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Barriers and Facilitators to Implementing Low-sodium Salts as a Population-level Intervention: A Qualitative Study

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ABSTRACT

**Background:** Using low-sodium salt as a public health intervention, to reduce excessive dietary sodium intake, can potentially achieve benefit at the population level. This study aimed to identify key barriers and facilitators to implementing low-sodium salt as an intervention at the population level.

**Methods:** Semi-structured interviews were conducted with key informants from academia, salt manufacturing industry and government. We used the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework to inform our interview guides. Both inductive and deductive methods were adopted for analysis. RE-AIM domains were used as an initial framework, while thematic analysis was conducted to generate new themes. Data were coded by two independent coders. Coding discrepancies were resolved by group consensus.

**Results:** Eighteen key informants (nine academic representatives, seven government representatives and two salt manufacturing industry representatives) from nine countries participated in the study. Many participants described that the use of low-sodium salts was particularly relevant for population groups whose sodium sources mostly came from home cooking. However, there was consistent concern on the perceived lack of evidence of low-sodium salts’ safety and sustainability when scaling up at the population level. The different taste and price differentials compared to regular salt, and the health literacy about the value of low-sodium salt was identified as critical factors influencing the adoption of low-sodium salts by individuals. The high cost of producing, low-profit return and low market demand for low-sodium salts were the key manufacturing barriers. Potential implementation strategies include lowering retail price through government subsidies or reduce manufacturing cost by mass production, tailoring health education to different population groups or organisations, and mass media campaign about the need to reduce excessive salt intake though the use of low-sodium salt. The shrinking market of low-sodium salts was found to be a barrier in maintaining the intervention.

**Conclusion:** The use of low-sodium salt can potentially be an effective population-level salt reduction intervention across country settings, though more evidence about its safety concerns, and policy solutions to overcome global market and industry barriers is required.
BACKGROUND

Hypertension is the major risk factor of cardiovascular disease and premature death worldwide. Excessive dietary sodium intake and inadequate potassium intake are both strong determinants of increased blood pressure levels and risk of cardiovascular diseases (CVDs). The World Health Organization (WHO) recommends a dietary sodium intake for adults of less than 2 grams per day and a potassium intake of at least 3.5 grams per day. Different population-level strategies are proposed by governments and authorities to reduce dietary sodium and increase dietary potassium. The United Kingdom (UK) has successfully implemented a population salt reduction programme, leading to a 15% reduction in the average salt intake of the population over seven years. The reduction of population’s salt intake was mainly achieved by working with food industry in gradual reformulation on a voluntary basis. However, this strategy may not have the same impact in East/Central Asia and low- and middle-income countries where most sodium comes from the salt added during cooking. Therefore, an alternative strategy is required to reduce the use of excessive sodium in the homes. Low-sodium salts may be a potential innovative solution to meet the WHO guidelines for sodium and potassium and further reduce the disease burden attributable to high blood pressure.

Regular salt is about 98%-100% sodium chloride (NaCl). Low-sodium salts, also known as salt substitutes, are table or cooking salts that have reduced 12%-100% sodium chloride content through substitution with potassium chloride and other minerals. Sodium intake and sodium-to-potassium ratio are generally known to have associations with higher blood pressure and risk of stroke whereas high potassium intake is related to lower blood pressure. Replacing regular salts with low-sodium salts in daily sodium sources, can reduce sodium intake, paired with the increased benefit associated with higher potassium intake. The effect of low-sodium salts on reducing sodium intake and blood pressure has been demonstrated in controlled research settings. The population level benefit of the use of low-sodium salts in reducing hypertension and therefore cardiovascular risk can be maximised by scaling it up into a public health strategy. Indeed, a comparative risk assessment model estimated that nationwide replacement of the salt supply with potassium-enriched, low-sodium salt in China would prevent 1 in every nine CVD deaths. A recent review has recommended population uptake of low-sodium salts as one of the priority strategies to reduce population sodium consumption.

This study is the third component of an environmental scan that aims to understand the potential scale-up of low-sodium salt interventions as a population health strategy. We found that despite excellent acceptability and effectiveness amongst hypertensive patients in trials, low-sodium salts are not widely available in the market and are more expensive than regular salts. Through an online search of low-sodium salts, we identified 54 low-sodium salts across 46 countries. The prices varied between USD 0.46 per kg and USD 87.0 per kg, and were all priced higher than regular salts. Therefore, to promote the sustainable uptake of low-sodium salts as a population health strategy, would require a deeper understanding of factors influencing its adoption, implementation and maintenance. Existing literature about low-sodium salts have mainly been about its effectiveness, with limited evidence to inform the implementation of low-sodium salts in the general population. This qualitative study aims to address this gap.
METHODS

The study protocol of the environmental scan, consisting of the systematic online search, systematic review and key informant interviews, has been published previously.15

Key informant identification and recruitment

We intended to include key informants who have been involved in the manufacturing, research, implementation and promotion of low-sodium salts. We used purposive and snowball sampling to recruit the interview participants. Academic representatives were identified through the systematic review, as part of the broader environmental scan. Corresponding authors of all eligible studies, identified from the systematic review, were contacted via corresponding authors’ email address. The academic representatives, who participated in the interview, were asked to pass on recruitment materials to potential key informants from government or salt manufacturing industry who might be relevant to the study, through a snowball sampling strategy. The final sample size of the key informants was determined by data saturation when no new themes emerged.16

Data collection

In-depth interviews were conducted between January 2020 and July 2020 by an experienced qualitative researcher who spoke fluent English and Chinese (XY). The interviews were conducted mainly in English. For key informants from China who preferred to speak Chinese, the interviews were conducted in Chinese accordingly. Interviews were conducted either over telephone or video conference or at the interviewees’ workplace at the key informants’ convenience. Semi-structured interview guides were designed based on the domains of the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework.17 The RE-AIM framework has been widely used for planning and evaluation of health programs and policies. The full use of the RE-AIM, include both qualitative and quantitative methods to understand the dimensions of the framework.18 In our study, we applied RE-AIM qualitatively to focus on for whom, how and why the low-sodium salt can be implemented across the individual RE-AIM dimensions. Example questions of each dimension were shown in Table 1. The interview guide (supplementary file 1) was adapted for different roles of the key informants.

Table 1 RE-AIM dimensions and research questions

| Dimension  | Example Questions                                                                 |
|------------|-----------------------------------------------------------------------------------|
| Reach      | • Who is your target population and how would you reach them?                     |
|            | • What groups do you think are not reached and why?                               |
| Effectiveness | • What do you perceive as the key benefits of low-sodium salt?                   |
|            | • Do you think the low-sodium salt can be an effective approach to reduce        |
|            | population sodium intake? Why or why not?                                        |
|            | Prompt: Are there other strategies that you think would be more appropriate?    |
| Adoption   | • How would you improve individual and organisational adoption of low-sodium     |
|            | salts?                                                                             |
Data analysis and rigor

The audio-recorded interviews were transcribed verbatim. Data analysis were conducted in either English or Chinese. Quotations in Chinese, presented in this paper were translated into English. This process involved forward-translation (from the source language into English) and back-translation (from English to their source language). Both versions were compared to check accuracy and equivalence. Any discrepancies that have occurred during the process were discussed between the two bilingual translators (XY, LS). Both inductive and deductive methods were adopted to evaluate the interview transcripts. The headings of RE-AIM were used as an initial framework (deductive approach), and thematic analysis was conducted to generate codes linking to the relevant dimension in the RE-AIM framework (inductive approach). The first round of the analysis involved the first author (XY) reviewing the transcripts verbatim and inductively assigning codes to emergent concepts. The second round of the analysis used the same coding framework to apply codes to the transcripts by another coder (LS) independently. The coding book was generated using constant comparison across perspectives. Coding discrepancies were discussed with a senior researcher (HL) and resolved by consensus to optimise inter-coder reliability. Revisions to the coding scheme were applied to all previously coded transcripts. The NVivo analytical software system (version 12.0) was used for data management and data coding. The study was reported according to the Consolidated Criteria for Reporting Qualitative Research (COREQ). (supplementary file 2)

Ethics

The study received its ethics approval from the University of New South Wales Human Research Ethics Advisory Panel (HC190921). Participants did not receive financial compensation. Informed consent was obtained verbally at the commencement of each interview. Consent included permission to be audio-recorded.

RESULTS

Eighteen key informants from nine countries participated in the interview. Of those, nine were academic representatives, seven were government representatives, and two were salt manufacturing
industry representatives. Twelve participants were from high-income countries, while six were from middle-income countries, with variable representation across the WHO regions. Findings were aggregated for each RE-AIM dimension around barriers and facilitators. Table 2 provides an overview of participant characteristics. Table 3 summarises the facilitators and barriers identified in implementing low-sodium salt as a population-level intervention based on the RE-AIM domains.

**Table 2. Participant characteristics**

| Characteristics        | Number of participants, N (%) |
|------------------------|-------------------------------|
| Roles of participants  |                               |
| Academia               | 9 (50%)                       |
| Salt manufacture       | 2 (11%)                       |
| industry representative|                               |
| Government representative | 7 (39%)                     |
| The world economies    |                               |
| high-income            | 12 (67%)                      |
| low-and middle income  | 6 (33%)                       |
| WHO Regions            |                               |
| South-East Asia Region | 1 (6%)                        |
| European Region        | 3 (17%)                       |
| Region of the Americas | 4 (22%)                       |
| African Region         | 1 (6%)                        |
| Western Pacific Region | 9 (50%)                       |

**Table 3 Themes under RE-AIM domains by facilitators and barriers**

| RE-AIM domains       | Themes of barriers                                                                 | Themes of facilitators                                                                 |
|----------------------|------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| Reach                | • Unavailability of low-sodium salts                                               |                                                                                  |
| Effectiveness        | • Uncertainty of effectiveness in population.                                      | • Strong efficacy/effectiveness evidence from trials                                    |
|                      | • Evidence gap in health impact among renal impaired patients                       |                                                                                  |
| Adoption             | • Higher price compared to regular salt.                                            | • Lowering retail price.                                                             |
|                      | • Different taste.                                                                 | • Health education tailored to different people/organisations.                      |
|                      | • Lack of knowledge of its health benefit.                                         | • Mass media campaign.                                                              |
|                      | • Unaware of its availability.                                                     |                                                                                  |
| Implementation       | • High cost of producing.                                                          |                                                                                  |
|                      | • Low profit return.                                                               |                                                                                  |
|                      | • Low demands for low-sodium salts                                                |                                                                                  |
| Maintenance          | • Market share decrease                                                            |                                                                                  |

**Reach**

All participants described that the goal of promoting low-sodium salts was to make it reach a wider general population, and not only hypertensive patients. Many participants described that the use of
low-sodium salts was particularly relevant for population whose sodium sources mostly came from home cooking. One participant described that the use of low-sodium salts in resource-poor settings with high cardiovascular burden in the general population, would improve health care equity. However, the main perceived barrier to reaching a wider population was the unavailability of low-sodium salts in most countries. Even in countries where low-sodium salts were available, participants highlighted the percentage of the total sales of low-sodium salts in the salt industry (market share) was small. An interviewee from China salt manufacture industry reflected that the market share was less than 10% and only available in the urban cities. An interviewee from Singapore reflected the market share of low-sodium salts was about 2%. The unavailability of low-sodium salts in rural areas, was also reflected by interviewees from Peru and India.

"Low-sodium salts from my perspective is that it is an intervention which is particularly suited to many of the poorest and least developed communities in the world because their sodium source was most from salt they added at the time of cooking or food preparation. This is fantastic for health equity." (Australia, academic representative)

**Effectiveness**

The strong evidence of the effectiveness of low-sodium salts on reducing sodium intake, renal albumin level, blood pressure and increasing potassium intake in trial settings were identified as facilitators. However, the uncertainty of its effectiveness in general population and in renal disease patients were identified as barriers to scaling up the intervention. Several participants highlighted that people might add more low-sodium salts to maintain the same taste of food. Behaviour interventions such as health education about the need to reduce excessive sodium intake, along with the use of low-sodium salt, was suggested to enhance the effectiveness of low-sodium salt at population-level.

Several participants highlighted that it was important to educate the general population about the proper use of low-sodium salt, specifically in two areas. First, although low-sodium salt was considered as a ‘healthier” salt alternative, most low-sodium salts still contain significant proportion of sodium chloride. Therefore, people should be still educated to shake less salt even when using low-sodium salts. Second, for hypertensive patients, despite low-sodium salt efficacy in reducing the blood pressure, adherence to anti-hypertensive medications was still required.

"If the general population uses the low-sodium salt and at the very end, they do not have sodium reduction. This means that they had used more amount of those product comparing with using normal salt. Using low-sodium salts doesn’t mean people will reduce sodium intake, and this is something that should be further investigated." (Italy, salt manufacture industry representatives)

Participants reinforced that more research is required on the effectiveness of low-sodium salts for renal disease patients. Two researchers confirmed that using low-sodium salts can decrease albuminuria level and further prevent renal clinical events. Yet, there was an evidence gap in the long-term safety and effectiveness of low-sodium salts on renal disease patients.

"I am convinced it is beneficial for albumin reduction. Albumin is a marker of the problems of kidney. After decreasing the albumin level, people will be better off, if there is a longer study
that can see the reduction in the progression of kidney diseases that would be a major achievement.” (Australia, academic representatives)

Although participants from salt companies described being confident in the safety of low-sodium salts, and researchers advocated for the substantial net benefits of low-sodium salts; government representatives expressed ongoing concerns about its safety as the key barrier to scaling up low-sodium salt as a population level intervention.

“There is much evidence for the benefits of low-sodium salt. We actually have considered it as one of salt reduction strategies. However, safety is a challenge when taking it as a public health intervention. Low-sodium salt contains potassium chloride; a tiny number of patients are not suitable for using low-sodium salt. Once a low-sodium salt caused hyperkalemia case is reported, it will cause trouble. From the perspective of policymakers, we take risks and responsibilities. I can advocate (for) low-salt, but I would not recommend low-sodium salt to the public.” (China, Government)

Adoption

Price compared to regular salt, the different taste of low-sodium salts and the knowledge, attitude and behaviour towards reducing excessive salt intake were identified as key factors influencing the adoption of low-sodium salts by individuals. Participants from developing countries reported that the affordability of the low-sodium salts was important. However, one participant from China said the price difference was not the primary barrier for people in purchasing low-sodium salt in urban cities. Rather, this participant thought that while the price of low-sodium salts was about 1.5 times that of regular salts, it was affordable to the general public living in cities, but that they lacked awareness of its availability and health benefits. Moreover, it was also highlighted that consumers may not like the taste. Potassium chloride tastes both salty and bitter as compared to the pure salty taste of sodium chloride. Researchers suggested that the sodium level in the low-sodium salts can be reduced gradually by the industry over time to increase the acceptability of the taste and advocated more research regarding the acceptability of low-sodium salts with a different formula.

“We were trying to be careful about the acceptance levels that will have an impact on their options. You need to figure out rather than assuming what sodium level of salt will work. I rather do it gradually. I think the ideal behaviour is to cook with the same or less amount of low-sodium salts when cooking. If the sodium changed dramatically, people would end up thinking this is not salt. I won’t use it when cooking.” (Peru, academic representatives)

Implementation

High manufacturing cost and low-profit return influenced the production of low-sodium salt. According to a salt manufacturing industry representative, they have limited investment in low-sodium salts. This was because the demand from consumer was limited, and the cost of producing low-sodium salts is high because of the higher cost of potassium. Moreover, the salt manufacturing industry was required to invest in research and development, for instance, in salt processing technology to improve the taste of low-sodium salts. Therefore, the participants from salt companies
described their decision-making process, and how they had to decide between their short and long-term profit returns when deciding to manufacture low-sodium salts.

“We went to a national company. It used to be the national compensation. They were not interested in low-sodium salt. How to switch this company to produce more quantities at a lower price? The answer is to produce a lot. It will be cheaper when mass production.” (Peru, academic representative)

Intensive health education to increase consumer demand, lowering the retail price by mass production, mass media campaign, and involving food industries were identified as potential implementation strategies. Ongoing health education was suggested by all participants, especially education to stakeholders or in certain settings (i.e. school-based health education to students, restaurant-based education to chefs, community-based education to homemakers, hospital-based education to physicians). The food industry also needed to be educated and incentivised so that they could recognise the public health importance of reducing sodium level in their products and how low-sodium salts could help them reformulate their products. Lowering the retail price through government subsidies was regarded as a strong strategy in underdeveloped areas where people were more price sensitive. Mass media campaigns by government peak bodies were suggested as a critical channel to pass information.

Maintenance

The small market share of low-sodium salts limited its reach to wider population. Meanwhile the decreased in market share of low-sodium was found as a barrier in maintaining an existing low-sodium salt intervention. Example came from China where had attempted to scale up low-sodium salt in several provinces a few years ago when the salts were produced by China’s state salt monopoly (China Salt). This centrally administrated State-owned enterprise can decide the price and distribution of products. Therefore, it has been easier to significantly increase the low-sodium salt market share with the state salt manufacture industry’s support. However, the market share of the low-sodium salt reduced significantly after the salt market reform in 2017. The market change brought numerous small salt companies in the market who were not interested in and capable of producing low-sodium salt because of its high cost and complicated technology.

DISCUSSION

To the best of our knowledge, this is the first study to examine key informants’ perspectives regarding using low-sodium salts as a potential population sodium reduction strategy. The findings highlighted the major barriers and facilitators that need to be considered when implementing low-sodium salt
intervention at the population level. The discussion will give recommendations for potential scale-up of low-sodium salts, across the RE-AIM framework domains.

Considering controversial opinions on the safety of low-sodium salts as expressed among key informants, evidence of its safety in population and for persons with impaired renal function is needed. Low-sodium salts have reduced sodium chloride content, most commonly through substitution with potassium chloride. One concern with scaling up low-sodium salts is the potential to increase the risk of hyperkalaemia and sudden cardiac arrest for a small number of people who are advised to limit dietary potassium due to impaired renal function and potassium excretion. Government representatives were cautious about recommending low-sodium salts to everyone in light of the safety concern. Apart from trials to evaluate the effectiveness of low-sodium salt on hypertensive patients, government representatives highlighted that predictive modelling, observational, quasi-experimental, and interventional studies, and surveillance data would be useful evidence required for policy change. This could potentially help to provide evidence-informed metrics and regulate salt labelling to address the safety issue.

Health education to improve the general population’s knowledge, attitude and behaviour to low-sodium salt is critical when introducing low-sodium salts as a population-level intervention. The baseline surveys of the Salt Substitute and Stroke Study (SSaSS) in China reported the awareness of low-sodium salts was only 5.9%, and none of the participants had heard about low-sodium salts at baseline of the Salt Substitute in India Study (SSiIS). Several low-sodium salt trials showed an increase in mean potassium levels but no changes in sodium levels after the intervention. Those results indicated to customers that the low-sodium salts intervention was accepted and adopted, but participants were probably using more low-sodium salts than regular salts when eating and cooking. Strategic health education campaigns including social marketing and behaviour change communication are needed to increase consumers’ awareness and to improve their capability to lower salt intake when using low-sodium salts. Health education works best as part of a comprehensive package rather than in isolation. The SHAKE technical package developed by WHO can be used to foster other complementary and synergistic salt reduction strategies for lower sodium intake.

Importantly, scaling up the use of low-sodium salts at a population intervention should be tailored to different social and cultural contexts. The influence of food culture and sodium source on implementation has been illustrated in a process evaluation of a national sodium reduction programme in Samoa. Null effects on population-level dietary sodium consumption were observed when replicating some successful interventions in high-income countries into lower-middle countries. Previous studies suggested that lower socioeconomic groups were less likely to adopt healthy behaviour after receiving health education. Similarly, participants in this study highlighted that it would be more challenging to deliver health education to a socioeconomically disadvantaged population. The health education should be complemented with fiscal strategies, such as lowering prices, to promote a healthier choice of salt. Price policies that address affordability and purchasing incentives (i.e. government subsidy) for low-sodium salts can be a key policy tool. One cluster randomised control trial of salt reduction intervention in rural China revealed that even having the same health education programme, the adoption of low-sodium salts was higher in villages where the price of low-sodium salts was subsidised compared with villages without a price subsidy. However, in high-income areas, lowering the price of low sodium salts, may not always stimulate demands. High-income consumers were less price-sensitive and more likely to pursue a healthy diet. Awareness
campaigns and health education delivered by trusted authorities can be used to increase public awareness and capacity of using low-sodium salts.33

Apart from health education and awareness campaigns directed at individuals, the most efficient and sustainable strategy is to create supportive environments for implementing a low-sodium salt intervention. “Upstream” policies focussed on changing food environment such as mandatory reformulation generally appear to achieve larger reductions in population-wide salt consumption than “downstream” policies focussed on individuals, such as health education.34 A collaborative approach involving multi-stakeholder partnership from government, food industry and individuals are necessary to create healthy food environment to maintain the population level low-sodium salt intervention. Different approaches can be complementary and synergistic. In population health, government plays a leading role in making strategic change, including shifting the food industry landscape and taking fiscal incentives in the market. For example, setting sodium reduction targets for food providers and recommending the use of low-sodium salts to providers who have failed to meet the target can be one effective method to involve food industries. Existing studies have shown that using low-sodium salts in bread, pizza, and noodles were widely accepted among consumers, which indicated its potential use in processed food for reducing sodium level without compromising taste.35-37 Low-sodium salts can potentially by incentivised for use in restaurants, schools, hospitals and public institutes canteens. For example, the effectiveness of a low-sodium salt intervention in nursing house has been demonstrated in trials.38 Fiscal incentives for using low-sodium salts, such as subsidies removing price differential to regular salt, can also be considered for low-sodium salt marketing.39

Strengths and limitations of our study

This study strengths include the scope of our sample and the use of implementation science framework. Perspectives of various key informants worldwide who were knowledgeable of low-sodium salts. Key informants covered academic, salt manufacture industry and government representatives, which largely managed to obtain representation from each role. RE-AIM framework was used to facilitate the key informant interviews to examine the feasibility and sustainability of implementing low-sodium salt in a different context. The current study has some limitations. First, the data were collected from key informants from nine countries, which may limit the transferability of the study findings to other countries. However, we have covered participants across the 11 countries in the 5 WHO regions to cover a broad spectrum of perspectives. Second, we acknowledged that while there was a diversity of key informants involved in this study, a picture of all potential barriers and solutions was not captured completely because we did not include representation from the food industry representative. Though we note that food industries’ attitude and action were described by the other participants.

CONCLUSION

This study provided crucial information about the facilitators and barriers of implementing low-sodium salt interventions in the future. Low-sodium salts can potentially be an effective population-level salt reduction strategy, particular for people whose dietary sodium mainly comes from cooking and food preparation. There is controversy for scaling-up low-sodium salts as a broader population strategy due to the uncertainty of its safety among renal patients; which limits policy makers buy in and subsidisation of low-sodium salts as a population health strategy. Health education can also
increase the consumer demands, thereby increasing the market demand, and together with policy incentives, can help to reduce the manufacturing cost. Therefore, long-term efforts addressing community awareness, industry barriers and long-term surveillance of the safety of low-sodium salts are needed to successfully develop and implement low-sodium salt as a meaningful population health strategy more broadly.

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**Conflict interests**

In the past 3 years, MDH received funding from the World Heart Federation to serve as its senior program advisor for the Emerging Leaders program, which is supported by Boehringer Ingelheim and Novartis with previous support from BUPA and AstraZeneca. MDH also receives support from the American Heart Association, Verily, and AstraZeneca and American Medical Association for food system surveillance related research. The George Institute for Global Health’s wholly owned enterprise, George Health Enterprises, has received investment funds to develop fixed-dose combination products containing aspirin, statin and blood pressure lowering drugs. MDH plans to submit patents for heart failure polypills, including for heart failure with reduced ejection fraction.
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