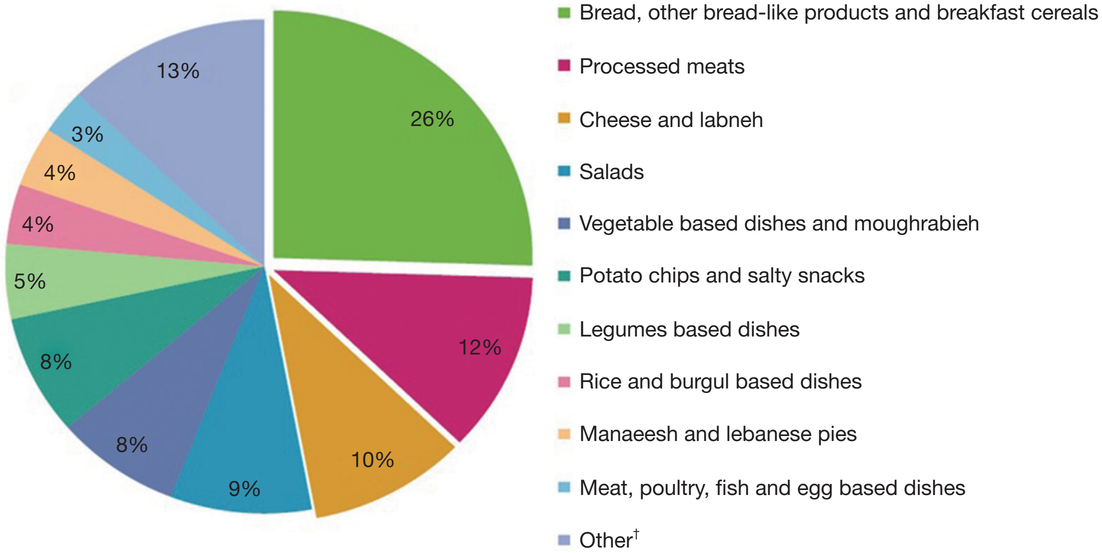

Figure 1 Major food group contributors to sodium intake in Lebanon. †, Other category includes pizza and pasta based dishes, processed poultry, sweets, kishk, tahini and falafel based dishes, gravies sauces and butter, soups, potato based dishes, and milk and milk based products.

convened, with the support of World Action on Salt and Health (WASH), under what became the LASH. The strategic plan of the campaign was based on four pillars, namely research, health communications, advocacy, and monitoring. After a situations analysis, the group recognized that the basic data to launch a public health initiative was not present. Therefore, it was agreed to launch a research arm and simultaneously prepare the ground for the public health initiative. However, at the outset, it was realized that research had to address some local challenges to get the buy-in of key stakeholders within the sector of the food industry to be targeted. Research was centered on: (I) how much sodium does the Lebanese population consume; (II) what are the major sources of intake; (III) what is the baseline knowledge, attitudes and beliefs of the population; and (IV) which tools for monitoring of sodium intake can practically be used in our setting. An overview of this will be presented in the sections that follow.

Research

Sodium consumption in the Lebanese population

In a systematic analysis, Powles *et al.* (2013) estimated the current daily dietary sodium intake in the Lebanese population to be 3.13 g per person per day (8). Based on a nationally representative survey conducted in 2008/2009 on Lebanese adults (n=2,543), the average sodium intake among Lebanese adults aged 20 years and above was estimated at 2.9 g/day, with intakes being significantly higher in males (3.4 g/day) compared to females (2.4 g/day). In total, nearly 60% of the adult Lebanese population was found to exceed the WHO maximum intake level of 2 g/day (9). This was based on dietary diary data and not on 24-hr urine sodium measures.

Major sources of sodium intake

Processed foods are the main dietary source of sodium in the Lebanese diet, led by bread and bread-like products (26%), processed meat (12%), and dairy products (9%) (*Figure 1*) (9). These percentages can be explained when looking at the average consumption of bread (136.8 g/p/day), bread-like products such as the traditional pies or "Mana'eesh" (32.1 g/p/day) (*Figure 2*), and dairy products such as cheese (49.5 g/p/day) and strained yogurt or "Labneh" (27.8 g/p/day) in Lebanon. A similar profile of sodium sources (processed foods) was observed in Canada and other developed countries (10), indicating a shift in the Lebanese diet from a Mediterranean to a Western cuisine.

To further dissect the problem, samples of the main breads consumed in Lebanon (white and brown Arabic/pita, white and brown French baguette, Markouk and Tannour breads) were collected from the main bakeries in Lebanon (n=48) (*Figures 3-6*) and analyzed using the AACC method 40-71 (American Association of Cereal Chemist) at the department of Nutrition and Food Sciences, AUB. The average sodium content of the white Arabic/pita bread, the most consumed bread type in the country (11), was 519 mg·100 g^{-1} (1.32% salt). The mean sodium level was 579 mg·100 g^{-1} (1.47% salt) for brown Arabic/pita bread, 821 mg·100 g^{-1} (2.1% salt) for brown French baguette, 866 mg·100 g^{-1} (2.2% salt) for white French baguette, 866 mg·100 g^{-1} (2.2% salt) for Tannour bread and 1,111 mg·100 g^{-1} (2.83% salt) for Markouk bread. Sodium was not detected in the zero-salt labeled bread and was found at a mean level of 127 mg·100 g^{-1} (0.32% salt) in the low-salt-labeled versions of Arabic/pita bread. This indicated credibility of the claims on sodium contents of these products.

Another category of high salt foods includes white brined cheeses and strained yogurt (Labneh) which are heavily consumed in the Arab Region. In a previous study (12), samples of regular and reduced-fat varieties of four white brined cheeses (Akkawi, Halloumi, Double Crème and Braided) and Labneh, produced from cow's milk, were analyzed for sodium content. The concentration of sodium was highest in the cheeses with large differences in sodium levels being noted between different brands of the same type of cheese. Double Crème had the lowest sodium content among brined cheeses with a range of 736-1,258 mg·100 g^{-1}, followed by Halloumi cheese with 652-1,320 mg·100 g^{-1} and Akkawi cheese with 777-1,965 mg·100 g^{-1}, whereas Braided cheeses exhibited the highest and most variable sodium levels with a range of 2,080-6,250 mg·100 g^{-1}. The range of sodium levels of Labneh was 73-278 mg·100 g^{-1}.

Figure 2 Photograph of traditional Lebanese pies or "Mana'eesh". The average sodium content of the traditional Lebanese cheese pies (Mana'eesh) is 716 mg·100 g^{-1} (1.32% salt).

Baseline knowledge, attitudes and beliefs of the Lebanese population

Recently published results of a survey by Nasreddine *et al.* [2014] about knowledge, attitudes, and behaviors (KAB) of Lebanese consumers regarding dietary sodium intake demonstrated a poor knowledge of the effects of sodium on health and its sources in the diet. This reflected in unfavorable attitudes and behaviors of the consumers towards reducing their daily sodium dietary intake. Although 78% of the participants linked high dietary sodium intake to poor health, almost half did not know it leads to stroke and heart attacks. Moreover, only 23% correctly recognized processed foods as the main source of dietary sodium. More importantly, only 32% correctly indicated the recommended upper daily intake limit. Furthermore, less than half of the participants (45%) were

Figure 3 Photograph of white Arabic/pita. The average sodium content of the white Arabic/pita bread is 519 mg·100 g^{-1} (1.32% salt).

Figure 4 Photograph of Markouk bread. The average sodium content of the Markouk bread is 1,111 mg·100 g^{-1} (2.83% salt).

Figure 5 Photograph of Tannour bread. The average sodium content of the Tannour bread is 866 mg·100 g^{-1} (2.2% salt).

concerned about the level of sodium in their diet and even less (38%) looked at sodium labels before purchasing food products. However, checking the labels did not seem to translate to a change in the decision of buying the high sodium product because only 44% of the later subgroup admitted it affected their decision. This could be partly explained by the finding that 56% stated that food labels on sodium are not comprehensible. Despite the deficiencies observed, around half of the participants perceived themselves as actively reducing their daily intake of sodium.

Intriguingly, women had better knowledge than men on many levels and consequently a more favorable overall attitude and behavior. This finding emphasizes the rationale

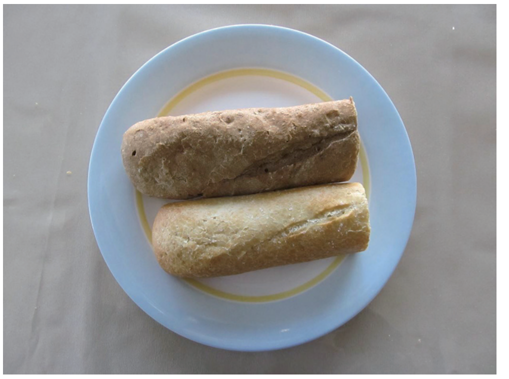

Figure 6 Photograph of white and brown French baguette. The average sodium content of the white and brown French baguette is 821 mg·100 g^{-1} (2.1% salt) and 866 mg·100 g^{-1} (2.2% salt), respectively.

for targeting women in health awareness campaigns as the data shows they have better baseline knowledge, and are a key element in the entire family's dietary intake, given their traditional role in grocery shopping and preparing meals in Lebanon (13). In comparison, a high cardiovascular risk population surveyed with the same questionnaire demonstrated great variability in terms of KAB. *Figure* 7 summarizes the main differences between the general population and the high-risk sample.

Tools for monitoring of sodium intake used in the Lebanese setting

Even though several methods have been proposed for the dietary assessment of sodium (24-hour urinary sodium excretion; 24-hour dietary recalls; food records), the validity, accuracy and/or applicability of several of these methods have been often criticized in the literature (14). The accurate assessment of sodium intake amongst free-living persons remains a difficult and labor-intensive process (14). The lack of adequate tools to evaluate sodium intake is still a problem in clinical practice as well as in research settings and this is particularly true for Lebanon (14). The 24-hour urine sodium excretion is recognized as the "gold-standard" for the assessment of dietary sodium intake (15). However, measurement of 24-hour urine sodium excretion is cumbersome and inconvenient (16) and is associated with low response rates. Among those subjects who agree to participate in such studies, many perform the collection incorrectly, with under-collection and thus underestimation of actual sodium intake being a common observation (16).

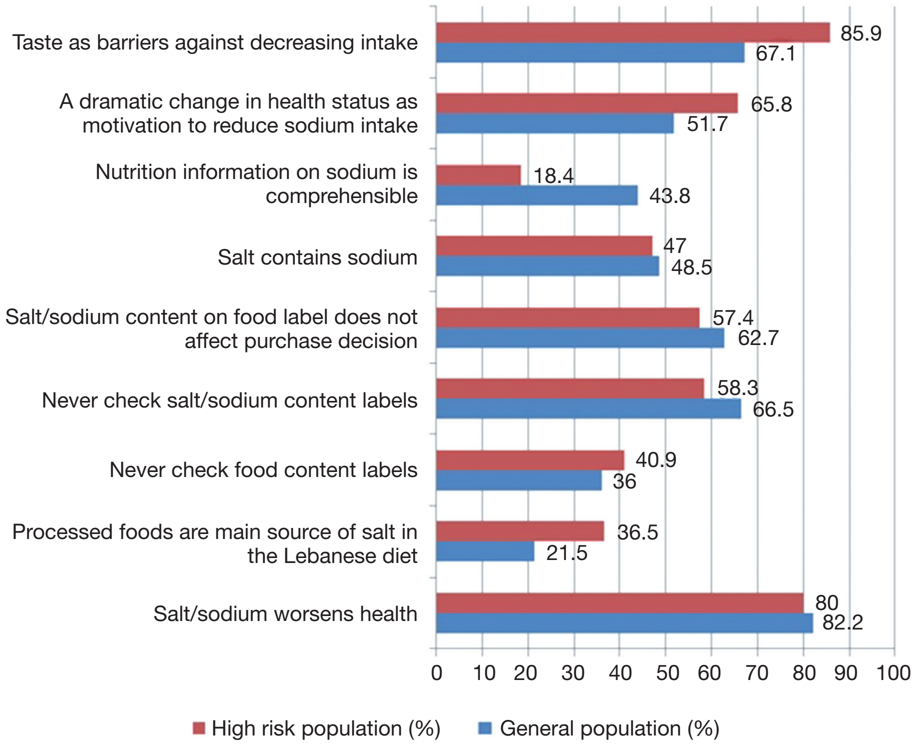

Figure 7 Comparison of knowledge, attitude, and behavior between general and high-risk Lebanese populations.

A pilot-study conducted in Lebanon showed that, in a sample of 90 adults, approximately 40% of the collected 24-hour urine samples were incomplete, thus highlighting the difficulty of adopting this approach in population-based studies. It has therefore been suggested that a preferable method, from the perspective of feasibility and convenience, would be the assessment of sodium excretion from spot urine samples. This would require measurement of the spot urine sodium concentration along with a measure of the state of concentration or dilution of the urine, such as the urine creatinine concentration (16). Despite the concerns raised regarding the validity of this approach, many studies showed that sodium intake estimates derived from spot urine collection strongly correlate with those derived from 24-hour sodium excretion (16-18). An ongoing study in Lebanon is aiming at investigating the validity of spot urine samples in estimating sodium intake amongst adults.

Dietary assessment methods [24-hour dietary recalls, diet records, food frequency questionnaires (FFQs)] may also be utilized for the assessment of sodium intake, particularly when conducting large-scale population studies, which usually require quick, simple and reliable methods for the estimation of dietary intakes. In this context, the 3-day food record approach is considered as one of the best dietary assessment tools. However, its use is limited by the burden placed on the study participants and by the risk of the individual changing his/her dietary habits during the study period (19,20). Previous dietary pilot-studies conducted amongst Lebanese adults documented poor compliance and significant under-reporting when adopting the three-day dietary records, compared to the 24-hour dietary recall approach. The latter has in fact also been adopted in studies assessing dietary sodium intake. Although the 24 -hour dietary recall, when undertaken through a detailed interview, provides detailed information on all food and beverages consumed by the individual, it is considered less accurate when compared with 24-hour urinary collection, resulting most often in an underestimate of salt and sodium intake (21) (WHO, 2013). The limitations of the 24-hour recall approach may be partially overcome when the recall is repeated on multiple days (22). Finally, the use of the FFQ, which allows for the assessment of the usual patterns of food intake over an extended period of time (14,23), has also been proposed for the assessment of dietary sodium intake (24). FFQs rely on recall from 'generic' memory, which may be more easily recalled than 'episodic' memory, but because of the importance of cultural sensitivity, all FFQs require some adjustments and validation when used for a select cultural group (25). An ongoing study in Lebanon aims at investigating the validity of repeated 24 hour recalls and a short FFQ for the assessment of sodium intake amongst Lebanese adults, with the validation being performed against 24-hour urine sodium excretion. It is important to note that one of the biggest challenges for the assessment of sodium intakes based on dietary assessment tools is the availability of up-to-date, culture-specific salt and/or sodium food composition tables. As region- and country-specific differences may exist in the levels of salt used in various foods, and particularly traditional types of foods, the use of international food composition databases may be a limiting factor to the data generated by dietary assessment methods.

Health communication

Once the amount and sources of sodium intake were determined (*Figure 1*), the public health arm was charged with: (I) developing a workable plan to reduce sodium intake; (II) creating and disseminating educational material for awareness raising; (III) identifying key stakeholders [ministry of health, ministry of industry (MoI), syndicate of bakeries, and others] and (IV) meeting these individuals and getting their buy-in for a plan that would include policy changes with monitoring activities. The efforts of the campaign were acknowledged by the ministries of public health and industry in Lebanon, with a promise of support and intervention on the national level. However, similar to other experiences across the globe, the public health arm was faced with resistance and delays. In our situation, we were particularly affected with the turmoil arising from the repercussions of the Arab Region revolutions. Simply, given the numerous public health challenges from the influx of refugees from neighboring Syria, and local security challenges in Lebanon, sodium reduction fell low on the list of priorities (26). Nonetheless, during the process there were numerous lessons learned that reshaped the group's understanding of the better course to be followed and this will be highlighted in the section below.

Based on the initial situation analysis, a health awareness campaign was planned to address the significant knowledge and behavior gaps in the population. To disseminate knowledge and awareness, LASH members developed educational material including a "low salt shopping guide", low salt posters, and information leaflets, in both English and Arabic. The shopping guide (http://www.aub.edu.lb/fm/vmp/events-activities/Pages/shopping-guide.aspx) serves as a guidebook for avoiding purchase of high sodium food while choosing lower sodium alternatives, in addition to tips on how to read labels and stay below the maximum allowable daily sodium intake. The posters (http://www.aub.edu.lb/fm/vmp/events-activities/Pages/lash-salt-posters.aspx) aim at raising awareness and driving attention towards the risk of consuming high levels of salt in the Lebanese diet. These posters were designed to correlate with the Lebanese context and utilize connotations specific to the population. Moreover, at the bottom of every poster, a "Fact" statement provides evidence-based salt information, including adverse health effects of high salt diets or hidden sources of salt. As for the information leaflets (http://www.aub.edu.lb/fm/vmp/events-activities/Pages/lash-salt_leaflet.aspx), they were designed to convey concise information regarding sources of sodium in the diet and reading labels. More importantly, the color and format were chosen to allow cheap, high-volume printing and nationwide dissemination.

Advocacy

LASH members participated in a vital workshop held by the World Health Organization Eastern Mediterranean Regional Office (WHO-EMRO) in September 2013 on methods for salt reduction and monitoring of salt content in food. Through the workshop, LASH members placed Lebanon on the regional salt reduction scene and were exposed to the efforts in the region that were successful in reducing dietary intake on the national level such as in Kuwait. The proceedings of the workshop and resulting policy statements were used by LASH as the backbone proposal when contacting key stakeholders and inviting them to the launching of the campaign, which took place during the World Salt Awareness Week, March 2014. Through the launch conference, the group gained the patronage of the Lebanese Ministry of Public Health (MoPH) and obtained contacts within the Lebanese MoI. The conference also generated massive media interest in the topic, which unfortunately did not last long as more eminent security threats shook the country throughout the year. After getting political coverage, a key element for the success of any national effort in Lebanon, LASH turned its gaze towards the industry and its influential lobbyers and policy makers. To that end, LASH had a preliminary meeting with the Director of MoI followed by a workshop in MoI headquarters to discuss the urgency and technical aspect of reducing salt in processed food products. Mandated by the ministry to take part, industry representatives got involved in the workshop after having refused to do so in past activities. It was agreed upon that pilot salt reductions in bread and other food items including cured meats, pickles, olives, cheese, and nuts, would take place in ministry-selected producers. Moreover, the MoI stressed on developing a plan to have clear and straightforward labeling of food products with simultaneous public training and capacity building to properly read and interpret food labels. The ministry also pledged to make this issue a priority, urging all attendees from the government and industry sectors to assume their responsibilities to have a tangible result in all mentioned food types by the next year.

Monitoring

Furthermore, after all the above efforts were undertaken with the different industry and government stakeholders, and given the relative lack of sophistication in the industry and government systems in Lebanon, the adopted approach was modified. The challenge in implementing any maximum bread salt levels at the bakery levels was due to the fact that, unlike Kuwait where a centralized mill distributes flour to all bakeries, the different bakeries get their flour from many different sources and often produce flours with different baking qualities. Accordingly, bakeries frequently end up increasing their bread salt level to make up for any diminution in functionality caused by a lower flour quality. This was highlighted in the discussions and comments aired by bakers during a meeting at the MoI. Accordingly, the following steps were suggested:

(I) Updating the MoI Lebanese Standards with respect to sodium levels in bread;
(II) Conveying to bakeries the potential added value of low sodium bread products;
(III) Asking producers of bread to include nutritional labels on their products;
(IV) Verifying the compliance of low sodium breads to specific standards (for example, low sodium foods are those containing 120 mg of sodium per 100 gram of product).

It is believed that this approach will create a clear niche category for low sodium bread. Coupling this with nutrition education, sodium level monitoring activities and the added value (higher profit) of this niche category, we estimate that this may: (I) lead to market dynamics that will further expand the low sodium bread category; and (II) build on achieving proper labeling for all bread types for future interventions.

Conclusions

All along, the campaign was logistically, academically, and financially supported by the hosting institution, the American University of Beirut (AUB), and the Vascular Medicine Program at AUB. The collaboration with Consumers International in Lebanon (http://consumersinternational.org/) after the WHO workshop also helped LASH members gain more insight into the dynamics of approaching government agencies and the industry representatives. To our knowledge, this campaign is one of rare salt reduction campaigns that originated from an academic setting and made it to the national level. This, of course, had its drawbacks in terms of financial capabilities, media coverage, and access to mass distribution of knowledge and research findings to the unaware public. Working with our governmental partners, the WHO, and others, we are continuing to provide a reliable research and knowledge base to make positive health changes on the national level.

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Review Article

WHO's supported interventions on salt intake reduction in the sub-Saharan Africa region

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Abstract: Reduction of salt intake is an important and cost-effective way for reducing hypertension and the risk of cardiovascular diseases (CVDs). Current global salt intakes are estimated at around 10 g/day, well above the World Health Organization (WHO) recommended level of <5 g/day. The sub-Saharan Africa (SSA) region has a prevalence of hypertension of 46% among adults aged 25 and over and therefore strategies to reduce salt intake are necessary. This requires an understanding of salt intake behaviors in the population along with government commitment to increase awareness and take actions that would create an enabling environment. It is also important to have the food industry and other key stakeholders on board. A review of the developed WHO's norms and guidelines, technical support provided to countries by WHO as well as country initiatives shows that countries in the African region are at different stages in the implementation of salt reduction interventions. For example, South Africa has enacted legislation to make the food industry reduce the salt content of a number of its products while Mauritius is requesting bakery owners to reduce salt in bread. A number of countries are currently undertaking studies to measure salt intake in the populations. Overall progress is slow as the region experiences a double burden of communicable and noncommunicable diseases, competing health priorities and limited resources for health.

Keywords: Africa; salt intake; sodium; non-communicable diseases (NCDs); cardiovascular diseases (CVDs)

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Introduction

Globally, cardiovascular diseases (CVDs) are the number one cause of death. In 2012, an estimated 17.5 million people died from CVDs. This represents 31% of all global deaths and over two thirds of these deaths are happening in low and middle income countries (1). Hypertension is the leading cause of CVD. It is estimated that at least 1 billion adults have hypertension globally, and that hypertension is associated with more than 9 million deaths annually (2,3). In the past two decades, sub-Saharan Africa (SSA) is experiencing an epidemic of hypertension and consequential CVD, which is mainly a result of the region's epidemiologic transition driven by the breakdown of traditional ways of life, urbanization, physical inactivity, high salt and fat consumption, and population growth and aging (4). According to the World Health Organization (WHO), in 2008 SSA had the highest prevalence of hypertension, with 46% of adults aged 25 and older affected in the region (3). Decreasing blood pressure at a population level is required to curb the predicted escalating increase in the rate of CVDs.

There is growing evidence that high salt diets are linked to raised blood pressure—a major risk factor for CVDs and a range of other illnesses. Reducing population salt intake has been identified as an important and cost effective measure for improving population health outcomes throughout the world (5-7). Therefore, salt reduction is a global priority. The WHO has been urging all countries to reduce average salt intake which is currently estimated at around 10 g/day to the recommended level of <5 g/day for adults (8). In order for this to happen, WHO advices countries to develop and implement national salt reduction strategies to enable populations achieve the recommended salt intake level globally (6,7). All countries have agreed to reduce salt intake by 30% by 2025, as part of the global action plan to reduce the burden of non-communicable diseases (NCDs) (7). Salt reduction has the potential to lower the burden of NCDs and their complications and save millions of lives as well as cost to governments in the long run (9).

This article focuses on the role of WHO in supporting African countries reduce salt intake through (I) its normative functions of developing guidelines, policies, norms and standards; (II) convening of meetings/consultations with Member States and other stakeholders; as well as (III) in providing technical support to countries to implement, monitor and evaluate specific actions in reduction of salt intake.

Methods

This is an overview of WHO supported interventions on salt intake reduction among Member States of the African region between 2005 and 2014 through a purposive sample based on library search using PubMed and Science Direct. The results are organized around three specific areas namely (I) normative functions—guidelines and tools development; (II) convening of regional and sub-regional meetings; and (III) monitoring progress and documentation.

Developing norms, guidelines and tools on reduction of salt intake

The documents include *WHO Salt reduction Fact sheet* (10) which creates awareness on the health risks associated with high salt intake and advises on how to reduce salt intake to recommended levels. In 2012, WHO has published *Sodium intake for adults and children* which gives the daily salt intake recommended for adults and children that will reduce the risks of salt intake related health problems (8). A series of three reports of joint technical meetings have been produced, namely on (I) creating an enabling environment for population-based salt reduction strategies (11); (II) strategies to monitor and evaluate population sodium consumption and sources of sodium in the diet (12); and (III) salt reduction and iodine fortification strategies in public health (13). These reports have reviewed the evidence of interventions that are cost-effective, discussed initiatives, policies and programmes that have worked and can be adopted in low and middle income countries.

Convening regional and sub-regional meetings

The WHO has convened consultative meetings at global, regional and national levels on reducing salt intake. In the African Region, a technical workshop on '*Creating an enabling environment for population-based salt reduction strategies in the African Region*' was held in 2012 in Mauritius. It brought together participants representing the health sector, Ministries of Industry and Trade, and academia who examined actions to reduce population-wide dietary salt intake. The meeting sensitized Member States and other stakeholders on population-based prevention strategies for salt reduction to contribute to implementation of Objective three of the WHO NCD Action Plan 2008-2013, the WHO Global Strategy on Diet, Physical Activity and Health as well as the Political Declaration of the UN High Level Meeting on NCDs of 2011.

WHO convened a multi-stakeholder dialogue on risk factors for NCDs in Johannesburg, South Africa in 2013. Consumption of unhealthy diets was among the special topics discussed during the 3-day meeting. Participants from 43 countries of the African region were drawn from nine different government ministries, civil society groups and NGO's and partners (14). Discussions evolved around issues related to unhealthy diet including the increasing intake of foods that are high in salt, sugar, saturated fats, trans-fatty acids and calories. The proposed recommendations to reduce salt intake included (I) legislation and regulation; (II) banning the marketing of unhealthy foods, especially to children; (III) instituting compulsory labeling of salt, sugar, fat and calories of processed foods to enable consumers make informed choices; (IV) imposing/increasing taxes on unhealthy foods; and (V) supporting awareness campaign to reduce sugar, salt and fat consumption.

In 2013, a meeting on salt reduction brought together 15 countries from the West African Health Organization (WAHO). The meeting proceedings focused on the health benefits of reducing salt intake and issued a statement on salt reduction which was adopted by Member States. The statement urges countries of the region to (I) develop and implement policies and plans that help communities reduce salt consumption to levels recommended by the WHO; (II) raise awareness on health benefits of dietary salt reduction; (III) work with the food and beverage industry to reduce the salt content of their products; and (IV) to establish an information system to facilitate the monitoring of dietary salt intake.

Implementation, monitoring progress and documentation

South Africa documented its national salt reduction initiatives in 2013 and this is published as a case study (15). It documents the measures taken by the Government of South Africa to reduce salt content of commonly consumed processed foods such as bread, breakfast cereals, cured and raw processed meat, savory snacks, butter and margarine. More recently, South Africa passed a new mandatory regulation limiting the quantity of sodium in processed foods which comes into effect in 2016. Mandatory regulation is essential in South Africa, especially for bread, which is a staple food and contributes 25-40% of daily sodium intake (16).

Mauritius carried out a survey on population salt intake in 2012 to establish intake levels among adults. The study found that the daily salt intake among adults was 7.9 gm (17). The findings were used to initiate measures to reduce salt intake to WHO recommended levels. In the same year an analysis of sodium content of bread was conducted (18). It revealed average sodium content of 461.2 (range, 232.0-711.6) mg·100 g^{-1}. Following this the Ministry of Health and Quality of Life undertook a dialogue with bakery owners to reduce salt content in bread.

In addition, and with WHO support, countries of the African region are collecting information on salt intake through STEPS surveys to monitor prevalence and trends of NCDs diseases and their risk factors. A dietary salt module has been included in STEPS surveys since 2013. Information gathered from participants include: amount of salt they add to food, details about food preparation at home, the amount of processed foods usually consumed and a self-rating about salt intake. Spot urine testing for salt is being proposed in future STEPs surveys to estimate population salt intake.

Over the years, across the region, health education messages emphasize salt intake reduction as one of the important measures in the prevention and control of hypertension and CVDs. Food for patients with high blood pressure and CVDs are salt free or salt reduced. Patients with NCDs are advised to reduce their salt intake to the WHO recommended level of <5 g/day. In addition, nongovernmental organizations (NGOs) carry out public awareness and education campaigns on the adverse health effects of high salt intake and the need to choose food items that are low in salt content (19).

Most of the experiences on effective reduction in salt intake are from Europe and the Americas where over 75% of the salt consumed comes from processed foods (20). In Africa, studies show that up to 46% of salt is added when food is prepared or consumed and preliminary results have shown positive effects of community-based strategies in reducing salt intake and high blood pressure (21). However, additional work needs to be done to understand how salt reduction initiatives can best be adapted to SSA.

Many households in Africa consume high amounts of added salt found in seasonings and high salt foods like cereals, breads, margarine, salted fish and processed meats (22). Whilst there are limited data on population salt intake in Africa, it is estimated to be higher than the recommended target of 5 g/day. The growing use of processed foods, ready-made food purchased from food vendors and changing dietary patterns are therefore a major source of salt intake. WHO also promotes the adequate intake and use of iodized salt to prevent iodine deficiency disorders (IDD) as well as promoting use of fluoridated salt as a cost effective intervention to prevent dental caries at population level. Over 330 million people are at risk of IDD in Africa (23). Given this situation, all salt reduction strategies should ensure that they do not jeopardize iodine intake.

Conclusions

The WHO at its three levels namely Country Office, Regional Office and Headquarters is actively supporting national and global salt reduction initiatives. The WHO support to countries is meant to enhance capacity to reduce salt intake among population. The guidance documents also provide direction in terms of implementation, monitoring and evaluation of salt intake initiatives to help countries achieve the 30% reduction target set for 2025. Countries are urged to reduce salt intake to the recommended <5 g/day as well as enacting regulations and legislations to promote low salt products. It would be prudent to engage food and beverage industry in order to support the reduction of salt intake.

Reducing salt intake remains a challenge for countries of the African region given that salt already exists in variety of foods ready for daily consumption by the population. Furthermore, the burden of disease associated with high salt intake is also on the rise in Africa and would overstretch the public health systems that are not adequately prepared. The WHO supported interventions, while limited in scope, remain a major source of critical information and strategies for countries in the African region to respond positively to reducing salt intake. However, competing public health priorities versus limited resources threatens to retard the progress and the health gains to date.

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Review Article

Salt reduction and hypertension in China: a concise state-of-the-art review

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Abstract: Hypertension (HTN) and its cardiovascular complications such as stroke and heart failure are a serious public health problem around the world. A growing number of studies confirm that salt plays an important role in the development of HTN. Increasing intake of salt leads to abnormal transport of sodium ions at the cellular level with activation of the sympathetic nervous system and renin-angiotensin-aldosterone system. Studies have shown that salt restriction can reduce blood pressure (BP) in patients with HTN, especially salt-sensitive HTN. Public health interventions to reduce salt intake, with the goal of decreasing adverse outcomes have been launched in numerous countries. In this review we will summarize the epidemiology of cardiovascular diseases and their risk factors, the relationship between salt and HTN, the effect of salt restriction on HTN and the current situation of prevention and treatment of HTN by salt reduction in China.

Keywords: Hypertension (HTN); salt sensitivity; pathogenesis; preventing and treatment

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Introduction

Hypertension (HTN) is a progressive clinical syndrome characterized by increased arterial blood pressure (BP) that can lead to cardiovascular complications such as stroke, heart failure, and aortic dissection. HTN is recognized as one of the major cardiovascular risk factors. Epidemiological investigations demonstrate that the prevalence of HTN has been increasing in China, and it is estimated that about a total of 270 million Chinese patients carried a diagnosis of HTN in 2013 (1). Although modern drug therapy for HTN has improved, morbidity and mortality associated with HTN is still significant. Furthermore, increasing data have demonstrated that HTN has become a significant burden for the Chinese society and a major concern for public health with the changes in socio-economic conditions, changes in lifestyle, and the aging of the Chinese population. Thus, exploring the pathogenesis of HTN is important to improve its prevention and treatment. In the 1970s, Kawasaki introduced the concept of salt sensitivity based on observations in individuals with more pronounced sodium storage and elevated BP following relatively high intake of salt (2). Since then a growing number of studies have confirmed that salt intake plays an important role in the development of HTN and consequently in cardiovascular diseases (3,4). Below we describe this relationship, with emphasis on the Chinese setting and efforts aiming to reduce salt intake in China.

Salt and cardiovascular diseases (CVD)

Epidemiology

CVD are a worldwide major public health problem accounting for e.g., 1.8 million premature (<75 years) death in Europe (5). Likewise in China, CVD was found to be the number one cause of death in 2012, leading to an estimated 3.5 million deaths (41% of the total causes of death) (6). Moreover, the morbidity and mortality of CVD in China remains high. The estimated number of patients with a diagnosis of CVD is about 230 million, including 200 million patients with high BP and more than 7 million people suffering from stroke. Thus, one of five Chinese adults was suffering from CVD (7). Furthermore, assessing regional differences of morbidity and mortality data shows higher rates in northern regions compared to the south, and higher rates in urban compared to the rural areas. These differences are attributed to changes of lifestyle, socio-economic status, and the acceleration of urbanization (7). It is estimated that by 2030, the number of CVD events will increase by more than 50%, due to overall population growth and the aging population (8). Taking the expected growth in prevalence of HTN, hypercholesterolemia and diabetes into account, an increase of cardiovascular events by 73% is estimated. Without changes in prevention and treatment, the number of Chinese patients with cardiovascular disease will increase by 21.3 million, and deaths of cardiovascular disease will increase by 7.7 million in 2030 (8).

Epidemiology of HTN and salt-sensitive HTN

In China, HTN is one of the main risk factors for CVD, associated with more than 50% of CVD cases. Evidence suggests that HTN develops secondary to interplay of genetic and environmental factors, with salt intake playing an important role. In the 1970s, Kawasaki described the concept of salt-sensitive HTN. Their observations showed increased BP of hypertensive patients after relatively high salt load. Epidemiological studies have demonstrated heterogeneity of salt-sensitive HTN in different countries and ethnic groups (9). Heterogeneity also exists between normal and hypertensive populations with detection rates of 15-46% and 29-60%, respectively (10). In China, the detection rate of salt-sensitive HTN in normal populations is an average of 27.1%, but 58.7% of hypertensive patients (10). However, the awareness rate of salt-sensitive HTN is still low, mainly because of the lack of readily available diagnosis methods. Common detection methods of salt sensitivity include salt-load test and cold-pressor test. The former is complex and difficult to apply in large patient populations, the latter is a new, indirect method of detection designed according to the pathogenesis of salt-sensitive HTN and may become a routine method.

Salt sensitivity and HTN

Salt intake and HTN

Physiologically, salt plays an important role in maintaining the balance of water and fluid, and is also involved in nerve and muscle function. Excess salt intake is associated with many pathophysiological effects such as sodium and water retention, weight gain, and increased BP. In China, the book of *Yellow Emperor's Classic of Internal Medicines* recorded that salt is relevant for the pulse as early as 2,600 years ago, revealing the relationship between salt intake and HTN. With the emerging concept of salt-sensitive HTN, a growing number of animal experiments have confirmed that salt intake is an important factor for HTN. For example: a study of chimpanzees found that high salt intake progressively increased BP; and BP decreased after salt reduction for 20 months (11). At the same time, many clinical studies have confirmed that salt intake is related to the development of human HTN, and BP increases with age. For example, the Intersalt study investigated the relationship between urine sodium and the BP in 10,079 adult subjects enrolled from 52 centers in 32 countries. Standardized BP measurement, urine collection and measurements of sodium concentration were performed. The results showed that in the low-salt group, mean arterial pressure and the extent of BP increase with age was smaller. On the other hand, mean arterial pressure was higher in high salt group, and increased more with the age. The Intersalt study also demonstrated this relationship was maintained after adjusting for potential confounding factors including age, sex, weight and alcohol consumption. Similar data has been described in observational studies of Chinese subjects. For example results from the 2002 *Nutrition and Health Survey of Chinese Residents*, reported by Zhai *et al*. confirmed that dietary salt intake was significantly and positively related to BP level (12). Compared to a daily intake of 6 g/d of salt, 12 g/d of salt intake increased the risk of developing high BP by 14%, and l8 g/d of daily salt intake increased the risk by at least 27% (12). Shi *et al*. (13) investigated a population of 29,914 farmers aged 35 years or older from the rural areas of Fuxin city, Liaoning Province, from 2004 to 2005. Results show that salt intake was significantly higher in the HTN group compared to the non-HTN group, with a prevalence rate of HTN of 36.2% after adjustment, increasing as salt intake increased. However, the level of salt intake was unrelated to the severity of HTN (13). *Taiwan's Hypertension Guidelines* [2015] state that a 1 mg increase in salt intake increases systolic BP by 2.1 mmHg and diastolic BP rise by 0.78 mmHg (14).

While these data demonstrate a direct relationship between salt intake and HTN, clinical outcome data from clinical trials including INVEST [2003], ONTARGET

[2008], TNT [2009], the VALUE [2009], ACCORD [2010] and NAUIGATOR [2010] suggest that the incidence of cardiovascular events increases under a certain value of salt intake despite further decrease in BP levels, consistent with a J-curve relationship of salt intake/HTN and clinical events. However, data is incomplete and future clinical trials are necessary.

Pathogenesis of salt-sensitive HTN

The mechanisms mediating BP increases after salt intake are incompletely understood. Abnormal sodium transportation likely affects renal natriuresis and endothelial function, and activates the sympathetic nervous system (15), the renin-angiotensin-aldosterone system (16), and the endocrine system (including androgens (17) and insulin resistance), eventually resulting in the development of HTN through inflammation and oxidative stress (18). In recent years, the role of gene mutation and polymorphisms in the pathogenesis of salt-sensitive HTN has been investigated (19). Potential targets include guanine nucleotide binding protein (G protein) beta polypeptide 3 (*GNB3*) and α-adducin (*ADD1*) gene, *ACE* gene's polymorphism (such as insertion and deletion) and others. However, due to the differences of studied populations, genetic testing and analysis methods, reliable identification of candidate genes of salt-sensitive HTN is not possible and further studies are necessary. Because China is a multi-ethnic country with large regional imbalances in economic development, it is necessary to carry out research in line with our country's own characteristics for the prevention and treatment of HTN.

Salt reduction and HTN

Status of salt intake in the world

A certain amount of sodium intake is necessary to support cellular function. As described above both lack and excess of salt intake is associated with an increased incidence of cardiovascular events. Research data from NUTRICODE showed that the worldwide sodium intake was about 3.95 g/day for a person in 2010 (20). Similarly, data from the Trials of Hypertension Prevention (TOHP) I and TOHP II indicated that the optimum amount of sodium intake is in the range of 2.0-4.0 g/day. Moreover, this investigation also demonstrated that additional sodium intake of 2 g is associated with 1.65 million cases of cardiac death (21). Therefore, AHA/ACC guidelines state that sodium restriction could reduce the incidence and risk of cardiovascular events (22). In 2012, the World Health Organization (WHO) published a new guideline on sodium intake for adults and children that recommended that adults consume less than 5 g/d. Since salt sensitivity is not widely prevalent in the population, and the presence of J-curve of sodium intake exists, salt restriction to less than 2.0 g per day has been questioned (23). Moreover, some studies have showed that long-term strict salt restriction can lead to contradictory pathophysiological effects of sodium such as the activation of sympathetic and the renin-angiotesin system (RAS), the imbalance of lipid metabolism (24).

Salt intake in China

Surveys about Chinese nutrition and health have been undertaken and have indicated that daily salt intake of Chinese residents is significantly higher than the 5 g/d recommended by WHO. For example the quantity of salt intake is about 8-9 g/day in the south and 12-18 g/day in the North (25). This high-salt diet is related to a combination of cooking methods, dietary habits, folk custom and ethnic diversity. While in Europe and North America 75% of the total salt intake originates from adding salt to food during processing. Chinese residents often apply more salt or condiments containing much salt (soy sauce) to cooking compared with Western countries (26). Moreover, residents like salty food, specifically pickled food. This may be related to food production, transportation, poor storage and poor supply conditions in China.

Advantages and disadvantages of salt reduction

Increasing evidence from clinical and animal studies prove the relationship between increased salt intake and high BP. As early as 1904, Ambard and Beaujard demonstrated that high intake of dietary salt could be harmful for the body and raised BP (27). Many clinical studies have confirmed this observation. For example in the Dietary Approaches to Stop Hypertension (DASH) study, DASH diet significantly reduced systolic BP by 11.2 and 8.0 mmHg, respectively, compared with normal diet and diet rich in fruits and vegetables. In the DASH-sodium trial, researchers showed that salt reduction could lower BP. During DASH diet, systolic BP was reduced in each group and there were obvious differences between the low salt intake group and intermediate to high salt intake group (28). Furthermore, the DASH diet with a low sodium level in patients with normal BP reduced systolic BP by 7.1 mmHg compared with the control diet with a high sodium level in patients with normal BP. In patients with HTN, the reduction was 11.5 mmHg (29). Similarly, salt reduction was also effective in adults with prehypertension and stage 1 of HTN (30). Compared with that of the control group, BP of the intermediate and lower sodium groups of each diet were significantly lower. The risk of HTN in the intermediate and lower sodium groups of each diet was much lower compared to that of the control group. Other studies have found that natives, who lived on some Pacific islands and rarely ate salt had a very low risk of HTN (31).

On the contrary, there are a few of studies that demonstrated low sodium intake might not reduce the incidence of cardiovascular diseases, but increased the plasma levels of renin and aldosterone and the adverse cardiovascular events. In 2011, Stolarz-Skrzypek and his colleagues recruited 3,681 participants without CVD, including 2,096 normotensives and 1,499 patients with BP, to investigate the relationship between the 24-hour urinary sodium excretion and BP and health outcomes. They found the decrease of systolic BP and urinary sodium excretion by the salt restriction didn't result in a lower risk of CVD complications. Conversely, low urinary sodium excretion (mean 106 mmol/d) was closely related to increasing the risk of CVD complications (32). Similarly, a study reported by Graudal *et al*. indicated that sodium reduction can increase cholesterol by 2.5%, and triglycerides by 7%, in spite of the reduced BP resulting from sodium reduction in both the normotensive and hypertensive participants (24).

Salt reduction in China

Government and health organizations

Dietary salt restriction and a healthy lifestyle has become a worldwide concern. As described in other articles of this Focus Issue, many countries around the world have taken many measures to control salt intake. The Chinese government and health organizations have begun to advocate healthy lifestyles characterized by reduced salt diet, proper nutrition, smoking cessation, limiting alcohol intake, moderate exercise and mental balance. China has also released a number of national standards, such as national standards GB/T 23789-2009 *Foods with Low-sodium Content* [2009], *China's Chronic Disease Prevention and Control Work Plan [2012-2015]* [2012] and national standards GB 28050-2011 *The General Principles of the Prepackaged Food Nutrition Labels* [2013], aiming to regulate salt intake based on scientific data with the goal to improve national health. The Chinese government has established a National Hypertension Day in 1998. In 2009, the theme of National Hypertension Day was "Salt Restriction and Control of Hypertension". In 2013, China formally released the *China Education Guide* for hypertensive patients emphasizing that salt restriction was one way of prevention and treatment of HTN (33). The Cardiovascular Disease Prevention Research Center in the Ministry of Health and the Chinese Hypertension League also published the brochure of salt and HTN in the World Hypertension Day of 2009. This information is communicated with patients by medical professionals, advocacy organizations that offer free health education, health lectures on TV, broadcast and internet. China is also conducting a nationwide survey of HTN, including salt intake level and ways to reduce salt, aiming to guide further the program of salt restriction.

Limit-salt-spoon

The Limit-salt-spoons campaign was designed to help people to reduce salt in their diets. In 2007, the Ministry of Health promoted the use of a small spoon (one spoon equals about 2 g salt) to encourage a "comprehensive healthy lifestyle". As part of the campaign, many provinces and cities, such as Shandong province, Beijing, Shanghai distributed this spoon for free, and carried out activities and projects on salt reduction. The goal was to inform people about healthy diets and reinforce behaviors to prevent and control HTN. The Shanghai 'limit-salt-spoon project' promoted public awareness of salt reduction, and salt intake dropped from 7.13 to 6.38 g/day. Moreover, many regions also conducted consulting and education about salt intake and health education. For example, Lu *et al*. gave the 'limit-salt-spoon' to community residents and taught them how to use the spoon. The authors found that salt intake were reduced after 1 month and 6 months. However, salt intake in China mainly comes from traditional cooking modes that limit the effectiveness of the 'limit-salt-spoon'. Although the limit-salt-spoon is distributed free of charge, its scope is still very small, especially in rural areas. Therefore, it is necessary to take advantages of media to further education.

Low-sodium salt

Low-sodium salt is based on sodium chloride with the addition of a certain amount of magnesium and potassium in order to improve the body's metabolism of sodium, potassium and magnesium. It is also used for prevention and treatment of HTN. Since the first standard of salt of low sodium was first presented in China in 1994, the standard has been revised for several times. Now, it is divided into three categories: (I) class I: 10 g low-sodium salt contains sodium chloride (7.00±1.00 g), potassium chloride (2.4±1.00 g) and magnesium (0.05±0 015 g); (II) class II: 10 g low-sodium salt contains sodium chloride (7.00±1.00 g), potassium chloride (2.4±1.00 g) and magnesium (0.06±0.02 g); (III) class III: 10 g low-sodium salt contains sodium chloride (7.00±1.00 g), potassium chloride (3.00±1.00 g). Up to now, this new kind of salt has been sold in many cities, including Beijing. From the study of dietary sodium and potassium interventions in rural areas in the North of China, researchers demonstrated that mean systolic and diastolic BP decreased by 8.1/3.5 mmHg with sodium reduction. However, mean systolic and diastolic BP increased by 9.1/4.0 mmHg with high sodium intake. During high sodium intake and potassium supplementation, systolic and diastolic BP was reduced by 4.6/1.9 mmHg, compared to high sodium intake (34). These studies show that salt reduction is an effective way to prevent HTN. Furthermore, the use of low sodium/high potassium salt can lead to salt reduction in the general population (35). However, there are barriers that may limit the feasibility and/or effectiveness of introducing low-sodium salt at a population level: First, the low-sodium salt is more expensive than normal salt. Second, low-sodium salt is currently not well known to the public. Third, a significant percentage of patients with HTN are not salt sensitive, but this is probably not really an issue where we are focusing on population-wide interventions.

Conclusions

There is sufficient evidence that salt reduction can contribute to reducing BP in subjects with or without HTN. Salt reduction can be accomplished through health-education, special programs, and the use of low-sodium salt. However, China is a country with traditionally high salt diet, a large inhomogeneous population, significant imbalances in regional economical development and limited public advocacy for salt reduction. All these conditions lead to a certain gap in the control of salt and HTN in China compared with Europe and the United Stated. There is also a need for systematic data collection about the relation between salt reduction and prevention and treatment of HTN in Chinese residents and a need to further illuminate the pathogenesis of salt-sensitive HTN. Therefore, while learning from the experience of other countries as described in this Focus Issue, we need to pay close attention to our population's own characteristics and develop salt reduction strategies in accordance to our country's traditions. Such strategies will eventually improve control of HTN and the quality of life of Chinese patients.

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Original Article

Sodium content in processed foods in Argentina: compliance with the national law

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Background: Despite the body of evidence that documents the unfavorable effects of excessive sodium consumption on blood pressure and cardiovascular health, public health efforts to decrease sodium consumption have been limited to a few countries. Argentina is the first country in Latin America to regulate sodium content of processed foods by means of a national law. The objective of this cross-sectional quantitative study is to provide a baseline comparison against the reduction targets set by the national law before its entry into force.

Methods: Data were collected in February 2014 in a leading supermarket chain located in Buenos Aires. Nutrient data from package labels were analysed for 1,320 products within 14 food groups during the study period. To compare sodium concentration levels with the established maximum levels we matched the collected food groups with the food groups included in the law resulting in a total of 292 products. Data analysis was conducted using SPSS version 20 software.

Results: Food groups with the highest median sodium content were sauces and spreads (866.7 mg/100 g), meat and meat products (750 mg/100 g) and snack foods (644 mg/100 g). Categories with the highest sodium content were appetizers (1,415 mg/100 g), sausages (1,050 mg/100 g) and ready-made meals (940.7 mg/100 g). We also found large variability within products from the same food categories. Products included in the national law correspond to 22.1% (n=292) of the surveyed foods. From the 18 food groups, 15 showed median sodium values below the established targets. Products exceeding the established maximum levels correspond to 15.1% (n=44) of the products included in the analysis.

Conclusions: This study is the first analysis of food labels to determine sodium concentrations of processed foods in Argentina and to provide a baseline against the national law standards. Upon the completion of this analysis, maximum levels have been achieved by most of the food groups included in the law. Thus, the introduction of further reductions for the existing maximum levels and the establishment of sodium targets for all relevant product categories not included in the law should be considered as the next steps in the process.

Keywords: Sodium reduction; processed foods; public health policies; Argentina; Latin America

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Introduction

There is compelling evidence of the close relationship between excess sodium intake, raised blood pressure and cardiovascular diseases (CVD) (1-4). In fact, excess sodium intake has been reported to cause 3.1 million deaths 5.6% of premature deaths and 2.4% of disability (62 million DALYs) globally (4-6). In Argentina, CVD is the first cause of death in the general population with 94,099 deaths per year (7). According to a study conducted in Argentina about the burden of disease attributable to cardiovascular risk factors, 37% of all cardiovascular deaths are attributable to hypertension (8). Furthermore, data from the National Risk

Factor Survey showed that 34.1% of the adult population is hypertensive (9). Sodium intake is also estimated to be at least double of the World Health Organization (WHO) recommendation of 2,000 mg/day (10) as it is the case of other countries (11-14) in the region. According to data from the National Ministry of Health (MoH), salt consumption per person is approximately 12 g/day (15).

The main source of sodium intake comes from processed foods (4,16) with a small proportion coming from the salt added during preparation or at the table as it has been estimated in developed countries (17,18). In Argentina, estimations from the MoH indicate that between 65% and 70% of dietary sodium intake comes from processed foods (10).

Sodium reduction policies are cost-effective and efficient in reducing the global burden of CVD (19,20) and improving the health of the general population (21). As has been the case of developed countries such as Finland and the United Kingdom that have promoted sodium reduction strategies and are already documenting reductions in dietary sodium intake (22-24), similar public health policies are needed in developing countries to achieve similar goals in order to prevent and reduce CVD and non-communicable diseases (NCD). In fact, the cost-effectiveness of preventive interventions to reduce CVD (25), cost-utility of salt reduction (26) and the feasibility of sodium reduction in processed foods in Argentina (10) have already been documented. As it has been estimated in a cost-utility analysis conducted in Argentina, a reduction of 3 grams of salt in the Argentinean diet would result in a 24.1% reduction in the incidence of heart disease, 21.6% reduction in acute myocardial infarction and 20.5% reduction in stroke cases. The intervention would also reduce mortality rates from heart disease in 19.9% (26).

The Argentinean government has shown leadership in engaging the food industry in a reformulation effort. In 2011, the MoH signed a voluntary agreement (27) with large food companies to gradually and progressively reduce sodium content in processed foods.

According to the food group and category, reductions vary between 5% and 18% over the maximum levels in a period of two years. This has been achieved under an initiative called *Menos Sal Más Vida* (Less Salt More Life) (28) that has the purpose of lowering sodium consumption in the general population in order to meet the WHO recommendation of a daily intake of 5 g of salt per person by 2020. Furthermore, the creation in 2011 of the Healthy Argentina Program (Programa Argentina Saludable), the Cardiovascular Disease Prevention Program (Programa de Prevención de Enfermedades Cardiovasculares) and the National Commission on Prevention of NCDs (Comisión Nacional para la Prevención de Enfermedades Crónicas No Transmisibles) are milestones in Argentina's public health policy arena regarding the prevention of NCD (27).

More recently, in December 2013, Argentina passed a sodium reduction law (Act 26905) which entered into force in December 2014, becoming one of the first countries in the region to regulate sodium content in processed foods. The law includes gradual reductions similar to the values set in the voluntary agreement (between 5% and 18% of reduction) in three main food groups and other two main measures regarding education campaigns to the general population and a restaurant strategy (restriction of salt shakers and low-sodium menus) (29).

This study is part of a comprehensive research strategy to monitor sodium reduction policies in Argentina. The qualitative analysis of the policy process has been published elsewhere. The objective of this study is to determine the baseline sodium levels of processed foods in Argentina provided by food labels and to compare our results with the maximum levels set in the national law. This quantitative analysis was conducted to provide a baseline comparison against the reduction targets set by the National Law before its entry into force.

Methods

Study design

This is a cross-sectional study design to obtain baseline sodium content information months before the entry into force of the national law by means of a systematic survey of the nutritional information of processed foods in Argentina and to compare these sodium levels with the maximum levels set in the national law. This study is part of the "The Food Monitoring Group" initiative to monitor the nutritional content of processed foods worldwide (30,31). The Argentinean component is a comprehensive research strategy that also includes the qualitative analysis of sodium reduction policies and the chemical analysis of a sample of breads (32).

Data collection

Data were collected in February 2014 in a leading supermarket chain according to market share information (33). Data collection was conducted by a member of the research team on-site. In order to obtain permission to access the supermarket, a formal letter was sent and approval from the supermarket officials was obtained. Each product was surveyed using the data collector application (34) developed by The George Institute. This process included the scanning of the bar code of each product and taking three photographs (front of the package, ingredients list, and nutritional information panel). This information was then uploaded and entered into The George Institute's branded food composition database (35) according to standardized methodology (30). For each product, manufacturer, brand and product name, serving size and the complete nutritional information per 100 g or 100 mL was entered.

Definitions of food groups and categories

Food groups and categories were defined using the classification system of The George Institute (30) and adapted to the food products available in Argentina. Food groups were defined according to the set of food products that use the same raw material and have similar nutritional content (e.g., bread and bakery products, dairy products, etc.). Food categories included products with the same manufacturing process (e.g., biscuits, bread, etc., within the bread and bakery products groups) (36,37). The final food categorization system included 14 food groups: bread and bakery products, cereals and cereal products, dairy products, meat and meat products, fish and derivatives, snacks and appetizers, fast food, oil emulsion dressings, sauce products and spreads, beverages, canned vegetables and fruit, ice cream, chocolate and seasonings. These groups were also classified into 40 categories.

For the comparison of the surveyed products with the national law we matched the food groups and categories from our database with those food groups and categories included in the national law. The law includes three main food groups: meat and meat products, farinaceous and soups, seasonings and canned food. Within these groups, 19 product categories are included: cooked, dry and ready-to-eat sausages, luncheon meat, processed poultry, bran crackers, crackers, snacks crackers, snacks, dry sweet biscuits, filled sweet biscuits, whole meal bread, white bread, frozen bread, bouillon cubes and granulated soup, clear soup, cream soup and instant soup.

Data analysis

In order to characterize the distribution of the data set in each food group and category, median values were used as they are robust measures of central tendency and they are less sensitive to extreme values. The mean and the range were added as a reference, as well as percentile 25 and percentile 75. The coefficient of variation as index of dispersion was also calculated.

To compare sodium concentration levels with the established maximum levels we matched the collected food groups with the food groups included in the law resulting in a total of 292 products that could be compared. The comparison in *Table 1* was made between the median values and the targets established by the law. In the same table, we added a column to show how the median of sodium concentration for the products analyzed are above or below the established targets. This showed how close or how far the median values were when compared with the established targets. The difference between the median values is showed in percentages and it was calculated as follows: [1- (median/target)] ×100. A positive value shows that the median values of the products are below the target and a negative value shows that the median is over the target established by law. Data analysis was conducted using SPSS version 20 software.

Results

Sodium content

Data collection included 1,655 products surveyed. Nutrient data from package labels was analyzed for 1,320 products within 14 food groups during the study period (*Table 2*). We excluded the products in which sodium content or serving size was not available as these two values allow the calculation of sodium content per 100 g.

From the total number of products, most products were bread and bakery products (18.5%), convenience foods (13.6%), dairy products (cheese) (12.9%), and beverages (11.1%), cereal and cereal products (10%), sauces and spreads (8.8%), snack foods (8.1%), meat and meat products (6.1%) and other products (11%). The number of products in the different food groups ranged from 19 (oil products and oil emulsions) to 241 (bread and bakery products) (*Table 2*).

Food groups with the highest median sodium content were sauces and spreads (866.7 mg/100 g), meat and meat products (750 mg/100 g), dairy products (cheese) (653.3 mg/100 g) and snack foods (644 mg/100 g). Confectionery (chocolate) (76 mg/100 g), ice creams (61.1 mg/100 g) and beverages

Table 1 Sodium content in the food products included in the national law (n=292)

Food groups	Products	Max. values: sodium mg/100 g	N of prod.	Sodium mg/100 g			N of prod. above the target	Median % above/under the target (%)
				Mean	Median	Range		
Meat and meat products	Cooked sausages and salt-cured cooked products with and without stuffing. It includes: mortadella, sausages, cooked ham and blood sausage	1,196	17	833.2	944.0	135-1,077.3	0	21
	Dried salami, sausages and soppressata	1,900	10	1,336.2	1,491.3	320-2,005	1	22
	Fresh sausages	950	4	1,041.0	1,070.0	922-1,102	3	−13
	Hamburgers	850	17	720.0	695.8	609.6-950	1	18
	Breaded chicken group: nuggets, bouchées, patynitos, supremes, medallions and chicken shapes	736	7	515.1	526.2	226.9-709.2	0	29
Farinaceous	Crackers with bran	941	2	275.2	275.2	7-543.3	0	71
	Crackers without bran	941	9	566.3	510.0	309.4-1,036.7	1	46
	Snack crackers	1,460	17	873.8	788.4	187.1-1,800	1	46
	Snacks	950	16	767.5	762.0	180-1,056	5	20
	Dry sweet cookies	512	69	225.0	225.0	0-538.7	1	56
	Filled sweet cookies	429	38	171.3	146.7	0-436.7	1	66
	Bakery products without bran	530	13	506.8	546,0	50-770	7	−3
	Bakery products with bran	501	46	456.6	492,0	0-883.3	23	2
	Frozen bakery products*	527					0	
Soups, dressings and canned foods	Bouillon cubes and granulated soup	430	9	352.1	388,8	33.2-415.2	0	10
	Clear soups	346	3	313.2	303,2	301.6-334.8	0	12
	Cream soups	306	6	258.8	280,7	140-300	0	8
	Dry soups	352	9	239.3	248,8	174-292.4	0	29

*, although this category is included in the law, we did not find products belonging to this group in the products surveyed.

Table 2 Sodium content of processed foods in the different food groups in Argentina (n=1,320)

Food group	N of Prod.	Sodium mg/100 g and 100 mL					
		Mean	Median	Range	%ile 25	%ile 75	CV* (%)
Edible oils and oil emulsions	19	347.9	240.0	140-720	140.0	570.0	62
Beverages (non-alcoholic)	145	18.7	16.0	0-191	7.0	21.0	119
Meat and meat products	79	849.8	750.0	65.1-2,550	650.0	1,050.0	50
Cereal and cereal products	131	277.5	203.3	0-991.2	41.2	447.5	91
Chocolates	22	100.4	76.0	28.6-240	39.3	164.3	71
Convenience foods	178	422.2	340.75	0-3,610	115.0	593.3	107
Canned fruits and vegetables	35	163.5	163.9	0-550	8.5	239.2	90
Ice cream**	40	67.9	61.1	5.2-174	54.6	72.8	40
Dairy products (cheese)	169	703.5	653.3	13.3-1,576.7	480.0	933.3	51
Bread and bakery products	241	335.6	283.3	0-1,283.3	166.7	475.0	69
Fish and fish products	26	357.2	311.65	44-954	173.3	490.0	60
Sauces and spreads	115	1,089.4	866.7	0-5,510	553.3	1,016.7	91
Snack foods	106	795.3	644.0	3.6-2,940	500.0	852.0	70
Condiments***	14	10,961.9	10,111.1	0-21,680	7376	16,560	58.3

*, coefficient of variation; **, ice creams are defined as a separate group from dairy as in the Argentinean Food Guide they are included in the "sweet and sugar" group. This is because they have a high proportion of sugar in their composition; ***, condiments (defined as an additive used during cooking to give food a particular flavor) showed a high sodium concentration when reported per 100 g. If reported considering a mean serving size of 5.9 g this would result in a median sodium content of 596.5 mg.

(16 mg/100 mL) had the lowest mean sodium content. Within the food groups, the categories with the highest median sodium content were appetizers (1,415 mg/100 g), sausages (1,050 mg/100 g) and ready-made meals (940.7 mg/100 g) (*Table 3*). Categories with the lowest median sodium content included canned fruits (0 mg/100 g), non-alcoholic beverages (16 mg/100 g) and pasta (55 mg/100 g) (*Table 3*).

We found large variability within products from the same food categories. Coefficients of variation for all the food groups ranged from 119% to 40%. Beverages (range, 0-191 mg/100 g; CV: 119%), convenience foods (range, 0-3,610 mg/100 g; CV: 107%), sauces and spreads (range, 0-5,510 mg/100 g; CV: 91%), cereal and cereal products (range, 0-991.2 mg/100 g; CV: 91%) and canned fruits and vegetables (range, 0-550 mg/100 g; CV: 90%) showed the highest variability in sodium contents (*Table 2*). Within the different food categories, we found the highest variations in canned fruit (range, 0-5.9 mg/100 g; CV: 283%), pasta (range, 0-991.2 mg/100 g; CV: 120%), non-alcoholic beverages (range, 0-191 mg/100 g; CV: 119%), canned herring (range, 148.3-681.7 mg/100 g; CV: 90%) and pre-cooked meals (range, 17.6-1,508 mg/100 g; CV: 90%) (*Table 3*).

Comparison of baseline sodium levels against targets set by National Act 26905

Products included in the groups selected in the national law correspond to 22.1% (n=292) of the surveyed foods (*Table 1*). For the 18 food categories included in the law, the number of products varied from 69 in the dried sweet cookies to two in the crackers without bran category. Products with the highest median sodium contents were dried salami, sausage and soppressata (1,491.3 mg/100 g), fresh sausages (1,070 mg/100 g), cooked sausages and salt-cured cooked products with and without stuffing (944 mg/100 g) and snack crackers (788.4 mg/100 g). Filled sweet cookies (146.7 mg/100 g), dried sweet cookies (225 mg/100 g), dry soups (248.8 mg/100 g) and crackers with bran (275.2 mg/100 g) are the categories with the lowest median sodium contents.

We also found large variability within products from the same food categories included in the law. Crackers with bran (range, 7-543.3 mg/100 g), filled sweet cookies (range,

Table 3 Sodium content in the different food categories in Argentina (n=1,306)

Food group	Category	N of Prod.	Sodium mg/100 g					CV* (%)
			Mean	Median	Range	%ile 25	%ile 75	
Edible oils and oil emulsions	Butter	6	160.0	140.0	140-260	140.0	140.0	31
	Margarine	13	434.6	470.0	200-720	200.0	650.0	48
Beverages	Non-alcoholic beverages	145	18.7	16.0	0-191	7.0	21.0	119
Meat and meat products	Sausages	41	1,033.2	1,050.0	135-2,550	884.0	1,200.0	50
	Processed poultry	7	515.1	526.2	226.9-709.2	350.8	698.5	35
	Hamburgers	17	720.0	695.8	609.6-950	675.4	750.6	12
	Others	3	431.9	533.3	65.1-697.3	65.1	697.3	76
	Spreads	11	693.6	700.0	590-750	650.0	750.0	8
Cereals and cereal products	Cereal bars	11	178.9	175.0	73.9-305.2	126.1	208.0	37
	Breakfast cereal	49	308.1	212.5	7-900	80.0	510.0	82
	Pasta	54	236.9	55.0	0-991.2	15.0	410.0	120
	Soy-based products	17	381.9	402.4	28-653.4	306.3	456.5	40
Chocolates	Alfajores	22	100.4	76.0	28.6-240	39.3	164.3	71
Convenience Foods	Bouillon cubes	9	352.1	388.8	33.2-415.2	375.6	400.0	34
	Pancakes	6	408.9	406.7	363.3-500	363.3	413.3	12
	Pizzas	18	505.4	551.6	155.2-880	329.6	600.0	41
	Ready-made meals	8	993.4	940.7	190-1,750	891.8	1,170.0	44
	Pre-cooked meals	26	380.7	289.4	17.6-1,508	115.4	542.5	90
	Instantaneous desserts	36	82.1	79.6	18.2-206.7	44.9	109.6	51
	Pre-mixtures	28	559.4	449.2	18.3-1,215	410.0	666.7	52
	Soups	18	258.2	265.8	140-334.8	248.5	294.0	20
	Puff pastry for empanadas	9	618.6	635.7	15-1,014.3	634.8	722.2	43
	Puff pastry for pies	10	624.7	655.0	413.3-750	510.0	716.7	18
	Frozen vegetables	10	751.1	55.9	0-3,610	29.0	304.0	190
Canned fruit and vegetables	Canned fruits	8	0.7	0.0	0-5.9	0.0	0.0	283
	Canned vegetables	27	211.8	211.7	8.5-550	150.0	254.6	63
Ice creams	Ice creams	40	67.9	61.1	5.2-174	54.6	72.8	40
Dairy products	Cheese	169	703.5	653.3	13.3-1,576.7	480.0	933.3	51
Bread and bakery products	Biscuits	125	243.9	225.0	0-1,036.7	133.3	310.0	72
	Bread	38	485.6	492.0	50-630	444.0	542.0	20
	Bakery products	53	387.1	300.0	19-1,283.3	211.7	496.7	75
	Toast	25	456.8	573.3	0-883.3	112.0	680.0	65
Fish and derivatives	Canned tuna	8	346.3	311.7	238.3-534	251.7	435.9	33
	Breaded fish	7	302.3	280.8	149.2-584.6	149.2	509.2	59
	Others	8	424.7	360.2	44-954	246.2	593.6	70
	Canned herring	3	334.4	173.3	148.3-681.7	148.3	681.7	90
Sauces and spreads	Seasonings	96	1,228.1	933.3	0-5,510	730.0	1,070.9	83
	Sauces	19	389.0	516.7	6.5-633.3	208.3	533.3	54
Snacks and appetizers	Appetizers	18	1,451.6	1,415.0	394-2,940	680.0	1,610.0	60
	Snacks	88	661.1	607.4	3.6-2,384	500.0	794.2	52

*, coefficient of variation. This table does not include the food group condiments (n=14).

0-436.7 mg/100 g), dried cookies (range, 0-538.7 mg/100 g) and bakery products with bran (range, 0-883.3 mg/100 g) had the highest sodium content variations against clear soups (range, 301.6-334.8 mg/100 g), fresh sausages (range, 922-1,102 mg/100 g), hamburgers (range, 609.6-950 mg/100 g) and dry soups (range, 174-292.4 mg/100 g) with the lowest sodium level variations (*Table 1*).

From the 18 food groups, 15 showed median sodium values below the established targets. We found that 50 out of 55 products (90.9%) from the meat and meat product food group, 171 out of 210 farinaceous (81.4%) and 27 out of 27 (100%) soups, dressings and canned foods had median sodium levels below the established targets. In the case of filled sweet cookies (n=38), for instance, median sodium concentration was 146.7 mg/100 g, while the maximum sodium level was established in 429 mg/100 g. This shows that the median value is 66% below the established target (*Table 1*).

Products exceeding the established maximum levels correspond to 15.1% (n=44) of the products included in the analysis (n=292). The number of products ranged from one (e.g., dried sausages, hamburgers, crackers, etc.) to 23 (bakery products without bran). In the bakery products without bran category, even when the median is below the established target, we found 23 products (n=46) that do not comply with the maximum levels being the category with the highest number of products exceeding the current established levels. This category also showed an important sodium level variability (range, 0-883.3 mg/100 g) (*Table 1*). In the case of bakery products with bran (n=13), the median sodium concentration is 3% above the established maximum level.

Discussion

Despite the body of evidence that documents the unfavorable effects of excessive salt consumption on blood pressure and cardiovascular health, public health efforts to decrease sodium consumption have been limited to a few countries. Argentina is the first country in Latin America to regulate sodium content of processed foods by means of a national law.

This study is the first analysis of food labels to determine sodium concentrations of processed foods in Argentina and to provide a baseline against the national law standards. This will be an essential input for future comparisons. The methodology used in this study and the use of our findings could also be used in other countries in the region to promote sodium reduction strategies in light of the recently published Regional Targets for Salt Reduction in the Americas by the Pan American Health Organization (38). Furthermore, the database will be updated regularly in order to better evaluate the progress of the current reformulation policy in our country.

As shown in other studies (39-42), one of the major findings of this analysis is that sodium concentrations vary significantly within the same food group and category. Similar findings were also found in a previous pilot study conducted in our country (36) using the same methodology. This shows that technical feasibility of having lower sodium food products in the market is achievable and that gradual and progressive reductions can be expected.

On the other hand, as it has already been agreed, prevention of CVD is essential to reduce premature mortality in our region. The sodium reduction law (National Act 26905) is a very important step forward in the prevention of CVD in Argentina, as well as in the rest of the Latin American countries who implement similar strategies (32). In our analysis, several months before the law entered into force, most products from the food groups included in the law are already below the established maximum levels showing that further reductions could be promoted in the short term. In fact, high compliance with the law at the moment of entering into force shows that the reduction targets had already been set in the voluntary agreement signed between the MoH and the food industry (27). As in the voluntary agreement the food industry was mainly represented by big companies who had already been working to achieve these targets, the enactment of this law may not have implied a big challenge for these companies. However, unlike the voluntary agreement, the current legislation reaches all the food companies (36) including small and medium food enterprises located throughout the Argentinean territory. Although this is a very positive aspect of the new legislation that will cover all the selected food products, it will be essential to implement effective monitoring mechanisms to the guarantee the universal compliance of the law, especially concerning small and medium enterprises.

One of the strengths of this legislation is the fact that the MoH has full authority to set new progressive and gradual reduction targets and to include new food categories. This is a very significant aspect as on the one hand, the law does not cover all the food groups that contribute to the sodium consumption of the Argentinean population and on the other, sodium content in the food groups included in the law is still high to achieve the WHO recommendation of 2,000 mg per day. As shown in our results, variability in the sodium content of these products shows that reductions are feasible and can be achieved in the near future.

Although this law constitutes an important step forward in the prevention of CVDs in our country, dietary sodium intake at the population level remains high (9), showing that the challenge ahead will be to guarantee the full implementation of the current law, to promote progressive and gradual reduction targets, especially for larger companies that have already achieved the current targets, and to continue with the efforts to add new food categories. Also, it is important to consider that reformulation efforts should be accompanied by other comprehensive policies to promote healthy nutrition in the general population such as the promotion of clear front-of-packaging labeling information, marketing of unhealthy foods targeted to children and policies to increase availability of fruits and vegetables, among others.

The present study will be used as an independent tool to monitor future changes in sodium content in processed foods marketed in our country. Also, our data will not only facilitate analysis over time, but also provide information for comparisons among the different countries participating in The Food Monitoring Group.

One of the most important limitations of our study is that we could not cover the complete food products available in the Argentinean market, especially those from small and medium enterprises. However, data collection in different areas of the country will be conducted in the future to include these products.

Conclusions

In conclusion, this baseline assessment of the median sodium content of processed foods provides valuable information on the development of a sodium reduction law in Argentina and allows objective and independent monitoring of the implementation of the law.

Upon the completion of this analysis, maximum levels have been achieved by most of the products surveyed. Thus, the introduction of further reductions for the existing maximum levels and the establishment of sodium targets for all relevant product categories not included in the law should be considered as the next steps in the process.

This national sodium reduction legislation could have an enormous potential to prevent CVD, guaranteeing the effective implementation of this policy which, together with discussion to add new targets and categories, should be a national public health priority.

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Original Article

Salt reduction in Australia: from advocacy to action

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Background: As part of its endorsement of the World Health Organization's Global Action Plan to prevent non-communicable diseases, the Federal Government of Australia has committed to a 30% reduction in average population salt intake by 2025. Currently, mean daily salt intake levels are 8-9 g, varying by sex, region and population group. A number of salt reduction initiatives have been established over the last decade, but key elements for a co-ordinated population-level strategy are still missing. The objective of this review is to provide a comprehensive overview of existing population-level salt reduction activities in Australia and identify opportunities for further action.

Methods: A review of the published literature and stakeholder activities was undertaken to identify and document current activities. The activities were then assessed against a pre-defined framework for salt reduction strategies.

Results: A range of initiatives were identified from the review. The Australian Division of World Action on Salt and Health (AWASH) was established in 2005 and in 2007 launched its Drop the Salt! Campaign. This united non-governmental organisations (NGOs), health and medical and food industry organisations in a co-ordinated advocacy effort to encourage government to develop a national strategy to reduce salt. Subsequently, in 2010 the Federal Government launched its Food and Health Dialogue (FHD) with a remit to improve the health of the food supply in Australia through voluntary partnerships with food industry, government and non-government public health organisations. The focus of the FHD to date has been on voluntary reformulation of foods, primarily through salt reduction targets. More recently, in December 2014, the government's Health Star Rating system was launched. This front of pack labelling scheme uses stars to highlight the nutritional profile of packaged foods. Both government initiatives have clear targets or criteria for industry to meet, however, both are voluntary and the extent of industry uptake is not yet clear. There is also no parallel public awareness campaign to try and influence consumer behaviour relating to salt and no agreed mechanism for monitoring national changes in salt intake. The Victorian Health Promotion Foundation (VicHealth) has recently instigated a State-level partnership to advance action and will launch its strategy in 2015.

Conclusions: 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 Australia is on track to achieve the proposed 30% reduction in salt intake within the next decade.

Keywords: Advocacy; Australia; salt reduction; public health; health policy

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Introduction

In 2013, the Federal Government of Australia signed up to the global targets to reduce population salt (sodium) intake by 30% by 2025. These were part of a broader set of United Nation (UN) nine targets to reduce the burden of non-communicable diseases (NCDs) by 25% by 2025 (1). NCDs, including cardiovascular disease, are the leading cause of death in the world, killing more people each year than all other causes combined (1). Almost 1 in 3 deaths in Australia was due to cardiovascular disease in 2012 (2). Ischemic heart disease was the leading cause of death followed by cerebrovascular diseases (strokes, haemorrhages, infarctions) (3).

There is strong evidence to show that reducing salt intake will reduce blood pressure with subsequent reduction in the number of premature deaths from heart disease and stroke (4). Additionally, population salt reduction has been identified as one of the most cost-effective strategies for reducing the burden of NCDs, both internationally (5) and in Australia (6).

How much salt are we eating?

Whilst there is no nationally representative study of salt intake based on 24-hour urine samples in Australia, most studies suggest that people are eating around 8-9 g each day, almost twice the World Health Organization (WHO) guideline amount (7). As much as 80% of salt in the Australian diet is likely to come from processed foods (8). Recent studies utilising dietary data indicate that around 19% of salt in the diet of both children and adults comes from bread with other main contributors including cereals, meat products, sauces, dairy and egg dishes and combination dishes, for example, pizzas, sandwiches, stir fry dishes (9,10). The average Australian diet derives 35% of daily energy intake from discretionary processed foods which are energy dense, nutrient poor and high in saturated fat, sugar and salt (11). Sources of salt in children's diets are similar to that of adults (12).

The existing range of salt levels of different brands in similar processed food products found in Australia (13) demonstrates significant potential capacity for reformation of processed food to reduce salt within and between different food categories. One of the advantages of such an approach is that it is possible to reduce the salt content of processed foods to a level that can achieve clinically significant reductions in daily salt intake without adversely impacting customer preference for specific foods (14). But a strong government policy or regulatory approach would be required to achieve this.

The regulatory environment for salt in Australia

Australia has a federal system of government, supplemented by eight state and territory governments, each of which contains multiple local government areas such as cities and shires. All levels of government in Australia have responsibilities for food policy, legislation and regulation. This complexity can be a barrier to nationally coordinated action on food policy, but also provides opportunity for advocacy and action at multiple levels of government. Public health advocates in Australia have commonly used this to encourage evidence-based experimentation in health policy and uptake of best practice across jurisdictions, for example through a high profile National Tobacco Scorecard (15).

The Australian National Healthcare Agreement 2012 (16) sets out the roles of Federal and State and Territory Governments in relation to health and provides a clear remit for State and Territory Governments to act alone or work in partnership with Federal Government on programs related to salt reduction, whether it is through food regulation, health promotion or health research. National food-related public health initiatives are agreed through the Australian Health Ministers' Advisory Council, through its Australian Population Health Development Principal Committee (APHDPC).

Australia currently has national dietary guidelines for salt and a Food and Health Dialogue (FHD), established in 2010, which has set voluntary salt targets for 11 food categories (17). Analysis of salt reductions against the initial targets has demonstrated positive progress (18). However, additional steps will still be needed to ensure a coherent government response of the magnitude required to ensure that Australia can meet the new global targets. The objective of this paper is to review existing population wide salt reduction activities in Australia with a view to identifying where there is a need for additional action.

Methods

A review of the literature and stakeholder activities was undertaken to provide a comprehensive overview of salt reduction activities in Australia. Peer-reviewed literature and grey literature were retrieved from PubMed, governmental

Table 1 Mapping existing Australian activities against the framework (19)

Action	Government	Other
(I) Leadership and strategic approach	Government action but no co-ordinated national strategy	Non-government stakeholders co-ordinated nationally through the Australian Division of World Action on Salt and Health (AWASH)
(II) Baseline assessment	No national representative government survey on salt intake, sources of salt in the diet	George Institute established national baseline on knowledge, attitudes and behaviour (KAB) and salt levels in foods Various estimations of salt intake based on regional sub-samples from research institute studies
(III) Implementation strategies		
(i) Working with the food industry	Food and Health Dialogue (FHD) established in 2010 and has so far established targets for salt level in 9 categories of foods	AWASH launched food industry strategy in 2008 but has since been superseded by FHD Heart Foundation Tick scheme helps to drive industry reformulation
(ii) Changing consumer behaviour	No co-ordinated communication campaign Dietary guidelines contain advice to limit consumption of salt	AWASH media, website and leaflets Heart Foundation media and Halt the Salt Campaign
(iii) Labelling	Health Star Rating system	Food industry % daily intake scheme Heart Foundation Tick scheme George Institute/Bupa FoodSwitch smartphone application
(iv) Interventions in public institution settings	All eight state and territory governments have policies or voluntary guidelines for healthy foods in institutions. 6/8 states and territories have mandated healthy eating policies in schools	Healthy Schools Canteen Association has developed nutrition standards for school meals
(v) Advocacy		AWASH Drop the Salt! Campaign and the Heart Foundation continue to provide sustained advocacy efforts on salt reduction, including through media initiatives, stakeholder events and consumer campaigns
(IV) Monitoring and evaluation	Commitment to monitoring progress against targets for the FHD but mechanism not clear No nationally representative mechanism for monitoring salt intake, or KAB planned Government currently tendering for organisations to evaluate the Health Star Rating system	George Institute monitoring changes in salt levels in foods through its food composition database

and non-governmental organization websites. Search terms used included salt or sodium and Australia. The literature review and stakeholder information was also supplemented by a questionnaire completed by a representative from the Department of Health. These activities were then assessed against an established framework for salt reduction strategies (19) within the following domains: leadership and strategic approach, baseline assessment, implementation (working with the food industry, changing consumer behaviour, food labelling, interventions in public institution in settings), monitoring and evaluation (*Table 1*).

Results

Leadership and strategic approach

Whilst a range of salt reduction activities currently exist in Australia, there is no co-ordinated national government strategy on salt. In fact, there is a paucity of national policy in relation to public health nutrition in general. A National Food Plan (20) was produced in 2013 , and was primarily orientated towards food industry, as opposed to public health, concerns. Similarly, a scoping study for a National Nutrition Policy (21) is in development, but without a

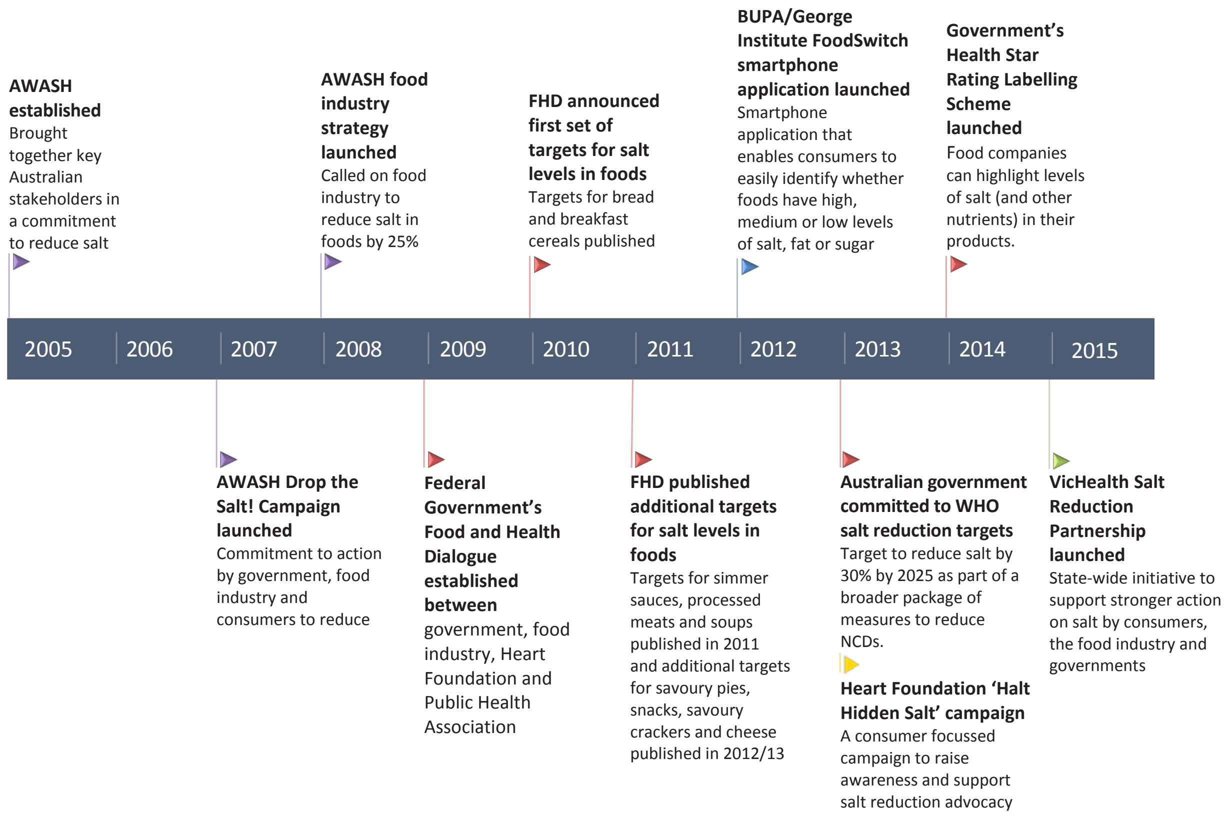

Figure 1 Chronological review of key population-level salt reduction activities in Australia.

publicly-available timeline for delivery. There is currently no obesity strategy in Australia, although a National Diabetes Strategy (22) is in development. Given this lack of national leadership on food policy by government, much of the salt reduction work to date has been led by non-governmental organisations (NGOs), such as the Heart Foundation, and advocacy networks. Since 2005 this has been co-ordinated through the Australian Division of World Action on Salt and Health (AWASH) (*Figure 1*).

National leadership

Australian Division of World Action on Salt and Health (AWASH)

AWASH was established in 2005, modelled on UK CASH and affiliated with World Action on Salt and Health (WASH). WASH was established in 2005 and is a global group with the mission to improve the health of populations throughout the world by achieving a gradual reduction in salt intake (23). In 2007, AWASH launched its Drop the Salt! Campaign to persuade the government to develop a national salt reduction strategy (8). Hosted by The George Institute for Global Health, the campaign brought together key stakeholders to persuade government to set a population salt reduction target, engage the food industry to reduce salt in foods, support a comprehensive social marketing campaign to change consumer behaviour, introduce clearer labelling of the salt content of foods and commit to regular monitoring of population salt intake. The main strategies of AWASH were government engagement, food industry engagement and media and communications, underpinned by a robust research and monitoring program.

National Heart Foundation of Australia

The National Heart Foundation's Tick Program has been challenging Australian food companies to reformulate to produce healthier products in specified food categories and highlight them to consumers using the Tick logo since 1989 (24,25). The Heart Foundation continues to be a key player in salt reduction. Its existing 5-year Strategic Plan (26) prioritises salt reduction by pushing for stronger government action on food reformulation and launching a consumer awareness/advocacy campaign (27). The Heart Foundation was instrumental in the establishment of the FHD in 2009 and has continued to play a critical role in its implementation. This has included providing reformulation expertise and nutritional analysis, and profiling of various food categories to support the nutrient target setting process. The Heart Foundation has argued strongly in recent years for a "super-charging" of the FHD (28).

Australian government

Whilst there is no overarching government policy or strategy on salt, the federal government has acknowledged the importance of reducing salt in the diet for several decades (29,30), and currently leads a number of initiatives related to salt reduction. These include the FHD with a remit to drive food reformulation as well as to implement a social marketing strategy to improve healthy eating (31); the Australian Health Survey (AHS), which recently reported on salt intake levels for Australia (32), and recently endorsed a Healthy Star rating labelling scheme to highlight the healthiness of foods on labels on the front of food products (33).

State and territory leadership

VicHealth salt reduction partnership

VicHealth is a statutory health promotion foundation in the State of Victoria which is home to about 6 million people, one quarter of the population of Australia. In recognition of the public health benefits that can be achieved, VicHealth has prioritised the establishment of a State-level partnership to reduce population salt intake. Principal partners include the World Health Organization Collaborating Centre on Population Salt at The George Institute, Deakin University and the National Heart Foundation (Victoria). The strategy and action plan, to be launched in 2015, outlines the intentions to work with governments, the food industry, non-government organisations and the Victorian public, to build a shared commitment to action on salt. This includes initiatives to get more Victorians talking about the current high levels of salt in foods; support for stronger government policy and leadership; work with food industry partners to find innovative solutions to lowering salt in foods and meals, and a program to monitor and evaluate progress made to reduce salt in Victoria.

Baseline assessment

The 2011-2012 AHS is the only nationally representative survey of salt intake in Australia and recently reported that mean population salt intake was about 6 g/day (32). However, this was based on dietary surveys (repeat 24-hour recall) which are known to under-estimate salt intakes and did not include discretionary salt (34). Most studies using 24-hour urine, indicate that salt intake in Australia is 8-9 g/day per person. There are marked regional differences, for example from 7.9 g/day in the city of Adelaide, South Australia (9) to 9 g/day in the market town of Lithgow, New South Wales (35). Most studies also demonstrate significant differences in salt intake between men and women. For example, the most recent Victorian study estimated a daily intake of 9.5 g for men and 6.9 g for women (36). Children are also eating more than the recommendations for adults. The recent AHS showed that almost all children were exceeding recommended upper levels, with intakes ranging from just under 4 g for 2-3 year olds to almost 7 g for 14-18 year olds (32). This is consistent with the salt intake assessed by 24-hour urinary sodium excretion in Victorian school children aged 5 to 13 years (37).

A national baseline for sodium levels in foods and consumer knowledge, attitudes and behaviour (KAB) towards salt was undertaken by The George Institute in 2008 (38,39). Subsequent regional assessments have been conducted (40). There is no agreed national mechanism for monitoring changes in salt intake or KAB. Objective monitoring of the food industry progress on reducing salt in foods is being undertaken via the establishment of a database of sodium levels in foods (13).

Implementation

Working with the food industry

The government's FHD is now the main vehicle for engaging the food industry to reduce salt levels in processed foods and meals. AWASH previously launched its food industry strategy in 2008 building on the efforts of the successful Heart Foundation Tick program which had been running since 1989 (41). The objective of the AWASH food industry strategy was to engage all sectors of the food industry in a voluntary collaborative effort to reduce salt in all food categories that contributed to salt in the diet. The four main goals were to achieve high level commitment from the food industries, to obtain individual company agreements and action plans; to develop product-specific targets for salt levels in major food categories; and to promote good practice and innovation by food companies.

The food industry engaged willingly in the strategy and over the first three years, commitments to salt reduction were received from 19 companies (including retailers, manufacturers, quick-food service and contract caterers) and detailed action plans from 10. A range of targets for salt reductions, most between 5-40%, were established to be delivered over the following few years. For example a major supermarket and snack food company committed to reducing the salt content of their products by 25% over five years, directly in line with the AWASH strategy. Media work to promote the good practice of food companies in relation to salt was a key element of the AWASH food industry strategy.

Food and Health Dialogue (FHD) targets

AWASH and the Heart Foundation both contributed to raising the profile of salt reduction on the government's agenda, including the establishment of the FHD in 2009 and the setting of salt reduction targets (42). The FHD brought the Federal Department of Health together with food companies and public health organisations, including the Heart Foundation and the Public Health Association, to agree action plans to improve the health of diets. Over the next four years salt level targets were set for 9 different categories of processed foods (bread, ready to eat breakfast cereals, simmer sauces, processed meats, soups, savoury pies, potato/corn/extruded snacks, savoury crackers and cheese) (43). Timescales for reporting were between 2010 and 2013. However, there has been some speculation as to the future of the FHD since the new government was elected in 2013 and many of the scheduled monitoring reports were very late or still missing in 2014 (43). The Australian Government's Assistant Health Minister, said in June 2014 that she was "currently considering the best and most appropriate way forward for the Food and Health Dialogue" (44) but no announcement have yet been made.

Changing consumer behaviour

The Australian Dietary Guidelines recommend limiting foods containing added salt but there has been no coordinated public awareness campaign to try and change consumer behaviour. The AWASH Drop the Salt! Campaign has a website, disseminates leaflets and undertakes regular media activity to try and raise awareness about the importance of reducing salt. In 2013, the Heart Foundation launched the "Halt Hidden Salt" consumer and advocacy initiative to raise the community's awareness of the issue and garner support for salt reduction advocacy activities. The Heart Foundation Campaign also provides direct advice to consumers to change behaviour, for example "Adding Something Else", "Sticking To Fresh", "Reading Labels" and "Knowing Your Foods" (45). However, whilst important, both of these initiatives have limited reach and are unlikely to result in mass behaviour change at this stage.

Front of pack labelling

Front of pack labelling on packaged food is another tool that can be used both to drive food industry reformulation, and to change consumer behaviour in relation to salt. The Heart Foundation's Tick scheme has helped consumers to make healthier choices within specific food categories for 25 years (46). In 2006, the food and beverage industry introduced the % daily intake (%DI) scheme and encouraged companies to include this information on front of pack (47). However, both schemes are voluntary and public health organisations have been calling on government to introduce a mandatory front of pack scheme. More recently, all nine Australian governments, and the government of New Zealand, endorsed the voluntary Health Star Rating interpretive front-of-pack-labelling system, developed jointly by health groups, industry and government, which applies to all packaged, manufactured or processed foods ready for sale, with the exception of agreed exemptions. As part of the Health Star Rating symbol, nutrient information on saturated fat, sugars, sodium and one optional positive nutrient relevant to the food can be displayed (48) along with the optional use of the word 'high' or 'low' where relevant criteria are met. A government funded education campaign is being planned to support the roll out of the Health Star Rating system.

FoodSwitch smartphone application

In response to the previous lack of government initiative in assisting consumers make healthier food choices, The George Institute partnered with Bupa Australia and in 2012 launched the FoodSwitch smartphone application (49,50). The app is supported by a comprehensive nutrition composition database which is updated annually and relies heavily on crowdsourcing. As an important tool for advocacy as well as behaviour change, the app allows consumers to scan the barcodes of food products and be immediately presented with the nutrition information interpreted in the form of colour–coded traffic light labels and provides a list of similar products that are healthier. Over 500,000 users have downloaded and regularly update the app which now includes a SaltSwitch option for people who are particularly interested in controlling their salt intake (49).

State-based work in public institutional settings

In addition to federal government action, many state and territory governments have developed settings based policies and guidelines that could influence the amount of salt in schools, health facilities, including public hospitals, and the workplace (51-55). However, salt is usually only one component of a wider nutrition policy and implementation is often minimally funded, if at all. For example, the Tasmanian State Government adopted the Tasmanian Food and Nutrition Policy in 2004 which specifies their commitment to promoting healthy eating including reducing salt intakes (56-59). The Victorian state government has developed a number of healthy food and drink policies and guidelines for settings such as schools, public hospitals, workplaces and residential aged care facilities which include sodium limits in the nutrient criteria (60) and has a Healthy Eating Advisory Service to support organisations in the aforementioned settings to meet the food and drink guidelines, including salt reduction (61).

Monitoring and evaluation

As the recent nationally representative AHS survey was based on repeat dietary recall, and other previous and recent surveys have used 24-hour urine and been non-representative, it has not been possible to demonstrate a reduction in population salt intake since 2005. In relation to the key implementation activities, there have been some research institute efforts to assess the impact of programs of work with the food industry and a further study on consumer behaviour. However, there have not yet been any attempts to assess the impact on salt arising from labelling initiatives or work in settings.

A recent study examining changes in the sodium content of the first three FHD targets—bread, breakfast cereals and processed meats—showed that there had been significant reductions (9%, 25% and 8% respectively) in each of the product categories, both by companies that had signed up to the targets and others (18). The targets were set in 2010 to be achieved by 2013. Previous analysis of changes in the sodium levels of pasta sauces, ready meals and bread showed that there had been limited change (62-64). Likewise, there were only very small changes in the sodium content of fast foods over the three years between 2009 and 2012 (65). The authors state that the new changes show that companies are able to make changes in response to the targets and provide a strong case for strengthening and extending the work of the FHD (18).

Whilst not nationally representative, a recent regional survey of KAB on salt also demonstrated that levels remained the same as in previous surveys (66).

Discussion

This review has assessed the existing programs of work on salt reduction in Australia between 2005 and 2015 against the criteria outlined in a framework for national salt reduction strategies (*Table 1*). A number of different initiatives exist and some evidence of progress has been documented. However, most of the activity to date has been led by NGOs. Whilst the impact of these organisations is impressive, there is a need for stronger government leadership to ensure that Australia will be able to meet its commitment to the global targets to reduce salt intake by 30% over the next decade.

The UK is well on its way to demonstrating that such a target is achievable. It launched its salt reduction strategy in 2003 and by 2013 had reported a 1.4 g (15%) reduction (67) in population salt intake, with parallel reductions in blood pressure estimated to be saving around 9,000 lives a year (68). It did this through a well-funded multi-faceted strategy combining the establishment of clear salt levels targets for the food industry to achieve, a sustained and wide-reaching consumer social marketing campaign and traffic light labelling (69). The main response of the Australian government to date is the FHD which brings together government, the food industry and NGOs. However, progress has been extremely slow: the FHD took more than four years to set targets for just 11 food categories, compared to three years for 80 voluntary targets in the UK, and two years for legislation on 14 targets in South Africa (70). A previous review of the FHD concluded it was inefficient and increased resources and more focus was needed (43). Whilst The FHD is making an impact as highlighted through this review, the existing government needs to make a stronger commitment to this program including through the provision of adequate funds.

The recently established Health Star Rating scheme could be a further opportunity to drive reformulation as well as informing consumers about the relative healthiness of different food products. However, it is too early to know what the update of this might be or whether it will have an impact. The fact that both the FHD and the Health

Star Rating scheme are voluntary initiatives means that there is no way of holding different companies to account if they don't comply and many would argue that legislation to mandate industry action would be a more effective approach (43,69,70).

Overall, analysis of existing activity in Australia against the framework for salt reduction strategies (19) shows that there are at least three major gaps: lack of sustained, high-level commitment, including salt reduction specific investment, across all levels of government to salt reduction; no existing national mechanisms for monitoring salt intake, and; no co-ordinated campaign to influence consumer attitudes and behaviour. The continued role of NGOs and research organisations and the new state levels activity in Victoria will provide important influences in this respect. However, the time required to build meaningful cross-sector (NGO, industry, government) recognition and alignment on the issue, particularly in view of government reticence to regulate, means that that further immediate action is required.

The VicHealth partnership provides a useful opportunity to both have a direct impact at State level and to influence federal government action. The State of Victoria is home to leading food industry organisations, many of whom are already engaged in reducing the salt content of their products. This means Victoria is well positioned to foster innovation and creative approaches to promoting salt reduction. It is also likely that action in Victoria will stimulate further action in other Australian states, thus further increasing the pressure on federal government and multiplying the impact at a national level.

A key element of the VicHealth partnership will be public awareness activities to generate public debate and influence consumer behaviour, which have not before been implemented in Australia. Evaluation of this work will be significant as most assessments of salt-reduction activities to date have studied the outcomes of a multi-faceted intervention as a whole and do not enable any assessment of the impact of the different strands of the intervention (19).

This review demonstrated the limited activity in relation to monitoring different salt reduction activities, with existing salt intake estimates based on dietary surveys or non-representative survey samples. There is also no clear understanding of socio-economic differences. One report examining salt intake in relation to socio-economic status in children in Victoria showed that there was a marked difference, with children of low SES consuming 0.5 g per day more than those of high SES due to the fact that they are eating more sodium from convenience style foods including pies, sausage rolls, savoury sauces, potato chips (crisps) and processed meats (71). It is important that comprehensive nationally representative mechanisms for monitoring changes in salt intakes using 24-hour urine samples are established. This should include the population in general but also for specific population groups including Aboriginal and Torres Strait Islanders (72) and children, and across SES status.

As salt is the main vehicle for iodine fortification to reduce iodine deficiency, it is important that respective programs are effectively co-ordinated (73,74). In 2009, the Australian government mandated iodine fortification of salt in bread to help solve the problem of re-emerging iodine deficiency (75). This may correct iodine deficiency in children and adults (76) but will not adequately address the needs of pregnant women who will still need to take supplements. The fortification of all food-grade salt with iodine (Universal Salt Iodisation) would be a better approach to ensuring that all at risk groups benefited from fortification as well as being in harmony with salt reduction initiatives. In addition, future studies of this type should include co-ordination with iodine deficiency elimination programs as criteria for salt reduction strategies.

Conclusions

A salt reduction strategy would be highly cost-effective and has the potential to prevent thousands of deaths by reducing the burden of chronic disease in Australia. An effective strategy should be co-ordinated by government and include food reformulation, public education, food labelling and work in public institutional settings backed by a robust monitoring an evaluation strategy (42). Whilst, a number of initiatives have been established and some progress in relation to reducing salt levels in foods has been made, key elements of a co-ordinated strategy to reduce population salt intake in Australia are still missing. Both state and federal government have a responsibility to take further action on salt reduction to ensure that Australia is on track to achieve the global targets of a 30% reduction by 2025.

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Original Article

Artificial neural network modeling using clinical and knowledge independent variables predicts salt intake reduction behavior

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Background: High dietary salt intake is directly linked to hypertension and cardiovascular diseases (CVDs). Predicting behaviors regarding salt intake habits is vital to guide interventions and increase their effectiveness. We aim to compare the accuracy of an artificial neural network (ANN) based tool that predicts behavior from key knowledge questions along with clinical data in a high cardiovascular risk cohort relative to the least square models (LSM) method.

Methods: We collected knowledge, attitude and behavior data on 115 patients. A behavior score was calculated to classify patients' behavior towards reducing salt intake. Accuracy comparison between ANN and regression analysis was calculated using the bootstrap technique with 200 iterations.

Results: Starting from a 69-item questionnaire, a reduced model was developed and included eight knowledge items found to result in the highest accuracy of 62% CI (58-67%). The best prediction accuracy in the full and reduced models was attained by ANN at 66% and 62%, respectively, compared to full and reduced LSM at 40% and 34%, respectively. The average relative increase in accuracy over all in the full and reduced models is 82% and 102%, respectively.

Conclusions: Using ANN modeling, we can predict salt reduction behaviors with 66% accuracy. The statistical model has been implemented in an online calculator and can be used in clinics to estimate the patient's behavior. This will help implementation in future research to further prove clinical utility of this tool to guide therapeutic salt reduction interventions in high cardiovascular risk individuals.

Keywords: Sodium chloride; dietary; artificial neural networks (ANNs); salt intake reduction; behavior prediction; dietary intervention

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Introduction

Hypertension is considered as the highest attributable risk for mortality in the world, accounting for 16.5% of global deaths annually (1). It is estimated that high dietary salt intake is accountable for up to 30% of the prevalence of hypertension (2). Furthermore, Mozaffarian *et al*. showed that excessive dietary sodium intake was responsible for 1.38 million cardiovascular disease (CVD) deaths worldwide in 2010; 45% were due to coronary heart disease (CHD), 46% due to stroke, and 9% due to other cardiovascular complications. From the preventive point of view, He *et al*.

showed in a meta-analysis that reducing salt intake to 6 g/person/day would reduce the incidence of stroke and ischemic heart disease (IHD) by 24% and 18%, respectively. Achieving this reduction through increasing awareness and knowledge of patients is thought to help reduce the overall burden of CVD.

Knowledge is believed to have a strong influence on attitude which in turn defines one's behavior (3). Numerous studies have used regression analyses to show that nutrition knowledge is a predictor of eating behavior for various food groups (4,5). In particular, studies have shown that consumers claim to eat less salt than their true intake due to lack of knowledge on main contributors to salt in the diet (6,7). However, the exact nature of the association between nutrition knowledge or attitudes and dietary behavior remains a considerably controversial topic (8).

Predicting the patients' adherence to a low salt diet from determining his baseline knowledge would be vital for guiding educational interventions and in bridging the knowledge gap. Nutrition behavior prediction algorithms proposed thus far have been predominantly based on least squares models (LSMs) methods of modeling applied to observed prediction accuracy. Known limitations of LSM might affect its applicability and accuracy in prediction models. In particular, as the complexity of the relationship between the dependent and independent variable increases and is non-linear, the LSM method becomes less capable in predicting the outcome correctly (9). The latter complexity, we hypothesize, could be a reason behind the controversial association between nutritional knowledge and behavior (9). One particular outcome prediction model gaining popularity in the clinical research field is artificial neural network (ANN) which aims to "uncover the hidden causal relationships between single or multiple responses and a large set of properties" (10). This computational model functions similarly to our central nervous system in the sense that a node, or neuron, incorporates signals and processes them. The complex integration of inputs follows the multilayered matrix decision model which in turn leads to the final outcome (11). ANN is widely used in behavior prediction with high accuracy, such as in predicting customers' behavior (12,13), intentional violations by employees (14), and pattern of physical activity level in children (15). Earlier attempts to use neural networks for prediction of nutrition behavior have hypothesized improved accuracy by neural network based algorithms and potential impact on the prevention of CVDs (16). In theory, ANN modelling approaches to nutrition behavior prediction may minimize or avoid some of the limitations of the LSM and may result in more accurate behavior prediction to direct a more influential educational intervention. Yet, to date, ANN modeling has not been applied in predicting salt use behavior. Accordingly, we aimed to compare LSM and ANN modeling using key knowledge independent variables (KIVs) to predict salt reduction behavioral class in a high cardiovascular risk cohort and to develop an online tool using this model that can facilitate its implementation in future research.

Methods

Study design

Data collection, inclusion, and exclusion criteria

We included adult patients, from both genders, with a history of acute presentation of Hypertension, coronary artery disease (CAD), congestive heart failure, and/or history of Stroke/Transient Ischemic Attack admitted to the Cardiac Care Unit. Sample size calculated was based on recent data that around 82.2% of adults in the Lebanese community are estimated to be aware that salt/sodium worsens health (17). Taking this percentage into consideration with a confidence interval of 7%, and considering a type 1 error of 5%, a representative sample of 115 patients out of 1,500 annual CCU admissions is needed. Patients who agreed to participate were surveyed using a questionnaire on knowledge, attitude, and behavior (KAB) pertaining to salt intake. The study was approved by the local Institutional Review board.

Study instruments

The development of the questionnaire (Supplementary 1) was based on a thorough review of the literature and the questions were modelled on those used in past surveys (18-20) but culture-specific modifications were introduced, such as the examples of foods that were included (Supplementary 1). The questionnaire was translated to Arabic. The Arabic version of the questionnaire was reviewed by two Arab speaking research nutritionists to ensure that the wording of the questions was culture-specific (17). The questionnaire was previously field-tested and adopted in a recent study conducted on adult Lebanese consumers recruited from shopping centers in Beirut (17). Patient answers were translated into numerical values to be used in the statistical methods. The questionnaire has three parts: knowledge, attitude and behavior questions. The knowledge questions are 31 objective questions that have one correct answer. Hence, numerically, every question was represented by either 0 (wrong answer/don't know) or 1 (correct answer). These questions addressed familiarity with daily salt intake requirements, as well as knowledge about different foods and their salt content. It also tackled knowledge on salt and its associated health hazards. The internal consistency of the knowledge questionnaire was previously shown to be relatively high, with the Cronbach's α reliability estimate being of 0.748 (17).

The attitude questions are 14 qualitative questions that have four choices. The choices were designed to reflect the patient's attitude towards reducing salt intake, from not favorable attitude to favorable attitude. Numerically, every question is represented by an integer number, ranging from 1 (not favorable) to 4 (favorable). These questions inquired on the patient's concern with salt levels in food, ability to comprehend nutritional information, appropriateness of information on food labels, incentives for reducing salt intake, and barriers against salt reduction. The internal consistency of the attitude questionnaire was previously shown to be relatively high, with the Cronbach's α reliability estimate being of 0.724 (17).

Similarly, the behavior questions are 11 qualitative questions that have four choices. The choices are designed to reflect the quality of behavior from not favorable to favorable behavior. Numerically every question is represented by an integer number between 1 (not favorable) and 4 (favorable). These questions tackled whether patients actively reduce their intake and how, whether they look at food labels and what they look for.

Twenty-four CIVs were added as real values extracted from medical tests performed on the subject. They included patient characteristics and laboratory values such as Blood pressure, BMI, family history, past medical history, blood cholesterol levels, and current medication. These values were then introduced into the statistical learning algorithms that were used in order to perform prediction.

Calculation of salt behavior score (SBS)

Using the 11 behavior questions, where every question represents one IV, we were able to compute a SBS for every subject. SBS was computed by adding up all integers representing the 11 questions. Hence, the lowest SBS that a subject can have is 11. It represents very unfavorable behavior. On the other hand, the highest SBS that anyone can achieve is 44. It represents a very favorable behavior. SBS was computed for all subjects. The mean score of the study sample was 29±5. Hence the behavior score categorized patients into one of three classes: a non-favorable class, labeled C, represented by a score less than 26; a less favorable class, labeled B, represented by a score between 26 and 31; and a favorable class, labeled A, represented by a score larger than 31. The three classes defined by this index are based on thirtiles of the behavior score for all subjects. The lowest cutoff point of 26 represents the 33% thirtile of the behavior score for all subjects, while the 2^{nd} cutoff point of 31 represents the 66% thirtile of the behavior score of all subjects. The choice of thirtiles is justified by the appended questionnaire. All the behavior-related questions have three different answers; one indicates if the behavior of the person is very favorable, another indicates a less favorable behavior and finally an answer that indicates unfavorable behavior.

Data analysis

The LSM is the starting point for devising any best-fitting model. It is essential to implement LSM because it gives an indicator about the relevance (P value) of each of the predictors. A linear LSM is given in general by $y = \beta'.x$ Eq. [1], where x is a column vector of all predictors, β a column vector of the coefficients associated with every predictor and y represents the predicted risk. The LSM algorithm finds the best vector β that fits this model.

After the data collection phase, we place the predictors for every subject in a matrix X, where every row corresponds to one subject, and the corresponding risks of all subjects are placed in a column vector y. Then the coefficient vector is computed using: $\beta = (X^TX)^{-1}X^Ty$. This method yields the best linear model that fits the data. Referring to it as best indicates that this is the model that minimizes the square error. Non-linear models can also be considered. However, in regression methods, there is no systematic way to know the non-linear function that relates the input vector x to the output y. One can try Log function or exponential function, but the best model might be more complicated than just a log or an exponential. The solution to this problem comes with ANN as described in the next section.

A detailed introduction to ANN has been described by Hagan *et al.* (21). In this study, a standard feed-forward multilayer network was used. It consisted of ten input layers and one output layer. The input layer consists of ten neurons, to which is connected all the observed IVs. The output layer consists of 1 neuron since the output of the network has to be a single real number representing the predicted class. In total, we have 11 neurons: a hidden layer containing ten neurons and an output layer containing another neuron. The network architecture was chosen using a standard systematic method where the number of hidden neurons is changed incrementally, and the network that gives the highest overall accuracy (derivation/validation) is chosen. The transfer function in the hidden and output layers is the tangent sigmoid function defined by $f(n)=\frac{e^{n}-e^{-n}}{e^{n}+e^{-n}}$ Eq. [2].

The training of the network was done using the Levenberg-Marquardt back-propagation algorithm. This algorithm finds the weights that minimize the error using a variation of Newton's method for minimizing functions (22). This algorithm was chosen because it is the fastest neural networks training algorithm for moderate size networks (21) as is the case in this study. The validation cohort was based on 25 patients from the total sample whereas 90 patients were used as a derivation cohort. During the training phase, the derivation cohort was randomly split into 80% training and 20% validation. The training was repeated 200 times and the model that yielded the lowest error was used on the validation set.

Reduced model (RM)

The nature and structure of the questionnaire suggests that a possible correlation exists between different predictors. Hence, a correlation study was performed over every part of the questionnaire independently including all the questions as predictors. The outcome of the ANN model is the behavior class.

For the KIVs, a cross correlation matrix was computed. This matrix shows the correlation between all possible combinations of predictors. Then the correlation coefficient R is examined. If two predictors are correlated with R >0.5, then one of the two predictors is dropped. This procedure was carried out over the attitude independent variables (AIVs) as well as the CIVs. This is a standard method used for feature reduction, it keeps the features that have high variance and if two features have both high variance but correlated together then one of them will be eliminated (23).

This procedure yielded a great reduction in the number of predictors used. This model is referred to later on in the paper as reduced model. We will also present in the results section, a comparison between the RM and the full model (FM).

LSM versus ANN performance comparisons

To compare the performances of the LSM and ANN in predicting the behavior class, the following method was used. The data was split randomly as 80% derivation cohort (92 subjects in total) and 20% validation cohort (23 subjects in total). Next a 200-iteration bootstrap was performed. In every iteration, 92 subjects were picked randomly with repetition from the derivation cohort (one subject might appear more than once). These 92 subjects were used to derive the optimal model. This model was then used to get the accuracy on the validation cohort (percentage of subjects that were correctly classified). It is important to note that the validation cohort was never used during the derivation phase. Finally, the average prediction accuracy over the 200 iterations, which represents the number of subjects that were correctly classified by our model, is used to evaluate the performance of the LSM model and the ANN model.

Results

Our cohort consisted of 115 high-risk patients (mean age in years: 60.63±15.39) including 74 (64.3%) men (*Table 1*). The mean BMI was 31.30±22.39 kg/m^2. Of the study sample, 74.6% were hypertensive, 43% were diabetic, 32.5% had a history of angina, 32.7% had a history of congestive heart failure, and 34.2% had a history of myocardial infarction. A history of coronary artery bypass graft (CABG) and percutaneous coronary intervention (PCI) were noted in 28.1% and 38.6% of the sample, respectively, while 30.7% underwent PCI during the current visit. A family history of CAD, hypertension, and diabetes was reported in 26.3%, 24.6%, and 25.4% of the sample, respectively. Two thirds of the participants were non-smokers (62.3%).

From the bootstrap analysis with 200 iterations we showed that using the FM variables to predict behavioral class, the highest accuracy achieved by LSM in the validation cohort was 40% CI (56-60%) (*Table 2*). This was attained from including knowledge and attitude questions only.

The LSM model obtained is given by the following formula:

Class =1.34+0.15.q9−0.14.q10b+0.38.q10c+0.07.q10d −0.03.q11−0.01.q13+0.24.q14a+0.06.q14n−0.11.q21+0.03. q22a−0.14.q25-0.6.q26+0.8.q27−0.01.q30+0.07.q32.

Where q9, q10, q11, q13 and q14 are equal 1 if the patient answers the corresponding question correctly and 0 otherwise, and q21, q22, q25, q26, q27, q30, q32 are

Table 1 Key sample demographics compared to the Lebanese population

Characteristics	N (%)	Lebanese population (2009)† %
Age (years)		
19-30	6 (5.21)	16.8
31-40	5 (4.34)	12.8
41-50	14 (12.17)	12.9
51-60	34 (21.57)	10.9
>60	56 (48.69)	11.2
Gender		
Male	74 (64.34)	49.02
Female	41 (35.66)	50.98
Health related field of study		
No	103 (89.6)	–
Yes	12 (10.4)	–
Educational level		
Intermediate or lower	40 (34.8)	38.2
High school or technical degree	25 (21.7)	27.7
University	50 (43.5)	34.1
Crowding index (CrI)		
<1 person/room	90 (78.26)	37.6
≥1 person/room	25 (21.74)	62.4

†, percentages for Lebanese population demographics were obtained from references (24-27).

the attitude scaled numbers calculated from the patient's answers to the corresponding questions (1 being not favorable to 4 being favorable).

Furthermore, the cross correlation study has shown that RM can be described using only 8 knowledge, 7 attitude, and 5 clinical questions instead of a total of 31, 14, and 24 questions, respectively. The eight remaining knowledge questions inquire about the effect of the salt/sodium on health, whether there is a causal relationship between salt and stroke, osteoporosis, and fluid retention, the recommended maximum daily intake of salt, the relationship between salt and sodium and knowledge of salt/sodium level in Bread. The seven remaining attitude questions cover the comprehensibility of nutrition information on sodium present on food labels, whether patients were concerned about artificial flavors in food products, the importance of reducing the amount of salt and sodium added to food and the amount of processed foods consumed. It also inquired on the worst possible scenario that could result from excessive salt intake, and who the responsible party is in terms of reducing salt intake per individual. The five remaining CIVs measure systolic and diastolic blood pressure, pulse, smoking status, and medical history of hypertension. In the RM bootstrap analysis, the LSM needed knowledge, attitude and clinical variables to attain the highest accuracy of 34% CI (17-47%) in correctly predicting behavioral class (*Table 3*).

Alternatively, *Table 2* shows that ANN outperforms LSM

Table 2 ANN FM *vs.* LSM FM predicting behavior class in the sample (n=115)

Independent variables	ANN accuracy 95% CI¶ [%]		LSM accuracy 95% CI¶ [%]		Relative increase in accuracy of ANN over LSM (%)
	Derivation	Validation	Derivation	Validation	Validation
Knowledge	60 [56-64]	58 [55-62]	71 [48-86]	35 [17-52]	65.7
Attitude	60 [55-64]	60 [57-66]	47 [35-60]	30 [17-43]	100.0
Clinical	72 [66-79]	61 [56-66]	67 [51-82]	28 [8-43]	117.0
Knowledge + attitude	76 [73-80]	62 [60-66]	89 [75-98]	40 [56-60]	55.0
Knowledge + clinical	86 [82-91]	62 [59-67]	99 [96-100]	38 [17-56]	63.1
Attitude + clinical	83 [80-89]	63 [60-66]	82 [64-97]	35 [8-56]	80.0
Knowledge + attitude + clinical	83 [79-90]	66 [62-69]	100 [100-100]	38 [21-52]	73.6

¶, the 95% confidence intervals (CIs) on the estimates of mean absolute error were computed by bootstrapping with 200 iterations. ANN, artificial neural networks; FM, full model; LSM, least-square models.

Table 3 ANN RM *vs*. LSM RM predicting behavior class in the sample (n=115)

Independent variables	ANN accuracy 95% CI[¶] [%]		LSM accuracy 95% CI[¶] [%]		Relative increase in accuracy of ANN over LSM (%)
	Derivation	Validation	Derivation	Validation	Validation
Knowledge	50 [45-55]	62 [58-67]	40 [26-56]	28 [17-43]	121
Attitude	46 [42-51]	58 [51-63]	37 [27-48]	29 [13-43]	100
Clinical	47 [45-50]	60 [56-67]	39 [26-51]	26 [13-39]	130
Knowledge + attitude	60 [57-64]	58 [55-62]	50 [37-64]	33 [17-47]	75.5
Knowledge + clinical	61 [57-67]	60 [56-65]	50 [34-62]	28 [13-47]	114
Attitude + clinical	50 [43-55]	58 [55-65]	45 [30-63]	30 [13-47]	93.3
Know+ attitude + clinical	54 [50-58]	61 [58-66]	54 [42-69]	34 [17-47]	79.4

[¶], the 95% confidence intervals (CIs) on the estimates of mean absolute error were computed by bootstrapping with 200 iterations. ANN, artificial neural networks; RM, reduced model; LSM, least-square models.

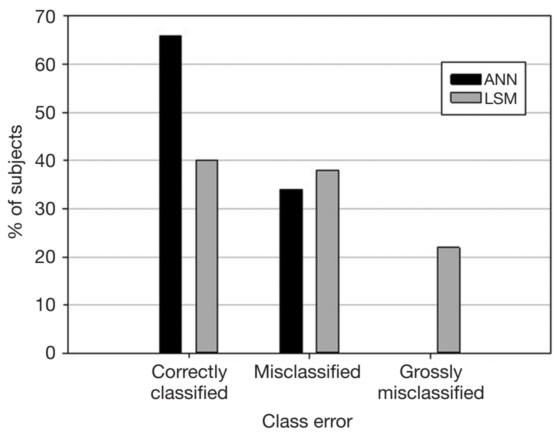

Figure 1 Accuracy and error in predicting patient behavior class using the best ANN FM *vs*. LSM FM (n=115). ANN, artificial neural networks; FM, full model; LSM, least-square models.

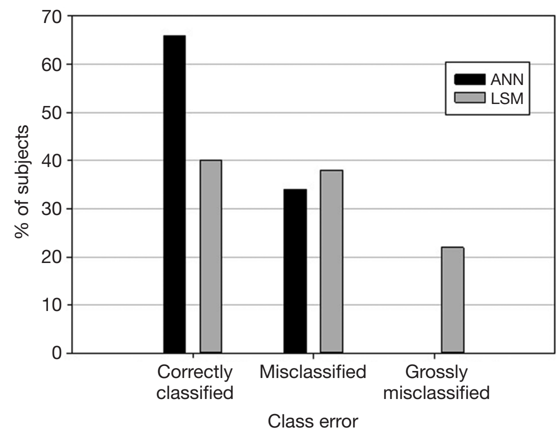

Figure 2 Accuracy and error in predicting patient behavior class using the best ANN RM *vs*. LSM RM (n=115). ANN, artificial neural networks; RM, reduced model; LSM, least-square models.

in any possible IV combination on the validation cohort and in some cases, ANN has double the accuracy of LSM. The highest validation accuracy was recorded at 66% for the knowledge + attitude + clinical in ANN FM, compared to 40% CI (56-60%) accuracy of the best LSM FM, using a set of 46 knowledge and attitude questions. The validation accuracy over that of derivation is noted to be comparable between the two algorithms. However, the average relative increase in accuracy between ANN and LSM over all possible IV combinations on the validation data is 82%.

Similarly, in *Table 3* we demonstrate the power of ANN compared to LSM as it outperforms it in all possible IV combination using the reduced model variables. On average, the relative increase in accuracy of ANN over LSM in all reduced models combined is 102%. The most accurate LSM RM is the one using the combination of knowledge, attitude and clinical set of 20 questions at 34% CI (17-47%), whereas the best ANN RM is the one using 8 knowledge questions only at 62% CI (58-67%). The ANN model obtained is given by the formula in Supplementary 2.

To illustrate further, *Figure 1* compares the best FM using each method while *Figure 2* compares the best RM using each method. *Figure 1* shows that using ANN, the behavior class of 66% of the patients was correctly predicted whereas 34% were misclassified by one behavioral class. No patients were grossly misclassified, that is, misclassified by 2 behavioral classes. On the other hand, using LSM, the behavior class of only 38% of the patients was correctly predicted whereas 40% were misclassified by one behavioral class, and 22% were grossly misclassified.

Similarly, *Figure 2* shows that using ANN, the behavior class of 62% of the patients was correctly predicted whereas 38% were misclassified by one behavioral class. No patients were grossly misclassified, that is, misclassified by two behavioral classes. Using LSM, the behavior class of only 34% of the patients was correctly predicted whereas 34% were misclassified by one behavioral class, and 32% were grossly misclassified.

Discussion

The ANN-based algorithm provided superior accuracy for predicting patient behavior towards salt intake reduction over the LSM-based model, with an average relative increase in accuracy of 82% between the best ANN RM over the best LSM RM, while in FM, the relative increase in accuracy was 65%. In FM, the ANN-based model requiring all IVs achieved the highest validation accuracy at 66% CI (62-69%). In ANN RM, only eight KIVs were required to achieve the highest validation accuracy at 62% CI (58-67%). While only 34% were misclassified using ANN FM, 40% were misclassified and 22% were grossly misclassified using LSM FM.

To our knowledge, no previous study has tried to predict salt intake behavior using an ANN-based model. However, a study by Borowiec *et al*. utilized neural networks to predict food type purchase patterns based on a set of independent variables including socio-demographics and the economic capability of buying thirteen different food product categories. Households were split into two clusters or nutrition status groups. The first can buy only basic food categories while the other group can buy all food categories. The obtained classification error rate for the best neural network was lower than the corresponding error rate for both Discriminant analysis and Logistic regression, and hence ANN improved the classification accuracy and outperformed statistical methods (16). Moreover, although both LSM and ANN can be used as non-linear regression or classification methods, the main drawback of LSM is the need to try out several non-linear models such as logarithmic and exponential, among others. Hence, only trial and error can tell which model fits best. However, the structure of ANN combined with its optimization algorithms will learn from the data the best model to use and its parameters (21).

Furthermore, though our ANN model improved the rate of correctly classified individuals, nearly 1/3 remained misclassified (none were grossly misclassified) (*Figure 2*). To contextualize this finding we compare this performance to other classification tools commonly used in cardiology. For example, the Heart Score model and coronary calcium score, both used to assess cardiovascular risk, have significant rate of discordance. Among those deemed as high risk by the Heart Score system in low-risk countries, only 17% would be classified as high risk by coronary calcium scoring (28). Similarly, the thrombolysis in myocardial infarction (TIMI) score, a commonly used scoring tool to risk stratify patients presenting with acute coronary syndrome, was found to have a short term AUC of 0.66 (95% CI, 0.64-0.68) and 0.73 (95% CI, 0.69-0.78) in derivation and validation cohorts respectively (29). This indicates that nearly 27-34% of individuals were misclassified. The above indicates that our ANN model's performance is within the same range of other very commonly used models in the field of cardiology. However, because of only 66% level of accuracy, future studies to further improve this tool are warranted for it to become applicable in the clinical setting.

The behaviour classification model we followed was inspired by prior nutrition studies (4,30). Sharma *et al*. used multiple logistic regression analysis to show that nutrition knowledge was a strong predictor of eating behavior for all food groups except fruits and vegetables. This was done by creating a nutrition knowledge score and an eating behavior score of recommended servings per day of food types as dichotomous variables; i.e., correct and incorrect knowledge and behavior (4). A systematic review examined the relationship between nutrition knowledge and dietary intake in adults, and showed that a higher intake of fruit and vegetables was associated with higher nutrition knowledge (30). Adopting this approach, we believed, would provide meaning to the number provided for the score directly. This is instead of having to take the score achieved and then refer back to the cut-points to see where an individual's score is relative to the distribution of scores. Ideally, this should be verified by a prospective study against 24-hour urine sodium, which will be further discussed in a subsequent section.

ANN FM had prediction accuracy higher by 4% than ANN RM. In terms of clinical applicability, a loss of 4% accuracy in determining patient behavioral class when using eight questions in ANN RM instead of 69 questions in ANN FM may be considered a worth loss in favor of wider applicability secondary to decreasing the number of questions. The average relative increase in accuracy between ANN and LSM over all possible IV combinations on the validation data is 80%. This shows the power of ANN for prediction over the standard LSM.

Implications for research and practice

Working with high-risk individuals to reduce their salt intake through raising their awareness about the health hazard of salt and how to cut it down is currently being practiced. However, having a tool that can predict a patient's behavior after an awareness raising activity can potentially identify the efficacy of this activity, and accordingly help modify it to improve it. At cardiac care units in general, including ours, dietary consultants—or other healthcare workers—meet with the patients and advise them about salt reduction. This is also provided for outpatients as part of preventive measures. Using efficacy assessing tools such as the one in hand, we can identify whether such efforts are possibly leading to an outcome (adopting salt intake reducing behaviors in this situation) or not. This will ensure proper allocation of resources, dietary consultants' time and effort, and avoid burdening our patients with inefficient interventions. At a larger scale, this tool can potentially be used to gauge consumer responsiveness to public media campaigns with the advent of being concise and rapid.

It is well known that the best outcome measure of a salt reduction intervention would be to perform a 24-hr urine collection of sodium. However, this is well known to be cumbersome for the patients. Therefore, having this tool as a surrogate of a behavioral change may be a reasonable approach, although certainly not ideal. To our knowledge neither the original survey, nor our culturally adopted version, have been cross validated against 24-hr urinary sodium. This is a short-coming that needs to be addressed in a future study. However, the results of this survey have been accepted as a measure of behavior in literature before (18-20), and our ANN analysis is a secondary analytical modification based on this.

Salt awareness level tool (SALT)

To facilitate the utilization of the ANN model, the SALT was developed in order to create an accessible interface to calculate the behavior class of a patient from a few questions as illustrated below in a screenshot of SALT (*Figure S1*). SALT gives the ability for the user to input eight KIVs and five CIVs and use them for prediction with 60% accuracy. The software was developed using C# and is also be available as an online calculator at http://www.aub.edu.lb/fm/vmp/research/Documents/ann-salt.htm.

Conclusions

ANN based model using knowledge and clinical variables predict salt intake reduction behavior with superiority over all possible LSM models. A minor loss in accuracy when using ANN reduced model over ANN FM is insignificant when compared to the practicality offered by the RM-based tool based. Because of only 66% level of accuracy, future studies to further improve this accuracy level are warranted for it to become applicable in the clinical setting. Furthermore, validation and improvement of the accuracy of the tool using larger cohorts of different health and ethnic backgrounds and against 24-hr urinary sodium is required to achieve its full potential and benefit in clinical and public health interventions.

Limitations

Despite proving the superiority of ANN over LSM in all models, 34% of the patients were misclassified using the best ANN model, which can be attributed to the small sample size used to conduct this study. Moreover, our cohort consisted of high-risk patients in the CCU, which might question the applicability of the tool on everyday patients who visit their physician's clinic or even on the general population. Accordingly, improving the accuracy of the model will require implementing the derivation and validation on larger cohorts, and from different ethnic and health backgrounds to validate the tool across different nations and societies. Importantly, the original survey used and the new tool need to be cross-validated against 24-hr urine sodium to ensure behavioral class is correlated with Na intake. The issue of validating against 24-hr urine sodium is crucial for this model to become utilized in clinics in general and in particular HTN specialized clinics.

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Supplementary 1

Knowledge, attitude, and behavior (KAB) questionnaire used in data collection

Knowledge, attitudes and behaviors related to sodium intake of Lebanese adults

Recruitment place:
Subject:
□ Patient

1. Sex
□ Male
□ Female

2. What is your age? (Years)
□ '19-30'
□ '31-40'
□ '41-50'
□ '51-60'
□ '61 plus'

3. Where do you live? (Governorates) (*Please tick one box only*)
□ Beirut
□ Mount Lebanon
□ North
□ South
□ Bekaa
□ Nabatieh

4. Have you ever or are you specialized in a health-related major (Biomedical, Nutrition, Food science, Medicine, Public Health, and Nursing)? (*Please tick one box only*)
□ Yes, *specify*: ________________
□ No

5. Which of the following best describes your highest level of education? (*Please tick one box only*)
□ Intermediate or lower
□ High school
□ Technical degree
□ University bachelor's degree (BS) or higher (Master or PhD)

6. What type of school did you attend? (*Please tick one box only*)
□ Private school
□ Public school

7. How many rooms are there in your house (excluding bathrooms, kitchen, balcony and garage)? ________________

8. How many people live in your house (excluding newborn infant)?________________

9. Which of these best describes what you think is the effect of the salt/sodium in your diet? (*Please tick one box only*)
□ Improves your health
□ Has no effect on health
□ Worsens your health
□ Don't know

10. Do you think these health problems can be caused or aggravated by salty foods? (*For each problem please select yes, no or don't know*)

Yes	No	Don't know	
□	□	□	High blood pressure
□	□	□	Stroke
□	□	□	Osteoporosis
□	□	□	Fluid retention
□	□	□	Heart attacks
□	□	□	Stomach cancer
□	□	□	Kidney disease
□	□	□	Memory/concentration problems
□	□	□	Asthma
□	□	□	Headaches

11. What is the maximum daily amount of salt recommended for adults? (*Please tick one only*)
□ 3 grams (½ teaspoonful)
□ 6 grams (1 teaspoonful)
□ 9 grams (1 ½ teaspoons)
□ 12 grams (2 teaspoons)
□ 15 grams (2 ½ teaspoons)
□ Don't know

12. How do you think your daily salt intake compares to the optimal amount recommended? (*Please tick one only*)
□ More than the maximum recommended
□ About the maximum recommended
□ Less than the maximum recommended
□ Don't know

13. Which of the following statements best describes the relationship between salt and sodium? (*Please tick one only*)
□ They are exactly the same
□ Salt contains sodium
□ Sodium contains salt
□ Don't know

14. Below is a list of everyday foods. For each please indicate whether you consider these foods to be: high, medium or low in terms of salt/sodium content. (*Please tick one box for each food*)

High	Medium	Low	Don't know	
☐	☐	☐	☐	Bread
☐	☐	☐	☐	Manaesh
☐	☐	☐	☐	Traditional pies
☐	☐	☐	☐	Pizza
☐	☐	☐	☐	Rice
☐	☐	☐	☐	Cheese
☐	☐	☐	☐	Milk
☐	☐	☐	☐	Pear
☐	☐	☐	☐	Vegetables ragouts
☐	☐	☐	☐	French fries
☐	☐	☐	☐	Sandwiches (e.g. shawarma, fajita, hamburger)
☐	☐	☐	☐	Soya sauce
☐	☐	☐	☐	Fresh Carrot
☐	☐	☐	☐	Ketchup
☐	☐	☐	☐	Salad dressings
☐	☐	☐	☐	Roasted nuts
☐	☐	☐	☐	Sausages and hot dogs

15. Which of the following do you think is the main source of salt in the diet of Lebanese people? (*Please tick one only*)

☐ Salt added during cooking
☐ Salt added at table
☐ Salt in processed foods such as breads, cured meats, canned foods and takeaway
☐ Salt from natural sources such as vegetables and fruits
☐ Don't Know

16. How often do you check food content labels when you are shopping? (*Please tick one only*)

☐ Often
☐ Sometimes
☐ Never
☐ I never do grocery shopping therefore this question is irrelevant

17. Does what is on the food content label affect whether or not you purchase a food item? (*Please tick one only*)

☐ Often
☐ Sometimes
☐ Never
☐ I don't do grocery shopping therefore this question is irrelevant

18. How often do you look at the salt/sodium content on food labels when you are shopping? (*Please tick one only*)

☐ Often
☐ Sometimes
☐ Never
☐ I never do grocery shopping therefore this question is irrelevant

19. How often does the salt/sodium content shown on the food label affect whether you purchase a product? (*Please tick one only*)

- ☐ Often
- ☐ Sometimes
- ☐ Never
- ☐ I never do grocery shopping therefore this question is irrelevant

20. What information on the food package do you use to determine how much salt is in the product?
- ☐ The sodium level in the nutrition information panel
- ☐ The ingredients list
- ☐ Claims for low or reduced salt on the pack
- ☐ Other (specify): ________________
- ☐ Don't know

21. Do you think present nutrition information on sodium is comprehensible? (*Please tick one only*)
- ☐ Yes
- ☐ No

22. Are you concerned about these aspects of the food you eat? (*Please tick 'yes' or 'no' for each option*)

Yes	No	
☐	☐	Artificial flavours
☐	☐	Artificial colours
☐	☐	Salt/sodium
☐	☐	Sugar
☐	☐	Energy (calories)
☐	☐	Saturated fat

23. Do you do any of the following? (*Please tick one box for every question*)

Often	Sometimes	Never	Not applicable	
☐	☐	☐	☐	Add salt during cooking
☐	☐	☐	☐	Add salt at the table
☐	☐	☐	☐	Try to buy 'low salt' foods
☐	☐	☐	☐	Try to buy 'no added salt' foods

24. Are you cutting down on the amount of salt you eat? (*Please tick one only*)
- ☐ Yes
- ☐ No
- ☐ Don't know

If yes, why are you cutting down on salt?
- ☐ I have been told to by a doctor/other health professional
- ☐ Another family member has been told to
- ☐ Because it's bad for you
- ☐ Because I am on a diet
- ☐ To help lower my blood pressure
- ☐ Because I have health problems
- ☐ To reduce my risk of a heart attack or stroke
- ☐ I don't like the taste of it
- ☐ Saw an advert/article about it/something on TV
- ☐ Trying to eat more healthily
- ☐ Other (specify): ________________
- ☐ Don't know

If no, why aren't you cutting down on salt?

- ☐ I recently cut back and don't need to cut back any further
- ☐ I didn't know I should
- ☐ I eat a healthy diet and know I'm not eating too much salt
- ☐ I'm not concerned by it
- ☐ I haven't been told to cut salt from my diet
- ☐ No particular reason, hadn't really thought about it
- ☐ You need to eat salt to stay healthy
- ☐ I don't have too much salt in my diet
- ☐ I don't add salt to my food (anymore)
- ☐ I don't eat food high in salt
- ☐ Other (specify): ________________
- ☐ Don't know

25. Reducing the amount of salt you add to foods is definitely important to you. (*Please tick one only*)

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neither agree nor disagree
- ☐ Agree
- ☐ Strongly agree

26. Reducing the amount of processed foods (e.g., breads, cured meats, canned foods and takeaway) you eat is definitely important to you. (*Please tick one only*)

- ☐ Strongly disagree 1
- ☐ Disagree2
- ☐ Neither agree nor disagree3
- ☐ Agree4
- ☐ Strongly agree5

27. Reducing your sodium intake is definitely important to you (*Please tick one only*)

- ☐ Strongly disagree 1
- ☐ Disagree2
- ☐ Neither agree nor disagree3
- ☐ Agree4
- ☐ Strongly agree5

28. What would motivate you to reduce your salt intake? (*Please tick one only*)

- ☐ A dramatic change in health status 1
- ☐ If my doctor advised it2
- ☐ If family members or friends advised it 3
- ☐ Other (specify): ________________ 4

29. What are the barriers against decreasing your salt intake? (*Please tick one only*)

- ☐ It tastes good 1
- ☐ I am not concerned with decreasing my salt intake 2
- ☐ I don't know which foods to avoid 3
- ☐ Other (specify): ________________ 4

30. What is the most frightening thing that could happen if you eat too much salt? (*Please tick one only*)
☐ Nothing bad will happen
☐ I could have a heart attack or stroke
☐ My blood pressure will go up
☐ Other (specify): ________________

31. Where do you get your health information from? (*Please tick one only*)
☐ My doctor
☐ My family and friends
☐ The internet
☐ The media (specify): ☐ television ☐ radio ☐ newspapers ☐ magazines ☐ other:________________
☐ Other (specify): ________________

32. If excess salt/sodium in the diet were known to cause a serious disease who do you think should be MOST responsible for helping you reduce the salt/sodium you eat? (*Please tick one only*)
☐ The government (public health campaign)
☐ Companies that make or sell foods with salt in them (food industry)
☐ Your doctor
☐ Yourself

33. Have you been previously advised by a physician, nurse or dietitian about the risks of a salt-rich diet and the need to moderate salt intake? (*Please tick one only*)
☐ Yes
☐ No
☐ Cannot remember

34. Have you been approached by a dietitian during your CCU stay? (*Please tick one only*)
☐ Yes
☐ No

Supplementary 2

The ANN model obtained based on bootstrap analysis with 200 iterations

To predict the behavioral class using ANN, the following procedure must be followed.
First you form the vector P by the following components:
P= (q9, q10b, q10c, q10d, q11, q13, q14a, q14n, sbpn, dbpn, pulsen, smk, htn)
Where q9, q10b, q10c, q10d, q11, q13, q14a, q14n are equal to 1 if the patient answers the corresponding question correctly and −1 otherwise.
Smk is 1 if the patient is smoker and −1 otherwise.
Htn is 1 is the patient has a history in hypertension and −1 otherwise.
Sbpn is the normalized systolic blood pressure given by: sbpn=0.0123.sbp−1.1595
dbpn is the normalized diastolic blood pressure given by: dbpn=0.0263.dbp−1.7895
pulsen is the normalized pulse rate given by: pulsen=0.0125.pulse−1.2727.
Where sbp, dbp and pulse are the corresponding non normalized values.
The output n1 of the first layer is given by:
N1=p.A1+b1.
Where A1 is shown in *Figure S2*.
And b1 is the following vector:
B1= (1.6118, −1.5348, −0.895, −0.85492, 0.29956, −0.27295, 0.43393, 0.92673, −1.2202, −1.6814)
The output N1 is then sent to the tansig activation function which is described earlier to get the final output A1 of layer1 as:
A1=tansig(N1)
The next step is to send A1 into the last layer of the network. The output of the second layer is calculated as follows:
N2= A1.B +0.489
Where B is following column vector:
B = (−0.898, 0.090858, −0.0062721, 0.076167, −0.3859, −1.3466, 0.4678, 0.56129, 0.35015, 0.39472)^T
Then the final output A2 is obtained by:
A2= tansig (N2)+2
If $A2 < 1.5$ then the patient is classified as unfavorable.
If $1.5 < A2 < 2.5$ then the patient is classified as less favorable
If $A2 > 2.5$ then the patient is classified as favorable.

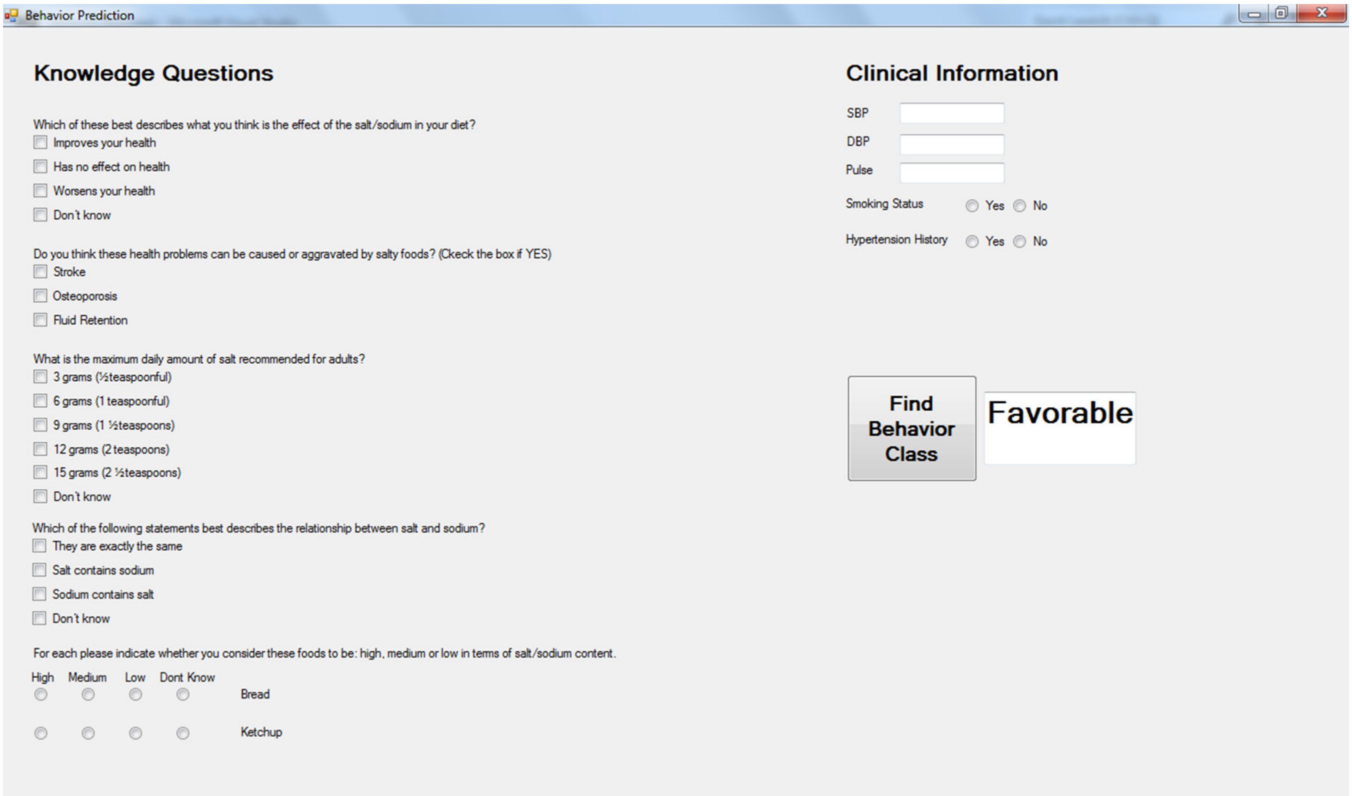

Figure S1 Salt awareness level tool (SALT) online calculator.

−0.452	−0.562	−0.366	−0.389	−0.168	−0.058	1.150	−0.125	−0.621	0.648	0.245	−0.666	0.105
0.098	0.073	−0.571	0.526	−0.344	−0.601	−0.220	−0.606	−0.296	−0.483	0.607	0.299	0.264
0.192	−0.316	0.462	0.073	−0.225	−0.490	−0.718	−0.269	0.685	0.634	0.447	0.651	0.391
0.054	0.198	−0.754	0.381	−0.517	−0.504	−0.082	−0.319	−0.252	−0.069	0.597	−0.058	0.739
−0.008	−0.188	−0.666	0.040	0.648	0.635	−0.548	−0.460	−0.091	−0.608	−0.724	−0.359	−0.226
−0.370	−1.085	0.046	0.366	0.025	−0.981	0.143	−0.885	−0.369	0.304	−0.171	−0.710	0.655
0.295	−0.363	0.510	−0.294	0.107	−0.704	0.162	1.166	0.466	−0.390	−0.090	−0.672	−0.211
0.514	−0.288	0.122	0.359	−0.093	−0.443	−0.318	0.697	−0.623	−0.158	−0.443	0.290	−0.887
−0.276	0.959	−0.428	0.460	−0.050	−0.157	0.473	0.162	−0.514	−0.471	−0.139	0.456	0.811
−0.023	0.878	0.495	0.664	−0.468	−0.484	−0.431	−0.308	−0.114	−0.510	0.445	−0.436	−0.421

Figure S2 Matrix for A1.

Original Article

Developing a national salt reduction strategy for Mongolia

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Background: The increase in prevalence of risk factors such as hypertension has contributed to an incremental rise in non-communicable diseases (NCDs) in Mongolia over recent decades, such that they now account for 80% of all deaths in the country. Salt reduction is one of the most cost-effective interventions to reduce the burden of NCDs.

Methods: In 2011, the Ministry of Health (MOH) instigated the development of a national salt reduction strategy for Mongolia. As part of a 2-week national consultation and training program on salt reduction, it established an inter-sectoral working party and organized a series of bilateral meetings and visits to factories. Actions arising included a baseline survey of population salt consumption patterns and the implementation of a series of pilot salt reduction initiatives.

Results: The results of the baseline assessment revealed that average daily intake of salt, based on 24 hour urine samples from a representative national sample (n=1,027), was 11.06±5.99 g in 2011, more than double the World Health Organization (WHO) five grams recommendation. Moreover, while most participants knew that salt was bad for health, few were taking efforts to reduce intake, and many were consuming highly salty meals and tea; salt in tea alone was estimated to contribute 30% of daily salt intake. A pilot Pinch Salt intervention to reduce salt consumption of factory workers was undertaken in Ulaanbaatar (UB) city between 2012 and 2013, and was associated with a reduction of 2.8 g of salt intake. Ongoing food industry initiatives have led to significant reductions in salt levels in bread, and companies producing processed meat have indicated a willingness to reduce salt. Relevant stakeholders have also supported the campaign by participating in annual World Salt Awareness Week events. The activities to date have demonstrated the potential for action and there is now a need scale these up to a national level to ensure that Mongolia is in a strong position to achieve a 30% reduction in population salt intake by 2025. The main goal of the Mongolian national salt reduction strategy is to create a social, economic and legal environment that supports salt reduction, including by influencing food supply, increasing partnerships between government and relevant stakeholders, and creating an enabling environment to support improved consumer choices. The strategy will be implemented from 2015 to 2025, with an interim review of progress in 2020.

Conclusions: Given that Mongolia has one of the highest rates of stroke in the world, which is strongly associated with population-wide blood pressure (BP) levels, the addition of a population-based stroke surveillance program would provide a reliable direct assessment of the impact of these salt reduction initiatives on the health of the Mongolian people. The results from this research would likely be widely generalizable to other populations experiencing similar lifestyle transitional changes.

Keywords: Sodium; salt intake; 24-hour urine; economic region; population; Mongolia

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Introduction

Non-communicable diseases (NCDs) are the main contributors to premature mortality and morbidity globally (1,2). In the Western Pacific region, for example, the major NCDs—cardiovascular disease (CVD), diabetes mellitus, cancer and chronic respiratory disease—account for more than 80% of all deaths (3). As an important primary risk factor for CVD, excessive salt intake is estimated to contribute to millions of premature deaths, mainly through elevations in blood pressure (BP) (4,5).

Reducing salt intake has been identified as one of the most cost-effective measures to reduce the burden of NCDs (6-10). New World Health Organization (WHO) guidelines recommend adults daily consumption of salt be reduced to less than five grams (5). The global strategy on NCDs, endorsed by the WHO's Western Pacific region in 2010, called upon member states to determine salt intake, identify which food products are the main sources of salt, and implement national strategies to reduce salt intake in populations (5,11-13).

Mongolia is the fifth largest country in terms of land area (1.6 million square kilometres) in Asia, but only had a population of 2.93 million (48.7% males and 51.3% females) in 2013, making it one of the least densely populated country in the world. However, urbanization of the population over the last century, and particular in recent decades, has resulted in over two thirds of the population (67.2%) now residing in cities (14,15), with associated rapid increase in NCDs. NCD related deaths now comprise approximately 80% of total mortality in this population (15,16), which is seven times higher than other countries of the Western Pacific region. NCDs, such as heart disease, diabetes mellitus, stroke, some preventable cancers and injuries, are the leading causes of premature death and disability in the largely young to middle aged structured population of Mongolia (15,17). In particular, the prevalence of risk factors for NCDs such as an unhealthy diet (including excess salt intake) is high.

Periodic NCD risk factor surveillance through WHO STEP wise approach to Surveillance (STEPs) (18) surveys in Mongolia have shown that unhealthy lifestyle behaviors are increasing, despite several health promoting initiatives (15,16). According to the three consecutive STEPs surveys in 2005, 2009 and 2013, the proportion of people aged 15-64 years with multiple combined risk factors was 23.8%, 26.4%, and 36.9%, respectively (18-20). Since 2011, the country's Ministry of Health (MOH) and National Centre for Public Health of Mongolia have been acting on WHO recommendations to reduce the salt intake of the population. This paper provides an overview of the work to develop the national salt reduction strategy in Mongolia for 2015 to 2020, and highlights a range of lessons for other countries for consideration when developing national salt reduction strategies.

Methods

Following on from the WHO regional consultation on salt reduction in Singapore in June 2010, the MOH in collaboration with Millennium Challenge Health project, WHO and the National Center for Public Health in Mongolia, organized a salt reduction consultation meeting in the capital city, Ulaanbaatar (UB). An inter-sectoral working group was established and a series of meetings were conducted with government officials and technologists from bread companies and the meat industry. The objectives of these meetings were to raise awareness of the burden of NCDs associated with high salt intake, introduce the WHO recommendations on salt reduction, and invite the food industry and other stakeholders to collaborate on efforts to reduce salt intake across the population. An action plan to establish a national baseline on salt consumption patterns and implement a series of pilot initiatives to reduce salt intake was developed and endorsed by all of the key stakeholders.

Baseline data on salt intake were obtained through a cross-sectional, nationally representative survey on a random sample of 1,040 residents (25-64 years) selected from 2010 population census in 2011 (21). Permission to conduct the study was granted by the Ethics Review Committee of the health care sector of the MOH, Mongolia (Resolution 14, 8 July 2011). The sample size was calculated in accordance with international protocols (21). The randomly selected participants were informed orally about the survey as well as being provided with a written participant information and consent form 1-2 days prior to the survey. People with major illnesses were excluded. Data collection comprised an interviewer-administered questionnaire on demographic information and health status, and knowledge, attitudes and behavior relating to salt. Participants were also asked to recall their dietary intake over the previous 24 hours, and to provide a single 24-hour urine sample.

Data analysis was undertaken using SPSS (Version 19). Descriptive statistics were calculated using One-Way ANOVA with 95% confidence intervals and comparisons

Table 1 Age and gender structure of participants of salt baseline survey

Age groups (years)	Total		Male		Female	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
25-34	293	28.5 (25.7-31.5)	132	45.1 (36.2-54.2)	161	54.9 (45.8-63.8)
35-44	251	24.4 (21.9-27.2)	109	43.4 (38.5-48.5)	142	56.6 (51.5-61.5)
45-54	281	27.4 (24.5-30.1)	125	44.5 (35.7-53.6)	156	55.5 (46.4-64.3)
55-64	202	19.7 (17.2-22.3)	97	48.0 (44.8-55.2)	105	52.0 (48.8-55.2)
Total	1,027	100.0 (100.0-100.0)	463	45.1 (41.2-49.0)	564	54.9 (51.0-58.8)

were made using one-Sample *t*-tests or multiple comparison post host tests (Tukey HSD test, Sidak test, and Tamhane test). The mean differences were assumed to be significant at P<0.005.

Data from the 24-hour dietary recall was analysed using FoodWorks adapted with Mongolian food composition and data from surveys of the nutritional composition of products in shops to assess the contribution of different foods to salt in the diet. A series of salt reduction initiatives were also implemented between 2011 and 2014. Results of these surveys and salt reduction initiatives informed proposals for a national salt reduction strategy in 2014.

Results

Establishing a national baseline 2011-2012

Salt intake

Twenty four-hour urine samples were collected from 1,027 participants (98.7% participation rate) (*Table 1*) and analysed for sodium, potassium and creatinine. Following exclusion of incomplete urine collections (based on volume and creatinine measurements), the mean (SD) salt intake was estimated at 11.06 (5.99) g per day, which is more than double WHO recommendations (5 g per day). Furthermore, the majority 89.2%; (95% CI, 87.3-91.0; P<0.001) of the population consumed over five grams of salt per day.

There were significant variations in mean levels of salt intake in relation to gender, region and residential location (rural versus urban) but there was no significant difference in relation to age. Mean salt intake (grams per day) in males was 11.68 (6.15) as compared to 10.54 (5.81) in females; mean difference 1.14 (95% CI, 0.58±1.70; P<0.001). Mean salt intake in the Western region was 13.48 (7.49), Khangai region 10.80 (5.45), Central region 10.07 (6.34) and Eastern region 9.98 (5.14) (P<0.001), and of UB 10.89 (5.49). Mean salt intake in urban areas was 11.32 (6.06) compared to 10.64 (5.86) in rural areas (P<0.005).

Consumer knowledge, attitudes and behavior

Most people (87.5%) understood the adverse effects of salt on health. However, about half of the survey participants reported regularly consuming salty tea and high-salt meals. About one third were not making any efforts to reduce their consumption of salt, with one fifth unable to correctly name food products high in salt. Salt intake was directly associated with a person's knowledge, attitude and behaviours related to salt. For instance, daily salt intake was 10.20 (5.43) g per day for people who reported never using table salt, as compared to 11.81 (6.34) g per day in those who reported using table salt regularly (P<0.001).

Interestingly, people who drank the popular salty tea had the highest intake of salt and were more likely to have hypertension. People who consumed salty tea on daily basis consumed 11.81 (6.34) compared to 10.20 (5.43) g of salt per day for those who avoided salty tea; mean difference of 1.61 (95% CI, 1.10-2.22; P<0.002). The frequency of hypertension was 40.4% (95% CI, 32.6-48.6) in people who consumed salty tea as compared to 37.8% (95% CI, 30.6-45.6) in those who drank tea without salt (P<0.001). Multivariate regression analysis showed that salt intake was 12.15 (95% CI, 10.73-13.58) gram per day in those who drank salty tea and had arterial hypertension as compared to 10.23 (95% CI, 9.48-10.98) in those who had normal arterial pressure and had tea without salt (1.92 difference, P<0.001).

Main sources of salt in the diet

The main sources of salt identified through the dietary survey were salted tea, sausage, smoked meat products, pickled vegetables, chips, traditional fast food (Buuz steamed dumpling, Khuushuur-fried dumpling), and Western fast food (burgers, hot dog and pizza), mayonnaise, spices, sauces, and canned meat products. For the 474 participants who reported consuming salty tea, salt from tea alone was estimated to contribute 30% of total salt consumption, with the remainder from meals (23%) and other processed foods (47%).

Implementation and monitoring of salt reduction initiatives

Pinch Salt Mongolia

Following the salt reduction consultation in May 2011, a pilot salt reduction initiative-Pinch Salt Mongolia-was implemented in UB. The main objective was to reduce salt intake of the employees of three of the main food producing factories (Makh Impex, Talkh Chikher and Goyo). Implementation strategies included the training of staff on the negative health impact of salt and how to consume a healthy diet, and the provision of reduced salt food and meals through company canteens and workers' kitchens (Talkh Chikher and Goyo).

Pre- and post-intervention monitoring was undertaken to determine salt intake using 24-hour urine tests (n=240) and a questionnaire. The results showed that salt intake reduced from 11.48 (7.32) g per day in 2011 to 8.65 (4.26) g per day in 2013. The number of respondents who didn't know which foods were high in salt declined from 18.5% (95% CI, 14.0-23.9) to 2.9% (95% CI, 1.1-7.4) during the same period.

Pre- and post-intervention monitoring to assess the salt content of meals served in two companies was also undertaken using the "NaCl ion by titration" method on 50 samples of meals in the laboratory of the National Center for Public Health. Mean salt content of meals prior to the intervention was 1.18 (1.11) per 100 g compared with 0.74 (0.36) per 100 g post-intervention, a reduction of 0.44 g or 37.29%.

Food industry initiatives to reduce salt in bread

A series of food industry initiatives to reduce salt in bread were initiated in parallel with the pilot project. The Talkh Chikher bread company first reduced the salt content in its "Atar" bread by 12% in May 2011, following a visit from the MOH and technical experts as part of the salt reduction consultation. Other companies followed suit, resulting in the salt content of bread in 10 bread and bakeries declining by 1.6% on average after May 2011. This equates to 22 tonnes of salt being cut from food processing in just one year. From 2012-2014, this initiative further expanded to other industries including the meat industry and mass catering services. For example, in 2014, the sausage industry agreed to reduce the salt content in three canned products by 10%. In addition, the media was used to increase public and professional awareness about the need to reduce salt in foods.

Annual World Salt Awareness Week activities

Since 2012, The National Public Health Institute and MOH have collaborated on implementing a range of activities as part of World Salt Awareness Week in March each year (22). For example, in 2014, and in line with the international theme "Stop… Look…Choose… the Lower Salt Option", a series of adverts on television were run, and campaign materials with information about salt and product labelling were promoted on the web-site of key stakeholders that included the Mongolian Food Association. Materials were also disseminated through institutional Facebook sites, posters and advertising boards. Media interest is usually significant with many multi-media programs asking to participate and conduct interviews.

Development of a salt reduction strategy for Mongolia

The pilot salt reduction activities in Mongolia have been viewed as a success and demonstrate the potential for action. However, there is now a need to scale them up to a national level and ensure that Mongolia is in a position to meet global targets (23). This will require the establishment of a policy and legal environment for limiting the production and consumption of salt which in turn needs to be backed by adequate financing.

The main goal of the Mongolian national salt reduction strategy that was agreed in 2014 is therefore: to create a social, economic and legal environment to support the reduction of population salt intake by 30% by 2025 (*Box 1*). Building on the progress of intervention initiatives to date, the three strategic priorities of the strategy are to advance the legal environment for salt reduction; to improve partnerships, and to create an enabling environment to support consumers to make the right choices. In addition to a reduction in salt intake across the population as a result of improved consumer attitudes and behaviours relating to salt and reduced salt levels in foods and meals, it is expected that the main outcomes of the strategy will be improved partnerships and inter-sector collaboration to re-enforce and monitor food supply.

The Mongolian national salt reduction strategy will be

Box 1 Lessons for other countries
A robust estimate of salt intakes, including variations in relation to gender, age, rural and urban and geographical location alongside a good understanding of different contributors to salt in the diet, provides a solid basis for a salt reduction strategy
Continued advocacy for strong government support and adequate financing is required
Stakeholder engagement and community participation help to obtain buy-in and ensure effective implementation of the salt reduction strategy
Pilot interventions can inform thinking on what will work in the country specific context and different settings
A strong regulatory and policy environment is required to support program implementation
A step-by-step approach to working with the food industry helps to build relationships and ensure effective collaboration
Regular (every five years at least) monitoring of progress ensures that changes and adaptations can be made to optimise the program and ensure that it is on track to meet the targets
Monitoring and implementation of strategies that focus specifically on children should also be considered

implemented during the period 2015-2025, and mid-term and final evaluations are to be undertaken in 2020 and 2025. Monitoring and evaluation of the strategy will be carried out by the Central Government Ministries responsible for health and food in collaboration with other relevant organizations such as city council and inspection organisations.

Discussion

There is strong stakeholder support for the national salt reduction strategy in Mongolia. The baseline assessment showed that the population is consuming on average 11 g of salt each day, more than twice that recommended by WHO, making it one of the highest salt intake countries in the Western Pacific Region. A key driver of this high salt intake is the population habit of adding salt to tea, making tea account for about one third of total salt intake for a large proportion of people. "Suutei tsai" (literally "tea with milk") is a traditional Mongolian beverage, usually consisting of tea, milk, butter and salt (1 g/200 mL tea), is consumed by 46% of the population in Mongolia regularly throughout the day. Mongolia is one of the few places in the world (in addition to Tibet and Kashmir) where salty tea is drunk.

The survey results are likely to be robust. The rigorous training and support provided to the survey team to ensure that the 24-hour urines were collected effectively, including text message reminders to each of the participants to collect the urine and record the times, resulted in an extremely high (98.7%) participation rate. What's more, the findings from the current study are in line with previous studies of salt intake in Mongolia which have also demonstrated differences in salt intake for normotensives and hypertensives (24,25), and shown that salt is a significant risk factor for Isolated Systolic Hypertension in Mongolia (26). The new findings add strength to the argument in support of a national salt reduction strategy in Mongolia.

The positive outcomes of the intervention projects and the strong stakeholder support demonstrate the potential for the salt reduction initiative to be scaled up to a national level. Plus there are a range of lessons for other countries (*Box 2*). The 2.8 g reduction in salt intake as a result of the pilot Pinch Salt intervention project and the 12% reduction in salt in the most popular bread sold in Mongolia are remarkable achievements within a relatively short time period. The success of the work is largely due to the strong support of the government as well as the availability of funding and stakeholder engagement. Robust baseline data relating to salt intake, consumer practices and salt content of major foods combined with the evidence of effectiveness of interventions in UB from the pilot studies, provide a solid basis for action.

However, reducing daily salt intake by 30% (to 8.5 g) will nevertheless be challenging. The pilot interventions were time-limited projects in selected groups, and representative of the processed food industry (e.g., pickled vegetable producers) have not yet agreed to reduce the salt content of their products.

That said, as most key stakeholders are united in their commitment to reduce salt, and the country has a good track record on NCDs, the chances of the salt reduction strategy being a success are considered positive. Mongolia has already successfully implemented its first National Programme for NCD risk factors during 2006-2013 (27), clearly demonstrating the potential to effectively address NCDs through high level commitment and through the participation of a wide range of community sectors. NCDs

Box 2 Mongolian national salt reduction strategy 2015-2025

Strategic priority I

To advance the legal environment for promoting the production, importation, marketing and service of lower salt foods and meals:

- Review and amend standards for salt levels in foods and meals in line with international standards
- Establish a legal coordination mechanism to limit the marketing and advertising of high salt foods and meals
- Improve national capacity and establish a program of surveillance and research related to salt intake

Strategic priority II

To improve partnerships between government and the private sector to reduce the salt content of foods and meals and by increasing controls on the production, service, marketing, importation and consumption of food:

- Establish a partnership between government and private sector to increase the production, marketing, and service of lower salt foods and meals and the production of iodized salt
- Implement and enforce governmental controls on the importation, production, service and marketing of high salt meals and food products
- Implement internal monitoring by food producing entities relating to the salt content of processed foods and meals
- Conduct regular surveys on population salt intake, consumer knowledge, attitudes and behaviour relating to salt and salt levels in foods and meals

Strategic priority III

To reduce population salt intake by creating an enabling environment which supports people to develop habits of adequate use of salt and make the right choices of meals and food products:

- Organize and support information, communication and education activities to improve health education of the population regarding salt intake
- Organize and promote campaigns and competitions to improve public awareness
- Promote good habits in kindergarten and school aged children regarding reducing consumption of salt
- Improve knowledge of doctors, health workers and health volunteers regarding salt intake and upgrade their counselling skills
- Organize regular training for food producers and food service personnel regarding adequate salt intake and increasing the production and service of lower salt food

Outcomes

Expected outcomes of the strategy:

- Population salt intake will be decreased by 30% by 2025 (from the 2011-2012 level)
- A monitoring system of government and private sector for the importation, production, service and marketing of high salt meals and food products will be established
- The salt content of commercially processed food products and public catering service meals will be reduced by 40%
- Knowledge, attitude and practices of food producers and food service providers, health workers, volunteers, staff of all level educational organizations, children, youth and general population regarding adequate salt intake will be improved
- Inter-sectoral collaboration, partnership and information sharing regarding an increase in the production, marketing, service and consumption of lower salt food and participation and support of government, private sector, entities and citizens will be increased

are a high priority for the Mongolian government which has commenced a second program of work in 2014 that includes commitments to: develop and support low salt content in food production, trade and service industries; provide and co-ordinate policy on the reduction of high salt foods; and increase the update of national food standards to limit the salt content of foods.

Although a policy framework has been established, the process of implementation and evaluation will take some time to develop. The social, legal and economic infrastructure to support the implementation of the salt reduction strategy will need to be strengthened, as Mongolians like salty foods and drinks and salt has been a traditional condiment for centuries. These things together, combined with the rapid urbanisation and the increased availability of highly processed salty foods, mean a major and sustained consumer education effort will be needed to reverse the current taste preferences in Mongolia.

Establishing a legislative framework to limit the intake of salt for both domestically produced and imported processed foods and meals, and the monitoring of salt levels in foods and meals will also be crucial elements of the salt reduction strategy. This study revealed that 75.4% of processed foods and 84.3% of meals are high in salt. One of the favourite foods of Mongolians is sausage. Domestic sausage producers are already examining opportunities to reduce salt, but more than 70% of the processed foods in Mongolia are imported. Whist the local food industry has indicated their willingness to participate, with early demonstrations of substantial reductions in salt levels, the same standards need to be applied to imported foods for the strategy to be sustainable.

The strategy could also be further enhanced through ongoing surveillance of NCDs, in particular a population-based study of the incidence of stroke, as Mongolia has one of the highest rates of stroke in the world (28). It would be extremely useful to demonstrate how the effective implementation of salt reduction in the population could translate into reduced incidence of stroke within a 5-10 year horizon.

Conclusions

The Mongolian government has identified the tackling of NCDs as a high priority health objective for its population. The national salt reduction strategy for Mongolia will help to ensure that this objective can be achieved. The strategy is clearly focused and unites all players: government, the food industry and community, in one ultimate goal—to reduce salt intake in Mongolia by 30% by 2025. Robust interim monitoring of the strategy will help ensure it is on track to meet these global targets. The addition of a population-based stroke surveillance program would provide a reliable direct assessment of the impact of the salt reduction initiatives on the health outcomes. The results would likely be widely generalizable to other populations experiencing similar lifestyle transitional changes.

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Brief Report

The World Hypertension League: where now and where to in salt reduction

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Abstract: High dietary salt is a leading risk for death and disability largely by causing increased blood pressure. Other associated health risks include gastric and renal cell cancers, osteoporosis, renal stones, and increased disease activity in multiple sclerosis, headache, increased body fat and Meniere's disease. The World Hypertension League (WHL) has prioritized advocacy for salt reduction. WHL resources and actions include a non-governmental organization policy statement, dietary salt fact sheet, development of standardized nomenclature, call for quality research, collaboration in a weekly salt science update, development of a process to set recommended dietary salt research standards and regular literature reviews, development of adoptable power point slide sets to support WHL positions and resources, and critic of weak research studies on dietary salt. The WHL plans to continue to work with multiple governmental and non-governmental organizations to promote dietary salt reduction towards the World Health Organization (WHO) recommendations.

Keywords: Salt; sodium; public health; hypertension; blood pressure

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Introduction

Increased blood pressure is the leading risk for death and disability. According to the Global Burden of Disease (GBD) Study almost 1 in 5 deaths and 7% of disability can be attributed to sub optimum blood pressure (1). Also gastric and renal cell cancers, osteoporosis, asthma severity, renal stones, increased disease activity in multiple sclerosis, headache, increased body fat, Meniere's disease, and direct renal, vascular and cardiac damage have been associated with high dietary salt (2-7). An estimated 40% of the global population over age 25 has hypertension, which in turn is attributed to over 50% of heart disease and stroke, two major global non-communicable diseases (NCD) (8). The predominant global burden of NCD is in low to middle income countries that do not have adequate resources to counter the increasing numbers of people with NCD (8). In fact, the threat to global development and economies caused by increasing NCD resulted in the United Nations convening its second meeting on health (9). Of nine health targets selected by the United Nations to be achieved by 2025, one was to reduce uncontrolled hypertension by 25%, and one was to reduce dietary salt by 30% (9). Based on the large burden of disease, the World Health Organization (WHO) dedicated World Health Day in 2013 to hypertension (8).

High dietary salt is estimated to cause about one-third of hypertension or more than 300 million people to have hypertension (1,10). Diets that are comprised of fresh fruits, vegetables, meats, fish and poultry without added salt generally have 0.25 to 2.5 gm salt (100 to 1,000 mg sodium)/day (11). Globally intake of salt now exceeds 5 gm (2,000 mg sodium)/day by age 5 in most of the world (12,13). Salt intake above 2.5 gm (1,000 mg sodium)/day is attributed to over 3 million deaths/year and intake above 5 gm (2,000 mg sodium)/day 1.65 million deaths/year according to the GBD Study (14) [Institute for Health Metrics and Evaluation (IHME). GBD Compare. Seattle, WA: IHME, University of Washington, 2013. Available online: http://vizhub.healthdata.org/gbd-compare, accessed Jan 11, 2015]. The WHO recommends adults consume less than 5 gm (2,000 mg sodium)/day with proportionally lower levels in children based on their lower caloric needs (15).

The World Hypertension League (WHL) is a coalition of national and regional hypertension organizations dedicated to the prevention and control of hypertension working also in official relations with the WHO and the International Society of Hypertension. The WHL developed and oversees World Hypertension Day each May 17th as a mechanism to draw attention to the highly preventable disease burden caused by increased blood pressure and also the critical need to reduce this burden. The WHL has currently prioritized two major programs, reducing dietary salt and increasing awareness of hypertension. This article outlines the activities of the WHL to advocate for reducing dietary salt. The various documents and resources referred to in this manuscript can be accessed at the WHL website www.whleague.org (16).

WHL salt reduction efforts

Dietary salt policy

Preventing and controlling hypertension is complex and requires a strategic approach (17). The WHL in advocating for strategic approaches to preventing and controlling hypertension has encouraged the incorporation of actions to reduce dietary salt (17). More specifically, the WHL with the International Society of Hypertension developed a policy statement to guide non-governmental organizations in advocacy for dietary salt reduction (18). The policy calls for specific governmental, industry as well as non-governmental actions to achieve the WHO targets for salt reduction and at a minimum to the United Nations target of a reduction in national consumption levels of 30% by 2025. A strong central role for governments to oversee a reduction in salt additives to processed foods is indicated to be the cornerstone of successful programs. Nevertheless, health care professionals and scientists play a critical advocacy role. A slide set about the policy statement on the WHL website is to assist clinicians and scientists advocate [World Hypertension League 2014. Available online http://www.whleague.org/index.php/j-stuff/resource-center, accessed Jan 12 2015]. To facilitate the uptake of the policy, the WHL has conducted a symposium on salt reduction at its regional meeting in Africa and at the International Society of Hypertension meeting. One outcome of the African regional meeting was an agreement to assess the feasibility of a salt reduction committee/coalition and to work with the WHO on dietary salt reduction.

Nomenclature

Salt, sodium, mg, gm, mmol, and meq: what does it all mean? In general, most of the world identifies dietary salt in gm/day while North America uses dietary sodium mg/day (5 gm salt is 2,000 mg sodium). To add to the confusion, some more recent investigators indicate sodium in gm, sometimes do not indicate if they are referring to salt or sodium and put different units (e.g., mmol) in the same manuscript without informing readers of how to interchange units (19). The WHL policy is to indicate salt gm (sodium mg)/day and we encourage other investigators to do likewise and for journals to adopt this standard. At a minimum, authors should use consistent units and indicate how to convert units to those generally used (salt gm and sodium mg). Further, different publications indicate the same level of salt intake as being high or low and in describing reductions in dietary salt indicate the same reduction as being large or modest. The WHL has developed recommended nomenclature for describing salt (sodium) intake based on diets of natural food without added salt and on current recommended intake of salt by the WHO (16). Recommendations for describing reductions in salt intake were based on the range of reductions in dietary salt from randomized controlled trials lasting four or more weeks. The WHL hopes that use of common terminology will help achieve a common understanding of the physiology and pathophysiology of dietary salt and of interventions to reduce dietary salt.

Fact sheets

Multiple groups and individuals using different and conflicting statistics and recommending differing interventions are confusing to policy makers and the public. Consistent use of accurate up to date information is critical to advocacy efforts. However, it is often difficult to obtain up to date accurate information that has been endorsed by credible organizations on the impact of dietary salt on health and of hypertension on health. The WHL with the International Society of Hypertension therefore has undertaken to develop and annually update facts sheets on dietary salt and also on hypertension (20,21). A slide set on the WHL website also provides standardized information of the impact of high dietary salt on health [World Hypertension League 2014. Available online: http://www.whleague.org/index.php/j-stuff/resource-center, accessed Jan 12, 2015]. Although the facts sheets produced by the WHL are aimed at the global population, the WHL recognizes that most interventions to reduce dietary salt and control hypertension will be at national or community level. To help address this, the WHL has published methods on how to obtain accurate data and statistics to develop national level facts sheets for hypertension and for reducing dietary salt (22).

Credible science

Throughout the history of research on dietary salt, there have been some studies that have found no impact or even a harmful impact of reducing dietary salt. Many of these studies have serious overt methodological flaws or weaknesses such as use of a single spot urine sodium to assess usual salt intake, failure to properly address confounding risk factors, reverse causality (whereby people who are sick less but die more), authors with conflicts of interest, and inappropriate selection of studies for analysis (meta-analysis that include studies lasting less than one week with extreme changes in salt intake) (23-26). It is also within reason that, perhaps to increase citations, several controversial studies have been published in high impact journals.

The WHL has highlighted some of these weaknesses in publications and symposia and has called for the setting of recommended standards for conducting clinical and population research on dietary salt (27,28). An international coalition lead by the WHL has been formed and will develop these recommended standards in 2015. Once the standards are set, regular systematic reviews of the literature will be conducted and, if deemed necessary by the overseeing committee, new recommendations for dietary salt will be developed. The WHL is currently a co-sponsor of a weekly literature summary based on a Medline review of research on dietary salt. Everyone is welcome to sign up for the free service at: http://www.hypertensiontalk.com/science-of-salt-weekly/.

Discussion

High dietary salt is one of the leading risks for death and disability globally with its major adverse health impact being increased blood pressure. The WHL has prioritized reducing dietary salt and works with national and international governmental and non-governmental organizations to advocate for reductions in dietary salt. The WHL website provides a venue for those interested in the WHL activities to stay up to date.

The WHL hosts World Hypertension Day. It is notable that the WHL has allocated this day to promote awareness of the diagnosis of hypertension and knowing your blood pressure between 2014 and 2018. Globally, it is estimated that about 50% of the more than 1 billion people with hypertension are not aware their blood pressure is high. In 2014, over 300,000 people had blood pressure screened for World Hypertension Day and the goal for 2015 is for more than 1 million. It is hoped that reducing dietary salt and increasing awareness of hypertension will be concrete steps to reduce the burden of hypertension related NCD.

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Perspective

The strides to reduce salt intake in Brazil: have we done enough?

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Abstract: Non-communicable chronic diseases (NCDs) are a major cause of morbidity and mortality in Brazil and inadequate diet is an important risk factor. Among the NCDs, cardiovascular diseases are very prevalent and sodium reduction in the population is a priority of health sector, because Brazilians consume more than twice the daily World Health Organization (WHO) sodium recommendation. Taking into account that sodium sources vary in the country among different age and income groups, several strategies are needed in order to reduce sodium intake, as consumer education, food reformulation, health promotion in school and work settings, food regulation and healthcare initiatives. So far, since 2011, the first results of sodium targets for processed foods and healthcare improvements are promising, and bring lessons that can be helpful for other countries. Nevertheless, more efforts on communication for healthy behaviors, food regulation, engagement of other partners and stakeholders and improving the monitoring system are key to advance in reducing sodium consumption from 4,700 to 2,000 mg per day until 2020.

Keywords: Sodium chloride in diets; food and nutrition programs and policies; Brazil

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Local epidemiology of health and nutrition

Brazil has experienced major changes in terms of economic, social and health indicators in the last decades, including achievements as significantly reducing poverty and malnutrition, especially among children, but meanwhile the food and nutrition security agenda in the country has faced several other burdens as overweight, obesity and chronic diseases.

Non-communicable chronic diseases (NCDs) are currently the main causes of morbidity and mortality in the world, including low and middle income countries, and represent over 70% of all deaths in Brazil. The main risk factors for these diseases are unhealthy diets, physical inactivity, tobacco use and harmful use of alcohol (1). Cardiovascular diseases were responsible, alone, for approximately 30% of all deaths in Brazil, totalizing 333,264 deaths in 2012, of which 45,056 were attributed to hypertension (2).

In the context of unhealthy diets, the main risk factors for NCDs are excessive sodium, sugar and fat consumption, considering all diet sources, including foods and meals consumed in the household and out of the household to processed foods, so multiple coordinated strategies are needed to reduce their intake.

In 2013, over 21% of the adults in Brazil have declared a medical diagnosis of hypertension, although the actual hypertension prevalence is most probably much higher (3). The first population data on hypertension prevalence along with the sodium intake based on urinary excretion from the National Health Survey 2013, however, will only be available in the end of 2015.

It is estimated by the Brazilian Cardiology Society that, solely by reducing the average salt intake by Brazilians to 5 g per day, deaths by stroke would be reduced in at least 15% and deaths by myocardial infarction would be reduced in 10%. By achieving the World Health Organization (WHO) recommendation, it is also expected that 1.5 million people would not need hypertension drugs and that life expectancy of hypertensive individuals would be increased in up to 4 years.

Salt intake and salt knowledge and behaviors

During the last decades, most countries' populations have shown excessive sodium intake, varying from 3,600 to 4,800 mg/person/day, equivalent to 9 to 12 g of salt (4), while the WHO's recommendation states that sodium intake for adults should be less than 2,000 mg per day (5 g of salt per day).

In Brazil, the average per capita estimated sodium intake, based on population food acquisition data, did not vary from 2002-2003 to 2008-2009 and reached around 4,700 mg of sodium or 12 g of salt per day. In both periods, most of the sodium was derived from kitchen salt or salt-based condiments and sodium intake from processed foods increased with household purchasing power (9.7% of total sodium intake in the lower quintile of the per capita income distribution and 25.0% in the upper quintile). Also, from 2002-2003 to 2008-2009 the relative participation of salt and salt-based condiments in sodium intake was slightly reduced from 76.2% to 74.4%, while the participation of processed foods increased almost 20% (15.8% to 18.9%) (5).

Food consumption data from 2008-2009 has confirmed that Brazilians consume too much sodium in average and that from 70% to almost 90% of the adults consume over 2 g of sodium daily. An additional concern is that from 73% to 89% of Brazilian adolescents also consume excessive sodium (6).

Meanwhile, in 2013, only 14.2% of the adults of Brazil perceived that their personal salt intake was high or very high, so education is still a key element in order to reduce sodium intake in the population, both considering added salt to foods and sodium from processed and ready to eat foods (3).

Health policies and healthcare systems

Preventing and controlling NCDs is a priority for health sector in Brazil and is supported by the National Food and Nutrition and the National Health Promotion Policies, by the National Food and Nutrition Security Plan and by the National NCD Plan. The three main directives for tackling NCDs are surveillance, integral health care and health promotion.

In particular, because of the multiple sources of dietary sodium, its reduction is based on several strategies, from consumer education and food labeling improvement to actions in settings (workplace, schools) and sodium reduction in restaurants, food services and processed foods and articulation with other policies and programs.

In terms of healthcare to people with chronic diseases, the Brazilian National Health System has been developing lines of healthcare for some of the main chronic diseases (hypertension, diabetes, obesity, cardiovascular and renal diseases). Other strategies have been based on implementing NCD healthcare networks, coordinating and integrating primary health care with more complex services, as clinics, emergency rooms and hospitals, along with instructional materials for health professionals, improvement of health facilities and equipments and training strategies. For example, the strategies for hypertension in primary health care units encompass population screening, individual diagnosis, patient treatment and monitoring, nutritional recommendations (for both prevention and treatment) and physical activity recommendations (7).

The access to medications is an important part of NCD treatment, so the National Health Systems provides free medicines for hypertension and diabetes at healthcare facilities and has also partnered drugstores in order to provide cheaper medicines for these diseases. As a result of these combined initiatives, the hospitalizations related to hypertension have been decreasing year by year, so the number of hospitalized people was reduced in 37% from 2002 to 2012 (reduction from 95.04 to 59.67 hospitalizations/100 thousand inhabitants).

Community interventions—schools and workplaces

Two of the main settings for promoting food and nutrition education and for providing healthy foods in Brazil are schools and workplaces, where important policies and programs take place.

In public schools, Brazil has one of the largest school meal programs in the world, which reaches up to 42.2 million students in the country with nutritionally balanced foods, with controlled salt, sugar and fat levels. Additionally, in order to stimulate the use of fresh produce and strengthen local circuits of food production, at least 30% of the foods for schools must be bought from local family farmers.

Also in public schools, by articulating health and education sectors at the local level through the School Health Program, health and nutrition contents are included in school activities and classes and health care and health promotion can be addressed in the school environment.

In private schools, the Ministry of Health has partnered with state school associations in order to implement healthy cafeterias and several states and municipalities have approved regulations that limit or prohibit unhealthy foods, especially energy-dense and rich in sodium, sugar and fat, in the school environment.

Within the workplace, the directives of National Worker's Food Program (PAT), mostly directed to industry workers, has been revised in order to improve the nutritional profile of meals, in particular in relation to calories, sodium, sugar and fats. Also, within the Federal Government all meals and coffee-breaks in workplaces and meetings and events have healthy standards to comply with, including the incentive to natural and minimally processed foods will limit processed foods and restrict highly processed foods, particularly those with high sodium, fat and sugar levels.

Community interventions—communication strategies

Taking in consideration that added salt to foods is the major source of sodium for Brazilians, educating consumers is fundamental to reduce sodium intake in the country. Hence, healthy dietary habits have constantly been a part of health promotion campaigns by the Ministry of Health, emphasizing salt reduction as a key behavior for NCD prevention.

The newly revised Dietary Guidelines for the Brazilian Population establish the main directives for the promotion of healthy eating, by prioritizing natural and minimally processed foods as the foundation of diets, valorizing the habits of cooking and eating together and emphasizing that oils, fats, sugar and salt should only be used in small amounts in the preparation of meals (8).

Also, other partners have been engaged in communication to the population concerning salt intake, as consumer protection associations and even the private sector, as the supermarkets. These communication strategies consider the contribution of all sodium sources in diet, especially added salt and processed foods, in order to enforce people to better health and diet choices when preparing, ordering and purchasing foods, including food labelling.

Community interventions—food industry

In Brazil, the government engaged with the Brazilian Food Industry Association since 2007 through a technical cooperation agreement which encompasses food reformulation (particularly by reducing sodium, sugar and fat contents) as a main directive (9). Firstly, a goal was set for tackling trans fatty acids, according to the Pan American Health Organization's Regional Targets, in 2008, and, 2 years later, monitoring showed that almost 95% of the food products in the Brazilian market achieved the targets, representing the exclusion of 230 tons of trans fats from foods per year (10). Following the positive results of this strategy, addressing sodium as the key ingredient for food reformulation became a priority for both government and food industries.

The work on sodium reduction started by selecting the food categories that most contributed to sodium intake and specific categories which are most commonly consumed by vulnerable groups as children and adolescents, based on data from household budget surveys. In Brazil instant pasta (noodles), industrialized bread, buns, mayonnaise, corn sacks, potato chips, cakes and cake mixes, cookies and biscuits, margarine, breakfast cereals, condiments, French bread (artisanal), soups, dairy and meat products are responsible for over 90% of sodium from processed foods in Brazil.

Based on the sodium content, food categories were individually discussed in order to set voluntary, biannual and sustainable reduction targets. The targets for each product were set as an upper limit in terms of sodium per 100 g of product, with intermediate biannual targets and a final reduction target for 2020.

Setting the targets involved the analysis of sodium content at the baseline of negotiations, through information from food labels and laboratory analysis. Specific criteria were set for establishing targets that represent meaningful and measureable impacts on sodium content, as removing upper and lower outliers and setting targets based on adjusted averages and medians, so that within four years from baseline, at least half of the brands should be lower than the baseline average and/or there was an impact on sodium reduction in over 50% of brands in a category. In the long term, considering the targets for 2020, the final targets should be based on international targets for similar food categories (as established in the United Kingdom, for example) and by the products with less sodium that already exist nationally (11).

According to the yet unpublished first monitoring results, in the reduction of sodium in instant pasta, industrialized bread and buns, it is estimated that food industries have used 1,295 less tons of sodium in these categories by the end of 2013, and that all targets already set will lead to reducing 28.5 thousand tons of sodium in all selected food categories. According to the first monitoring results, in the reduction of sodium in instant pasta, industrialized bread and buns, it is estimated that food industries have used 1,295 less tons of sodium in these categories by the end of 2013, and that all targets already set will lead to reducing 28.5 thousand tons of

sodium in all selected food categories. It has been found that 94.9% of instant pasta brands, 97.7% of breads brands and 10% of bun brands have achieved the first sodium targets and that the average sodium content of these categories has been reduced in 10% to 15% from 2011 to 2014.

In order to assist industries and food services in achieving lower sodium products, the National Health Surveillance Agency (Anvisa) along with the Ministry of Health and other partners elaborated Guides of Good Nutritional Practices. Currently, two guides have already been released: for artisanal bread and for restaurants, so the standards for sodium levels can be achieved also in small businesses around the country (12,13).

Health policy advocacy

Advocacy on sodium reduction is very important, both nationally and internationally, so Brazil has worked on building partnerships and articulating with institutions and associations that can participate in supporting, implementing and evaluate salt reduction actions.

Nationally there are important forums to discuss, within food and nutrition policies, the joint strategies for sodium reduction, as the Interministerial Food and Security Chamber and the Intersectoral Food Chamber. Annually, the Ministry of Health also holds a comprehensive seminar with representatives of government offices, consumer associations, councils of health professionals (nutrition, nutriology, cardiology, nephrology), food companies, laboratories and other stakeholders, in order to discuss strategies and to monitor the results of sodium reduction policies.

Regionally, Brazil has discussed sodium reduction policies in the Mercosul region as part of the Action Plan for the Food and Nutrition Security Working Group, with Argentina, Paraguay, Uruguay and Venezuela, and working on the proposition of regional targets for sodium content in selected food categories. Also in the international context, Brazil has been a reference in addressing sodium reduction, especially in terms of the approach towards processed foods and in harmonizing salt reduction with the protection against iodine deficiency disorders (IDD), along with institutions as the WHO (14), the Pan American Health Organization (PAHO) (15) and the International Council for Control of Iodine Deficiency Disorders (ICCIDD) (16).

Conclusions

Brazil now faces a multiple burden of food and nutrition insecurity, where malnutrition, micronutrient deficiencies, obesity and NCDs coexist not only in the country, but even in some households. As cardiovascular diseases are major causes of death and disease and excessive sodium intake is an important risk factor, the country has developed many strategies in order to reduce population dietary sodium by addressing consumer behaviors, processed foods, foods prepared and consumed out of the household, food regulation, intersectoral policies and education of health professionals and food producers, but there is a long way to achieving 2,000 mg per person daily in the country.

So far, the strives have shown promising preliminary results, as in the first sodium targets for processed foods and in improving healthcare and access to medicines, but especially in terms of behaviors towards discretionary salt, there is still a huge challenge, because most Brazilians do not yet acknowledge their excessive sodium consumption.

Besides, policymakers and other stakeholders face several challenges in terms of technologies in food reformulation, improving the monitoring framework of population sodium consumption, food sources and behaviors, strengthening food regulation (especially food labelling, simplifying the information to consumers, as with front of package labeling and food publicity regulation), enabling more protective settings (in particular to children and adolescents) and expanding and strengthening communication and education both by government as by private and civil society partners.

There are many lessons that can be already taken from the Brazilian experience in tackling excessive dietary sodium consumption. For countries where sodium sources vary from discretionary salt at home and at food services to processed foods, the experience on building different approaches in order to educate consumers while reducing sodium content of processed foods can be particularly useful. The need for permanent improvement of monitoring and evaluation instruments is also a very important learning, so that even though initiating sodium reduction policies does not depend on having gold standard methods at hand at baseline, the tools must be constantly improved through time.

Specifically on the reformulation of processed foods, the lessons are many: larger market shares can be reached by negotiating with food industry associations instead of individual industries, having transparent and meaningful criteria for establishing sodium targets allows better accountability by civil society and clearer monitoring of results, setting gradual targets can be helpful for industries to have time to develop new technologies and formulations with reduced sodium and also reduces possible consumer rejection to products with less sodium and learning from the technological and sensorial functions of salt and other sodium salts can allow different food industries to assist each other and to ensure that the largest reductions possible may be achieved.

The strides of Brazil show that, although there is strong commitment to comprehensive and articulated health and intersectoral policies, there is much more to be done in order to gradually reduce sodium consumption from 4,700 to 2,000 mg per day by 2020.

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Salt Labyrinth

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Using ordinary table salt, artist Motoi Yamamoto created "Labyrinth" on site at Bellevue Arts Museum over a 1-week period (February 27 to March 4, 2012) for the exhibition "Making Mends" on view March 1 to May 27, 2012 (*Figure 1*).

For more information of the artworks, please visit the artist website: http://www.motoi.biz/english/e_top/e_top.html.

The artist has permitted *Cardiovascular Diagnosis and Therapy* to use *Figure 1* as the cover of the journal in issue Vol. 5, No. 3 (June 2015).

Figure 1 LABYRINTH, Salt, 5 m × 14 m, Making Mends/ Bellevue Arts Museum, USA, March to May, 2012.

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