Salt and Sodium

Population-level interventions in government jurisdictions for dietary sodium reduction: a Cochrane Review

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Accepted 7 December 2016

Abstract

Background: Worldwide, excessive salt consumption is common and is a leading cause of high blood pressure. Our objectives were to assess the overall and differential impact (by social and economic indicators) of population-level interventions for dietary sodium reduction in government jurisdictions worldwide.

Methods: This is a Cochrane systematic review. We searched nine peer-reviewed databases, seven grey literature resources and contacted national programme leaders. We appraised studies using an adapted version of the Cochrane risk of bias tool. To assess impact, we computed the mean change in salt intake (g/day) from before to after intervention.

Results: Fifteen initiatives met the inclusion criteria and 10 provided sufficient data for quantitative analysis of impact. Of these, five showed a mean decrease in salt intake from before to after intervention including: China, Finland (Kuopio area), France, Ireland and the UK. When the sample was constrained to the seven initiatives that were multicomponent and incorporated activities of a structural nature (e.g. procurement policy), most (4/7) showed a mean decrease in salt intake. A reduction in salt intake was more apparent among men than women. There was insufficient information to assess differential impact by other social and economic axes. Although many initiatives had methodological strengths, all scored as having a high risk of bias reflecting the observational design. Study heterogeneity was high, reflecting different contexts and initiative characteristics.

Conclusions: Population-level dietary sodium reduction initiatives have the potential to reduce dietary salt intake, especially if they are multicomponent and incorporate intervention activities of a structural nature. It is important to consider data infrastructure to permit monitoring of these initiatives.
Introduction

In almost all countries worldwide, most people consume too much salt.\(^1\) In 2010, estimated global mean salt intake was 10.1 g/day\(^2\) which is twice the World Health Organization (WHO) recommendation of less than 5 g of salt per day.\(^3\) There is strong evidence to suggest a causal relationship between salt intake and high blood pressure, which is a key risk factor for cardiovascular disease.\(^4-6\) Globally, raised blood pressure is estimated to affect 40% of adults and cause 7.5 million deaths, approximately 12.8% of all deaths.\(^7\)

In an attempt to reduce sodium intake, there has been a growing number of national, population-level sodium reduction initiatives.\(^8,9\) Population-level interventions refer to interventions that target whole populations (e.g. jurisdictions) including individuals at high risk as well as individuals with lower risk profiles. This is in contrast to the high-risk strategy where efforts are targeted at individuals with the highest risk. The population-level approach has the potential for significant impact because the societal implications of shifting the entire distribution of risk in a favourable direction is potentially very large.\(^10\) Modelling studies demonstrate that modest reductions in population intake could substantially improve health outcomes and yield substantial health care cost savings.\(^11-14\)

When undertaking population-level sodium reduction interventions, it is important to ensure that they do not worsen socioeconomic inequities in health\(^15-17\) by either exacerbating existing inequities in dietary sodium intake or introducing new ones.\(^18-20\) Knowledge of whether, or the degree to which, population-level interventions are equitable in their impact remains limited. Using dietary sodium reduction as a case example, this review provides insight into the broader question of whether and how population-level interventions can achieve both overall and equitable impact.

Building on the foundational work of Rose, we\(^18,21\) distinguished between population-level interventions that are more agentic (target behaviour change among individuals) and those that are more structural (target settings in which behaviours occur). Structural interventions are hypothesized to be more impactful and equitable.\(^18,21\) Using this continuum as a guide (Figure 1), we identified six types of intervention activities that may be part of a population-level dietary reduction initiative in a government jurisdiction: (i) large-scale food product reformulation; (ii) large-scale pricing interventions (e.g. taxation); (iii) food procurement policy in specific settings (e.g. schools); (iv) restrictions on marketing to children; (v) on-package nutrition labelling; and (vi) public information/education campaigns.

Other Cochrane reviews on dietary sodium reduction have examined the long-term effects of advice to restrict dietary sodium intake on adults participating in randomized controlled trials\(^22,23\) of advice to restrict dietary sodium intake, but none has focused on the impact of sodium reduction initiatives in government jurisdictions nor how equitable they are in their impact. Our objectives were: (i) to assess the impact of population-level interventions for dietary sodium reduction in government jurisdictions worldwide; and (ii) to assess the differential impact of these initiatives by social and economic indicators. This paper is based on a Cochrane review first published in the Cochrane Library.\(^24\)

Methods

Search strategy

We searched the following electronic databases from their start date to 5 January 2015: CENTRAL; Cochrane Public Health Group Specialized Register; MEDLINE; EMBASE; Effective Public Health Practice Project Database; Web of Science; TRoPHI; and LILACS. The detailed search strategy is provided elsewhere.\(^24\) Searches were not restricted by publication date or language. We also searched grey literature websites and resources: OpenGrey, World Health Organization, Public Health Agency of Canada, Centres for Disease Control, Pan American Health Organization,
World Action on Salt and Health and Institute of Medicine. We examined the reference lists of included studies and conducted cited reference searches.

The review was conducted in parallel with a comprehensive review of national sodium reduction efforts underway worldwide, through which we gained additional information from national programme leaders via questionnaires. All 75 countries identified as having a national salt reduction strategy in our companion review were considered for inclusion in the present review. The initiative, or country, was the unit of analysis.

Selection criteria
An initiative was included in the review if: (i) it was population-level in nature (applied to a government jurisdiction); (ii) activities were under way (versus planning stages); (iii) a start date of the initiative could be identified; and (iv) there was at least one pre-intervention data point and at least one post-intervention data point that were comparable in terms of the sample and the method used to determine dietary sodium intake. No study design restrictions were imposed.

The titles and abstracts (when available) of all articles identified through searches were independently screened by two authors. Two authors independently reviewed the full texts of articles that appeared to be suitable for inclusion. Discrepancies were resolved through discussion.

Data extraction and risk of bias assessment
Two review authors collaboratively extracted the following data: study design, participant characteristics, sampling strategy, sample size, response rate, intervention activities, estimates of dietary sodium consumption, axes of inequality, source(s) of funding, conflict of interest and sources of data points. We contacted study authors or country contacts (i.e. national programme leaders of sodium reduction initiatives who coordinated questionnaire completion as noted above) in the case of missing data or uncertainty.

We appraised studies using an adapted version of the Cochrane risk of bias tool that included seven bias domains: sampling, confounding, reliability/validity of outcome measure, blinding of outcome assessment, representativeness of sample, risk of selective outcome reporting, and other sources of bias. Two authors and a research assistant independently assigned a rating of high, low or unclear for each bias domain for each initiative. The rating was based on the worst (highest risk of bias) rating across all available data points. Disagreements between assigned ratings were discussed until a consensus was reached.

The quality of the entire body of evidence was assessed using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) criteria.

Data analysis
We included estimates of daily average sodium intake obtained using any method (e.g. dietary survey, urine sample). Because different studies reported different estimates (e.g. salt versus sodium; intake versus excretion) we converted all estimates to the common and easily interpretable metric of salt intake in grams per day with standard deviation, when possible. First, if the original source presented estimates of sodium intake, we used the conversion 1 g of...
salt = 393.4 mg of sodium, to calculate salt intake in grams per day. Second, if the original source presented estimates of 24-h urinary sodium excretion, we used the conversion 1 g of salt = 17.1 mmol of sodium, to calculate salt intake in grams per day. We analysed overall impact by computing the mean change in salt intake (g/day) from before to after intervention.

We intended to examine differential impact by multiple axes of social inequality based on PROGRESS indicators\(^{27}\) (place of residence, race/ethnicity, occupation, gender, religion, education, social capital and socioeconomic position); however, the data only permitted differential analysis by sex. We intended to examine differences in overall impact by type(s) of intervention activities but were unable to do this, since most of the interventions involved more than one type of intervention activity. Instead, we considered separately the mean difference in salt intake before and after intervention for a subset of initiatives that we identified as multicomponent and including intervention activities of a structural nature.

Heterogeneity (between study variation) was assessed using Cochrane’s I\(^2\) statistic.\(^{25}\) A funnel plot was created to explore potential publication bias. Analyses were performed using RevMan software (version 5.3).

The Conjoint Health Research Ethics Board at the University of Calgary approved this study (ID # E-24264) and the University of Sydney Human Research Ethics Committee approved the questionnaires that were sent to national programme leaders (#14923).

**Results**

**Search results**

The database search yielded 15 706 unique records. Of these, 14 995 records were eliminated after an initial title/abstract screening (711 retained). The grey literature search returned 170 documents. Thus a total of 881 full-text documents were assessed for eligibility, of which 828 were excluded. Main reasons for excluding published or grey literature documents were: not empirical research; the study population was not a jurisdiction; they assessed the salt content of foods rather than individuals’ intake; or they were simulation/modelling studies. Of the 75 countries identified in our companion review,\(^9\) 45 had estimates of salt intake at two or more time points and were considered for inclusion.

Ultimately, 15 countries (15 national initiatives) met inclusion criteria (Table 1): Austria,\(^{28}\) Canada,\(^{20,29,30}\) Denmark,\(^{3,34}\) Finland,\(^{3,32–35}\) France,\(^{3,36,37}\) Ireland,\(^{3,38–42}\) Japan,\(^{3,45}\) The Netherlands,\(^{3,46}\) New Zealand,\(^{3,47,49}\) Switzerland,\(^{28,49,50}\) Thailand,\(^{3,51,52}\) Turkey,\(^{3,53}\) the UK,\(^{3,54–62}\) and the USA.\(^{3,63–66}\) The UK initiative has been evaluated through data collected separately for England only, Scotland only and the UK as a whole; therefore, there may be overlap among the data sets. However, because we considered the UK as only one initiative, and because we did not pool results (see below), this concern about overlap is moot. Key documentation for these countries included: 25 published articles, 15 grey literature documents, 13 country questionnaires and associated correspondence (Figure 2). Of the 45 potentially eligible countries from our companion review,\(^9\) 18 were excluded and an additional 12 countries were classified as ‘ongoing’ (Table 2).

**Initiative characteristics**

The 15 included countries are diverse in terms of their setting and initiatives. Most countries (\(n = 12\)) are ‘high income’ and three are ‘upper-middle income’.\(^{67}\) Four of the six WHO regions were represented: Europe (\(n = 9\)); Western Pacific (\(n = 3\)); the Americas (\(n = 2\)); and South-East Asia (\(n = 1\)).

Most initiatives (\(n = 12\)) had more than one intervention activity under way during the time frame (data points) considered in this review, and most of these (\(n = 11\)) incorporated intervention activities of a structural nature (e.g. large-scale food product reformulation). The remaining four initiatives (Canada, China, Japan and the USA) involved fewer (1–2) intervention activities of a less structural nature (e.g. public information campaigns).

The start year of the intervention ranged from 1979 (Finland) to 2011 (Austria and Turkey) with only three initiatives beginning before 2000. In some cases, discretion was involved in determining a start date since most initiatives are complex and evolve over time.

Fourteen initiatives were evaluated using an uncontrolled pre-post design and one initiative (China) was evaluated using an open cohort design. The most common measures used to assess dietary salt intake were: various forms of dietary surveys; spot urine samples; and 24-h urine samples. Details on initiative characteristics are presented in Table 1.

**Methodological quality and publication bias**

We assessed seven bias domains (see Figure 3 for a summary). Although uncontrolled study designs are understandable in this context, such designs make it difficult to rule out alternative explanations for effects observed. Accordingly, all initiatives received a high risk of bias rating on the confounding domain, which resulted in a summary risk of bias rating of ‘high’ in all cases. In an effort to capture differences in the methodological quality across our included initiatives, we computed the proportion of
bias domains scored as ‘high’ or ‘unclear’ for each intervention (out of 7). Based on that metric, the initiatives in our sample from highest to lowest methodological quality are: France, Finland, UK-England, UK-Scotland (1/7); Canada, China, Ireland, and UK-whole, USA (2/7); Denmark (3/7); Austria, The Netherlands, Switzerland (4/7); and Japan, New Zealand, Thailand and Turkey (5/7).

Based on the GRADE criteria, our overall quality of evidence rating for the one outcome measure in this review (salt intake in g/day) is ‘very low’. There was substantial between-study variation based on the I² measures (> 90% in all cases), reflecting different contexts and initiative characteristics, and therefore we do not present any pooled results. A funnel plot (not shown) did not show evidence of a publication bias, which is consistent with our comprehensive search and inclusion of grey literature.

Effects of initiatives

Ten of the 15 included initiatives provided sufficient data for quantitative analysis of overall impact (Table 3). Please note that for the UK, our assessment of overall impact was based on the predominant effect across the three sources of data (UK-England, UK-whole and UK-Scotland). The total sample size for the 15 initiatives exceeds 260 000 participants. Of those 10 initiatives (64,798 participants), five showed a mean decrease in salt intake from before to after intervention, including, China, Finland (Kuopio area), France, Ireland and the UK (UK-England and UK-whole). These decreases ranged from −1.15 g/day [95% confidence interval (CI): −1.69, −0.61] in Finland to −0.35 g/day (95% CI: −0.52, −0.18) in Ireland. A mean increase in salt intake from before to after intervention was observed for two initiatives [Canada: 1.66 g/day (95% CI: 1.56, 1.76); and Switzerland: 0.80 g/day (95% CI: 0.19, 1.41)]. Five initiatives (Denmark, Japan, New Zealand, Thailand and Turkey) were omitted because they lacked variance estimates to accompany means, which could not be resolved using other reported data or contacting authors.

When we constrained our sample to the seven initiatives (34,227 participants) that were multicomponent and incorporated intervention activities of a structural nature...
<table>
<thead>
<tr>
<th>Country</th>
<th>World Bank country classification</th>
<th>World Health Organization region</th>
<th>Start date of initiative</th>
<th>Intervention activities</th>
<th>Study design</th>
<th>Main method used to determine dietary salt intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>High-income</td>
<td>Europe</td>
<td>2011</td>
<td>1. Food product reformulation 2. Food procurement policy in specific settings 3. Public information/education campaign</td>
<td>Uncontrolled pre-post</td>
<td>24-h dietary recall</td>
</tr>
<tr>
<td>Canada</td>
<td>High-income</td>
<td>The Americas</td>
<td>1982</td>
<td>1. Public information/education campaign</td>
<td>Uncontrolled pre-post</td>
<td>24-h dietary recall</td>
</tr>
<tr>
<td>China</td>
<td>Upper-middle-income</td>
<td>Western Pacific</td>
<td>2006</td>
<td>1. Public information/education campaign</td>
<td>Open cohort</td>
<td>24-h dietary recall</td>
</tr>
<tr>
<td>Finland (Kuopio area)</td>
<td>High-income</td>
<td>Europe</td>
<td>1979</td>
<td>1. Food product reformulation 2. Food procurement policy in specific settings 3. On-package nutrition information 4. Public information/education campaign</td>
<td>Uncontrolled pre-post</td>
<td>24-h urine</td>
</tr>
<tr>
<td>France</td>
<td>High-income</td>
<td>Europe</td>
<td>2001</td>
<td>1. Food product reformulation 2. Food procurement policy in specific settings 3. Public information/education campaign</td>
<td>Uncontrolled pre-post</td>
<td>7-day food record</td>
</tr>
<tr>
<td>Ireland</td>
<td>High-income</td>
<td>Europe</td>
<td>2003</td>
<td>1. Food product reformulation 2. On-package nutrition information 3. Public information/education campaign</td>
<td>Uncontrolled pre-post</td>
<td>Food frequency questionnaire</td>
</tr>
<tr>
<td>Japan</td>
<td>High-income</td>
<td>Western Pacific</td>
<td>2001</td>
<td>1. Public information/education campaign</td>
<td>Uncontrolled pre-post</td>
<td>Nutritional intake survey</td>
</tr>
<tr>
<td>New Zealand</td>
<td>High-income</td>
<td>Western Pacific</td>
<td>2005</td>
<td>1. Food product reformulation</td>
<td>Uncontrolled pre-post</td>
<td>Total diet study</td>
</tr>
</tbody>
</table>
Table 3), four showed a mean decrease in salt intake from before to after intervention, ranging from Finland to Ireland (see above). One initiative (Switzerland) showed a mean increase in intake from before to after intervention (see above). The other two initiatives (Austria and The Netherlands) did not show a change in salt intake.

Nine initiatives provided data that permitted quantitative analysis of impact by sex. For women, three initiatives showed a mean decrease in salt intake [China: −0.76 g/day (95% CI: −1.07, −0.45), Finland: −0.90 g/day (95% CI: −1.57, −0.23), France: −0.28 g/day (95% CI: −0.47, −0.09)], and two initiatives showed a mean increase in salt intake [Canada: 2.41 g/day (95% CI: 2.30, 2.52), the USA 0.76 g/day (95% CI: 0.09, 1.43)]. The remaining four countries (Austria, The Netherlands, Switzerland, and the UK (UK-whole and UK-Scotland)) did not show a mean change.
in salt intake from before cessation to after cessation of the intervention (Table 4). For men, five initiatives showed a mean decrease in salt intake, ranging from the UK-whole [-1.32 g/day (95% CI: -1.90, -0.74)] to France [-0.57 g/day (95% CI: -0.88, -0.26)]. One initiative showed a mean increase in salt intake [Canada 0.87 g/day (95% CI: 0.70, 1.04)] and the remaining three countries (the Netherlands, Switzerland and the USA) did not show a mean change in salt intake from before cessation to after cessation of the intervention (Table 5).

There was insufficient information to assess differential impact by other social and economic axes. Some studies reported estimates by social and economic indicators at one or more time points (see summary in the full review24). However, the different methods and meanings of these indicators across studies precluded a quantitative assessment of differential impact.

### Discussion

The findings of this review provide some evidence that population-level sodium reduction initiatives have the potential to reduce salt intake, particularly if those initiatives are multicomponent and incorporate intervention activities of a structural nature (e.g. food product reformulation and food procurement policy). This finding is consistent with Rose’s population strategy of prevention10 and highlights the importance of distinguishing between population-level interventions of a more structural nature (target settings in which behaviours occur) versus those of a more agentic nature (target behaviour change among individuals).18 Additionally, our results suggest that the impact of national sodium reduction initiatives in terms of salt intake may be stronger among men than women. This finding could reflect in part the observation that globally, men consume more salt than women.2

There was insufficient information to determine differential impacts of these initiatives by other axes of...
Table 3. Mean change in salt intake (g/day) from before to after intervention overall, and by the subset of multicomponent initiatives that incorporate structural activities

<table>
<thead>
<tr>
<th>Country</th>
<th>Year of post-intervention data point</th>
<th>Post-intervention salt intake: mean, SD, n</th>
<th>Year of pre-intervention data point</th>
<th>Pre-intervention salt intake: mean, SD, n</th>
<th>Effect estimate: salt intake: mean (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria*</td>
<td>2012</td>
<td>8.15 g/day, SD = 2.99, 380</td>
<td>2008</td>
<td>8.3 g/day, SD = 3.53, 2123</td>
<td>-0.15 g/day, (-0.49, 0.19)</td>
</tr>
<tr>
<td>Canada</td>
<td>2004</td>
<td>7.77 g/day, SD = 1.54, 10499</td>
<td>1970–72</td>
<td>6.11 g/day, SD = 3.46, 4340</td>
<td>1.66 g/day, (1.56, 1.76)</td>
</tr>
<tr>
<td>China</td>
<td>2009</td>
<td>11.49 g/day, SD = 6.6, 6932</td>
<td>2006</td>
<td>12.7 g/day, SD = 7.11, 6826</td>
<td>-0.76 g/day, (-0.99, -0.53)</td>
</tr>
<tr>
<td>Finland (Kuopio area)*</td>
<td>1987</td>
<td>10.63 g/day, SD = 4.1, 400</td>
<td>1979</td>
<td>11.78 g/day, SD = 4.72, 670</td>
<td>-1.15 g/day, (-1.69, -0.61)</td>
</tr>
<tr>
<td>France*</td>
<td>2006–07</td>
<td>7.54 g/day, SD = 2.34, 1922</td>
<td>1998–99</td>
<td>8.0 g/day, SD = 2.58, 1345</td>
<td>-0.46 g/day, (-0.63, -0.29)</td>
</tr>
<tr>
<td>Ireland*</td>
<td>2007</td>
<td>7.85 g/day, SD = 3.7, 9172</td>
<td>2002</td>
<td>8.2 g/day, SD = 5.9, 5992</td>
<td>-0.35 g/day, (-0.52, -0.18)</td>
</tr>
<tr>
<td>The Netherlands*</td>
<td>2010</td>
<td>8.58 g/day, SD = 3.36, 342</td>
<td>2006</td>
<td>8.58 g/day, SD = 3.19, 317</td>
<td>0 g/day, (-0.50, 0.50)</td>
</tr>
<tr>
<td>Switzerland*</td>
<td>2011</td>
<td>9.2 g/day, SD = 3.8, 1448</td>
<td>1984</td>
<td>8.4 g/day, SD = 3.6, 147</td>
<td>0.80 g/day, (0.19, 1.41)</td>
</tr>
<tr>
<td>UK-England*</td>
<td>2007</td>
<td>5.46 g/day, SD = 1.12, 4269</td>
<td>2003</td>
<td>6.32 g/day, SD = 1.18, 1668</td>
<td>-0.86 g/day, (-0.93, -0.79)</td>
</tr>
<tr>
<td>UK-whole*</td>
<td>2008</td>
<td>8.64 g/day, SD = 4.39, 692</td>
<td>2000–1</td>
<td>9.53 g/day, SD = 4.48, 1147</td>
<td>-0.89 g/day, (-1.31, -0.47)</td>
</tr>
<tr>
<td>UK-Scotland*</td>
<td>2009</td>
<td>6.8 g/day, SD = 4.95, 1045</td>
<td>2003</td>
<td>6.8 g/day, SD = 5.19, 1148</td>
<td>0 g/day, (-0.42, 0.42)</td>
</tr>
<tr>
<td>USA</td>
<td>2010</td>
<td>8.64 g/day, SD = 5.08, 525</td>
<td>1988–94</td>
<td>8.34 g/day, SD = 4.83, 1249</td>
<td>0.30 g/day, (-0.21, 0.81)</td>
</tr>
</tbody>
</table>

*Initiatives that are multicomponent and incorporate intervention activities of a structural nature.

bDecrease in mean salt intake (g/day) from before to after intervention.

Increase in mean salt intake (g/day) from before to after intervention.

Whereas our companion review identified 75 countries worldwide that had national sodium reduction initiatives,9 the present review only included 15 of these countries, 10 of which provided sufficient data for quantitative analysis. In many cases, these exclusions reflected limited data infrastructure. For example, seven countries lacked a pre-intervention (baseline) data point and were excluded due to the impossibility of going backwards and generating pre-intervention data (Table 2). Going forward, it is important that countries develop a plan to monitor the impact of sodium reduction initiatives, including equity of impact, which employs high-quality methods.

Our review has limitations. First, despite our best efforts to accurately characterize the intervention activities for each initiative, some uncertainty remains. For instance, a country contact speaking to national efforts may have been unaware of activities that were occurring in smaller jurisdictions (e.g. provinces, states, cities). Second, since dietary salt intake was the only outcome considered in this review, it is unknown whether, or the extent to which, national sodium reduction initiatives impact on other...
outcomes such as blood pressure; this is important for future reviews to consider. Third, though our companion review identified national sodium reduction initiatives in countries at all levels of economic development and in all WHO regions, this review did not include any initiatives in lower-middle or low-income countries, nor in the African or Eastern Mediterranean regions. Thus, the generalizability of our findings to those countries and regions remains unknown. Fourth, it is possible that for some initiatives, not enough time has yet passed for a reduction in dietary sodium intake to be detected. In future reviews, it will be important to examine the impact of differential initiative duration, as data permit. Finally, a pooled analysis was not appropriate due to the high level of heterogeneity across the studies. Although less heterogeneity is desirable from a research point of view, it is not necessarily a reasonable or desirable goal for population-level initiatives. These initiatives are embedded within their unique social, cultural, economic and political contexts, and the initiative and its impact are inextricably related to those dimensions of context. We recommend that, in circumstances where it is not possible or appropriate to employ traditional methods of quantitative synthesis for these reasons, researchers and the systematic review community focus on developing alternative thoughtful and rigorous ways to synthesize and interpret these initiatives and their findings.

An important strength of this review is the comprehensive systematic search of the peer-reviewed and grey literature as well as the additional information gained directly from country contacts that would otherwise have been missed, since much of it is not available in published form. Many of the initiatives, especially those included in the quantitative synthesis, had methodological strengths including large, nationally representative samples and rigorous measurement of dietary sodium intake.

**Conclusion**

In summary, across the 10 studies included in the quantitative synthesis, five showed a reduction in dietary salt intake from pre-intervention to post-intervention levels. However, when we focused on the seven multicomponent initiatives, a reduction in salt intake was more apparent, with four of seven countries showing a decrease. A pooled analysis was not appropriate because of high levels of heterogeneity across studies. These findings suggest that while national population-level dietary sodium reduction initiatives in general have the potential to achieve population-wide reductions

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**Table 4. Mean change in salt intake (g/day) from before to after intervention for women only**

<table>
<thead>
<tr>
<th>Country</th>
<th>Year of post-intervention data point</th>
<th>Pre-intervention salt intake: mean, SD, n</th>
<th>Post-intervention salt intake: mean, SD, n</th>
<th>Year of pre-intervention data point</th>
<th>Pre-intervention salt intake: mean, SD, n</th>
<th>Effect estimate: salt intake: mean (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>2012</td>
<td>7.6 g/day, SD = 3.11, 232</td>
<td>7.6 g/day, SD = 3.1, 1345</td>
<td>2008</td>
<td>7.6 g/day, SD = 3.2, 143</td>
<td>0 g/day, (−0.43, 0.43)</td>
</tr>
<tr>
<td>Canada</td>
<td>2004</td>
<td>7.41 g/day, SD = 1.44, 5612</td>
<td>5.0 g/day, SD = 2.7, 2566</td>
<td>1970–72</td>
<td>5.0 g/day, SD = 2.7, 2566</td>
<td>2.41 g/day, (2.30, 2.52)</td>
</tr>
<tr>
<td>China</td>
<td>2009</td>
<td>11.43 g/day, SD = 6.35, 3695</td>
<td>12.19 g/day, SD = 6.86, 3584</td>
<td>2006</td>
<td>12.19 g/day, SD = 6.86, 3584</td>
<td>−0.76 g/day, (−1.07, −0.45)</td>
</tr>
<tr>
<td>Finland (North Karelia and Kuopio area)</td>
<td>1987</td>
<td>9.5 g/day, SD = 3.78, 220</td>
<td>10.4 g/day, SD = 4.15, 327</td>
<td>1979</td>
<td>10.4 g/day, SD = 4.15, 327</td>
<td>−0.90 g/day, (−1.57, −0.23)</td>
</tr>
<tr>
<td>France</td>
<td>2006–07</td>
<td>6.65 g/day, SD = 1.88, 1082</td>
<td>6.93 g/day, SD = 2.16, 732</td>
<td>1998–99</td>
<td>6.93 g/day, SD = 2.16, 732</td>
<td>−0.28 g/day, (−0.47, −0.09)</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>2010</td>
<td>7.42 g/day, SD = 2.49, 188</td>
<td>7.89 g/day, SD = 2.96, 180</td>
<td>2006</td>
<td>7.89 g/day, SD = 2.96, 180</td>
<td>−0.47 g/day, (−1.03, 0.09)</td>
</tr>
<tr>
<td>Switzerland</td>
<td>2011</td>
<td>7.8 g/day, SD = 3.3, 742</td>
<td>7.3 g/day, SD = 2.9, 95</td>
<td>1984</td>
<td>7.3 g/day, SD = 2.9, 95</td>
<td>0.5 g/day, (−0.13, 1.13)</td>
</tr>
<tr>
<td>UK-England</td>
<td>2007</td>
<td>4.12 g/day, SD = 2.47, 2343</td>
<td>4.73 g/day, SD = 3.12, 333</td>
<td>2003</td>
<td>4.73 g/day, SD = 3.12, 333</td>
<td>−0.61 g/day, (−0.83, −0.39)</td>
</tr>
<tr>
<td>UK-whole</td>
<td>2008</td>
<td>7.66 g/day, SD = 4.77, 398</td>
<td>8.1 g/day, SD = 3.88, 891</td>
<td>2000–01</td>
<td>8.1 g/day, SD = 3.88, 891</td>
<td>−0.44 g/day, (−0.97, 0.09)</td>
</tr>
<tr>
<td>UK-Scotland</td>
<td>2009</td>
<td>5.7 g/day, SD = 4.37, 598</td>
<td>6.1 g/day, SD = 3.87, 640</td>
<td>2003</td>
<td>6.1 g/day, SD = 3.87, 640</td>
<td>−0.4 g/day, (−0.86, 0.06)</td>
</tr>
<tr>
<td>USA</td>
<td>2010</td>
<td>7.55 g/day, SD = 3.84, 267</td>
<td>6.79 g/day, SD = 6.18, 604</td>
<td>1988–94</td>
<td>6.79 g/day, SD = 6.18, 604</td>
<td>0.76 g/day, (0.09, 1.43)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Note</th>
<th>Decrease in mean salt intake (g/day) from before to after post intervention.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Note</td>
<td>Increase in mean salt intake (g/day) from before to after intervention.</td>
</tr>
</tbody>
</table>

Table 5. Mean change in salt intake (g/day) from before to after intervention for men only

<table>
<thead>
<tr>
<th>Country</th>
<th>Year of post-intervention data point</th>
<th>Post-intervention salt intake: mean, SD, n</th>
<th>Year of pre-intervention data point</th>
<th>Pre-intervention salt intake: mean, SD, n</th>
<th>Effect estimate: salt intake: mean (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>2012</td>
<td>8.7 g/day, SD = 2.79, 148</td>
<td>2008</td>
<td>9.4 g/day, SD = 3.56, 778</td>
<td>−0.7 g/day (−1.21, −0.19)</td>
</tr>
<tr>
<td>Canada</td>
<td>2004</td>
<td>8.19 g/day, SD = 1.65, 4837</td>
<td>1970–72</td>
<td>7.32 g/day, SD = 3.8, 1924</td>
<td>0.87 g/day (0.70, 1.04)</td>
</tr>
<tr>
<td>China</td>
<td>2009</td>
<td>12.45 g/day, SD = 6.86, 3327</td>
<td>2006</td>
<td>13.21 g/day, SD = 7.37, 3242</td>
<td>−0.76 g/day (−1.10, −0.42)</td>
</tr>
<tr>
<td>Finland (North Karelia and Kuopio area)</td>
<td>1987</td>
<td>12 g/day, SD = 4.45, 180</td>
<td>1979</td>
<td>13.1 g/day, SD = 5.2, 343</td>
<td>−1.1 g/day (−1.95, −0.25)</td>
</tr>
<tr>
<td>France</td>
<td>2006–07</td>
<td>8.69 g/day, SD = 2.83, 840</td>
<td>1998–99</td>
<td>9.26 g/day, SD = 3.01, 613</td>
<td>−0.57 g/day (−0.88, −0.26)</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2010</td>
<td>10.09 g/day, SD = 3.65, 154</td>
<td>2006</td>
<td>9.51 g/day, SD = 3.19, 137</td>
<td>0.58 g/day (−0.21, 1.37)</td>
</tr>
<tr>
<td>Switzerland</td>
<td>2011</td>
<td>10.6 g/day, SD = 4.2, 706</td>
<td>1984</td>
<td>10.4 g/day, SD = 3.9, 52</td>
<td>0.20 g/day (−0.90, 1.30)</td>
</tr>
<tr>
<td>UK – England</td>
<td>2007</td>
<td>5.16 g/day, SD = 3.36, 1926</td>
<td>2003</td>
<td>g/day, SD = 3.46, 735</td>
<td>−0.94 g/day (−1.23, −0.65)</td>
</tr>
<tr>
<td>UK – whole</td>
<td>2008</td>
<td>9.68 g/day, SD = 4.1, 294</td>
<td>2000–01</td>
<td>6.1 g/day, SD = 5.02, 833</td>
<td>−1.32 g/day (−1.90, −0.74)</td>
</tr>
<tr>
<td>UK – Scotland</td>
<td>2009</td>
<td>7.3 g/day, SD = 3.78, 447</td>
<td>2003</td>
<td>11 g/day, SD = 5.17, 508</td>
<td>−0.30 g/day (−0.87, 0.27)</td>
</tr>
<tr>
<td>United States</td>
<td>2010</td>
<td>10.02 g/day, SD = 6.25, 258</td>
<td>1988–94</td>
<td>7.6 g/day, SD = 7.81, 645</td>
<td>−0.02 g/day (−0.99, 0.95)</td>
</tr>
</tbody>
</table>

*aDecrease in mean salt intake (g/day) from before to after intervention.

*bIncrease in mean salt intake (g/day) from before to after intervention.

In salt intake, those that are multicomponent and incorporate intervention activities of a structural nature are likely to be the most impactful. Unfortunately, a substantial proportion of existing national sodium reduction initiatives had to be excluded because they lacked comparable pre-intervention and/or post-intervention data. Furthermore, information was insufficient to indicate whether a change in mean salt intake occurred from before intervention to after intervention by social and economic indicators (though we were able to consider differential impact by sex). Thus, the differential impact of these initiatives remains largely unknown. It essential that countries developing a sodium reduction initiative incorporate data monitoring infrastructure in their plans, to permit evaluation of both overall impact and differential impact across social groups. Future reviews should consider health outcomes related to sodium consumption.

Funding

This work was supported by an Operating Grant from the Canadian Institutes of Health Research (CIHR) (Priority Announcement – Sodium and Health – Knowledge-to-action) in partnership with the CIHR Institute of Nutrition, Metabolism, and Diabetes and the CIHR Institute of Population and Public Health (# SOK 116970). L.M. holds an award funded by the CIHR (Institute of Population and Public Health, Institute of Musculoskeletal Health and Arthritis), the Public Health Agency of Canada and Alberta Innovates – Health Solutions. N.R.C.C. holds an award from the Heart and Stroke Foundation of Canada (HSF) Canadian Institutes for Health. J.W. is supported by a National Health and Medical Research Council and National Heart Foundation Career Development Fellowship and grants from the NHMRC, the Victorian Health Promotion Foundation and the WHO.

Conflict of interest: N.C. received consulting fees and travel support from Novartis Foundation in 2016, travel funds from Dieticians of Canada and Boehringer Ingelheim and salary from the HSF and the CIHR.

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