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Estimating the Cost-Effectiveness of the Sodium Reduction in Communities Program

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Abstract

Objective: This study assessed the cost-effectiveness of the Centers for Disease Control and Prevention's (CDC's) Sodium Reduction in Communities Program (SRCP).

Design: We collected implementation costs and performance measure indicators from SRCP recipients and their partner food service organizations. We estimated the cost per person and per food service organization reached and the cost per menu item impacted. We estimated the short-term effectiveness of SRCP in reducing sodium consumption and used it as an input in the Prevention Impact Simulation Model to project the long-term impact on medical cost savings and quality adjusted life years gained due to a reduction in cardiovascular disease and estimate the cost-effectiveness of SRCP if sustained through 2025 and 2040.

Setting: CDC funded eight recipients as part of the 2016–2021 round of the Sodium Reduction in Communities Program (SRCP) to work with food service organizations in eight settings to increase the availability and purchase of lower-sodium food options.

Participants: Eight SRCP recipients and 20 of their partners.

Results: At the recipient level, average cost per person reached was $10, and average cost per food service organization reached was $42,917. At the food service organization level, median monthly cost per food item impacted by recipe modification or product substitution was $684. Cost-effectiveness analyses showed that, if sustained, the program is cost saving (i.e. the reduction in medical costs is greater than the implementation costs) in the target population by $1.82 through 2025 and $2.09 through 2040.

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Authorship: Benjamin Yarnoff led the study and led manuscript development. Emily Teachout provided study oversight and contributed to reviewing and revising the manuscript. Kara E. MacLeod provided study oversight and contributed to reviewing and revising the manuscript. John Whitehill provided study oversight and contributed to reviewing and revising the manuscript. Julia Jordan provided study oversight and contributed to reviewing and revising the manuscript. Christina Bradley conducted analysis. Zohra Tayebali conducted analysis.

Conflict of Interest: None

Ethical Standards Disclosure: The RTI IRB reviewed this study and determined it not to be human subjects research.

Conclusions: By providing evidence of the cost-effectiveness of a real-world sodium reduction initiative, this study can help inform decisions by public health organizations about related cardiovascular disease prevention interventions.

Keywords

Sodium; Cost-Effectiveness; Community Health Interventions

INTRODUCTION

High sodium intake can lead to hypertension and increase the risk for heart disease and stroke. [1, 2]. In 2014, U.S. adults between the ages of 20 and 69 consumed sodium at an average of 3,608 mg/day[3]. The *2020–2025 Dietary Guidelines for Americans*[4] and the Dietary Reference Intakes for Sodium and Potassium[5] recommend adults consume no more than 2,300 mg/day of sodium for adults each day. It has been estimated that every 1000 mg/day increase from this recommendation increases the risk of cardiovascular disease events by 17%.[2] A large proportion of the sodium consumed in the United States comes from processed foods and foods prepared in restaurants and cafeteria settings—sources over which consumers have little control[6]. Accordingly, this gap between recommended intake and actual intake among U.S. adults requires a public health approach that expands beyond a focus on individual behavior change. Public health approaches to sodium reduction should include strategies that focus on reducing the sodium content in prepackaged and pre-prepared foods[7, 8].

The Sodium Reduction in Communities Program (SRCP) began as a demonstration project in the U.S. in 2010 to address this growing public health concern. As part of the 2016–2021 round of SRCP, the Centers for Disease Control and Prevention (CDC) funded eight recipients, including local and state health departments and a research university, to work with food service organizations in eight settings to increase the availability and purchase of lower-sodium food options, with the goal of reducing sodium intake to within the recommendation of the *2015–2020 Dietary Guidelines for Americans*. The program focuses on four distinct sodium strategies: (1) implementation of food service guidelines and nutritional standards that include sodium; (2) introduction of meal and menu item modifications; (3) integration of lower-sodium food procurement practices; and (4) implementation of behavioral economic strategies to promote lower-sodium items (e.g., placement interventions).

Early outcome data suggest that partnering with local food service organizations to provide consumers with lower-sodium options is an effective strategy to lower population-level sodium consumption.[9] However, little is known about the cost-effectiveness of strategies implemented in SRCP, which is important for public health policy and planning decisions. In this study, we aimed to provide this information by estimating the cost of achieving implementation outcomes and the cost-effectiveness of strategies implemented in SRCP. First, we estimated the cost per unit of improvement in implementation outcomes, such as persons reached, and food items affected by sodium reduction efforts. This approach provides evidence of the cost of achieving implementation objectives. Second, we estimated the long-term cost-effectiveness of SRCP by integrating the estimates of short-term implementation outcomes and costs with a simulation model, the Prevention Intervention Simulation Model (PRISM)[10–12]. These estimates of cost-effectiveness can be used to support decision making about future sodium reduction efforts.

METHODS

Program Description

Eight recipients were funded as part of the 2016–2021 round of SRCP. Funded recipients include state (New York and Oregon) and local (Los Angeles County, Marion County-Indiana, New York City, Seattle and King County, and Philadelphia) public health departments and a research university (University of Arkansas for Medical Sciences). The recipients partnered with food service organizations to implement sodium reduction strategies in ≥1 of eight settings: worksites, hospitals, schools, early childhood education centers, higher-learning institutions, restaurants, emergency food services, and distributive or congregate meal sites. Recipients identified and recruited food service organization partners based on their target populations and partner openness to implementing sodium reduction strategies.

Recipients and their partner food service organizations worked to implement the four strategies of SRCP. Table 1 shows examples of implementation activities for each sodium reduction strategy. Table 2 summarizes implementation in each of the eight settings including the number of recipients working in each setting, the number of food service organizations reached in each setting, and the number of people reached in each setting. The populations reached in each setting differ most notably in the frequency with which they are reached. For example, schools, early childhood education centers, and distributive/ congregate meal programs reach their populations regularly (e.g., schools provide lunch to students every day). Conversely, restaurants may reach different people each day.

Data Collection

Cost Data—We used two different data collection tools to collect data on SRCP implementation costs. The first collected implementation costs from recipients and the second from partner food service organizations. We collected data on implementation costs from recipients using an Excel-based cost-collection instrument. The instrument used an activity-based costing approach.[13] Respondents were asked to report all resources (labor and nonlabor) used to implement SRCP for six categories: (1) labor; (2) materials, travel, and equipment; (3) contracted services; (4) indirect and overhead costs; (5) in-kind labor; and (6) in-kind nonlabor. In-kind costs included costs incurred to support program implementation but not paid for using funds from the cooperative agreement such as staff time paid for by the health department and resources donated by the health department. Within each resource category, respondents were asked to allocate each line item across five main program activities: (1) building and maintaining partnerships, (2) designing sodium reduction interventions, (3) implementing sodium reduction interventions, (4) performing administrative activities, and (5) conducting evaluations. We collected data from the recipients in February 2018 to report all costs incurred to implement the program from

September 30, 2016 through December 31, 2017 (15 months); in February 2019 to report all costs incurred from January 1, 2018, through December 31, 2018 (12 months); and December 2019 to report all costs incurred from January 1, 2019 through September 29, 2019 (9 months). The funded costs and in-kind costs were similar for the first two reporting periods and lower for the third. Combined, these costs represent implementation costs for the first 36 months of the program. Data were reported by SRCP program managers with input from other program staff for all eight recipients. We provided technical assistance for data collection by answering respondents' questions via email and phone over the data collection period and conducted a data quality review upon submission.

During May-June 2019, we collected data on the in-kind contributions of partner food service organizations to SRCP implementation over the period September 30, 2016, through April 30, 2019, using a cost survey. All partner costs were considered in-kind because they were paid for by the partner organizations themselves. In the partner food service organization cost survey, respondents were asked about a set of key sodium reduction activities including implementation of nutrition guidelines, recipe development and modification, changing food procurement practices, modification to food preparation practices, healthy food promotion, meetings, and other activities. For each activity, respondents were asked the number and types of staff who worked on the activity, the average monthly number of hours each staff member worked on that activity, and the number of months worked by each staff member. Respondents reported the monthly average across the reporting period. Additionally, for each activity, respondents were asked to report any nonlabor expenditures like materials and supplies. Participation was voluntary. Recipients provided contact information for 45 of 88 key partner food service organizations. We sent invitations to those 45 food service organizations and received completed surveys from 20 (44%). The only information we had about partner characteristics was the venue in which they worked. We examined the completion rate for each venue to assess potential response bias: 6 out of 8 congregate meal partners, 1 out of 1 early childhood education centers, 0 out of 3 emergency food services, 3 out of 10 higher learning institutions, 2 out of 8 hospitals, 2 out of 2 restaurants, 4 out of 10 schools, and 1 out of 3 worksites.

Program Implementation and Effectiveness Data—As part of SRCP, recipients conduct program evaluations including the collection and reporting implementation and short-term effectiveness performance measures at baseline (2015–2016) and each program year thereafter (2016–2017, 2017–2018, and 2018–2019). CDC offered a list of implementation and effectiveness outcomes that the program, as a whole, aims to achieve and ways to measure the performance toward those outcomes. CDC provided guidance on data sources and method for computing each performance measure and recipients followed these approaches. Recipients selected target performance measures that fit their needs and capacity levels. Because all recipients did not select the same performance measures to report, data are not available on all measures for all venues. Recipients were encouraged to collect and report performance measure data for all venues in which they worked but some did not collect all measures in all venues. Therefore, performance measures are not representative of all recipient activities. Some recipients reported performance measures even more finely, down to the specific partner food service organization. For recipient-level analysis we aggregated partner-level data for each recipient to create a recipient average. For partner-level analysis we utilized this finer data to link partner performance measure data with partner cost data (N = 13).

We used four measures of program implementation for the analysis of the cost of achieving implementation outcomes in the present study: (1) number of food service organizations reached, defined as the number of food service organizations that partnered with the recipient to implement sodium reduction strategies (reported by recipients for 17 out of the 17 venues); (2) number of people reached per day, defined as the average number of people served by partner food service organizations each day computed from sales data provided by food service organizations (reported by recipients for 17 out of the 17 venues); (3) number of menu items affected by recipe modification, defined as the number of menu items served by partner food service organizations for which the recipe was modified to reduce sodium computed from recipe data provided by food service organizations (reported by recipients for 12 out of the 17 venues); and (4) number of menu items affected by procurement changes to substitute ingredients or entire items, defined as the number of menu items served by partner food service organizations that were replaced with a lower-sodium alternative entirely or in part (i.e., one ingredient) through changes in procurement computed from procurement records and menus provided by food service organizations (reported by recipients for 14 out of the 17 venues). We also used two short-term program effectiveness measures as inputs in the analysis of long-term cost-effectiveness in the present study: (1) change in average daily sodium intake as measured by the average sodium content of purchased food, computed from a combination of sales data and menu nutrition data provided by food service organizations (reported by recipients for 6 out of the 17 venues); and (2) percentage of people in the targeted food service organization who purchased lower-sodium items computed from sales data provided by food service organizations (assumed to be the percentage of people reducing sodium consumption) (reported by recipients for 14 out of the 17 venues).

Data Analysis

We assessed (1) the cost of achieving implementation outcomes and (2) the potential long-term cost-effectiveness of sodium reduction strategies.

Analysis of the Cost of Achieving Implementation Outcomes—We assessed the costs of a one-unit increase in implementation outcome measures (e.g., person reached) by mapping expenditures reported in the cost study with implementation outcome measures reported by recipients in their performance reporting. We conducted implementation outcome analyses separately for recipients and partner food service organizations that participated in the cost study.

We computed the total cost of all activities and average cost of each activity across recipients. We aggregated total costs across recipients to compute total program costs. We subtracted the total evaluation costs, as they were not intended to contribute to implementation. We aggregated the number of food service organizations reached and the number of people reached annually in implementation. We then combined cost and reach to estimate the recipient cost per food service organization reached and per person reached as

$$\begin{aligned}&Cost\ per\ Food\ Service\ Organization\ Reached\\&=\frac{Total\ Cost-Evaluation\ Cost}{Number\ of\ Food\ Service\ Organizations\ Reached}\end{aligned} \tag{1}$$

$$Cost\ per\ Person\ Reached=\frac{Total\ Cost-Evaluation\ Cost}{Number\ of\ People\ Reached} \tag{2}$$

These two metrics represent key implementation outcomes for recipients. Their primary goal is to recruit food service organizations to implement sodium reduction strategies and then catalyze change in those organizations to reach people with sodium reduction strategies.

We computed the average cost per food service organization to implement each activity. Not all food service organizations engaged in all activities, so not all incurred costs related to each activity. We also computed total cost per person served to account for differences in size across food services organizations. For a subset of 13 food service organizations, recipients reported organization specific data for the performance measure: number of items with lowered sodium through recipe modification or item or ingredient substitution. For this subset of food service organizations, we linked the performance measure data with the cost data and computed cost per food item affected as

$$\begin{aligned}&Cost\ per\ Item\ Affected\\&=\frac{Total\ Cost}{Number\ of\ Items\ Affected\ by\ Recipe\ Modifcation\ or\ Subsitution}\end{aligned} \tag{3}$$

The primary goal of food service organizations was to reduce sodium content of menu items, so this metric represents a summary of their activities. However, it is possible that total cost includes some costs related to activities not specifically aimed at reducing sodium content of food items (e.g. administrative meetings).

Long-Term Cost-Effectiveness Analysis—We used PRISM to simulate the potential long-term health outcomes and medical costs if reductions in sodium consumption are sustained. This modeling process included five steps: (1) generate estimates of the short-term program effectiveness on reduced sodium consumption to be used as a model input, (2) estimating the long-term health gains and medical cost savings from sustained reduction in sodium consumption from SRCP, (3) estimating the long-term costs of sustaining sodium reduction strategies, (4) computing the cost-effectiveness ratio, and (5) conducting sensitivity analysis of key assumptions.

(1) Generate an estimate of short-term program effectiveness: The PRISM module for examining the impact of changes in average sodium consumption requires, as an input, the population-level reduction in average sodium consumption achieved across recipients which is computed as

$$\text{Population Sodium Reduction} = \%\ \text{Targeted Population Reducing Sodium Intake} * \text{Average Sodium Reduction Amongst Population Reached} \quad (4)$$

It is important to include the percentage of people reducing sodium consumption as an input, because PRISM is a population model and models the impact across the entire target population. We took the values to compute this input from two short-term program effectiveness performance measures reported by SRCP recipients: (1) percentage of people in the targeted food service organization who purchased lower-sodium items (assumed to be the percentage of people reducing sodium consumption) and (2) change in average daily sodium intake as measured by nutritional analysis of items purchased at participating food service organizations conducted by the recipient. As noted above, the performance measure for the percentage of people reducing sodium consumption is based on sales data of the percentage of people that purchase lower sodium menu options. The food service organizations participating in SRCP serve largely the same customers every day, so this is a reasonable proxy.

The average percentage of people in the targeted population that purchased lower-sodium items was 20% across all reporting SRCP venues (ranging from 1% to 91% across venues), and the average reduction in sodium intake was 399 mg per person across all reporting SRCP venues (ranging from 1 mg to 542 mg across venues). Using these inputs in Equation (4) generates the PRISM input for the short-term effectiveness of the program as 79 mg/day reduction in sodium consumption across the target population (i.e. 20%*399 mg/day).

(2) Estimate the long-term health gains and medical cost savings from SRCP: We used the estimate of the short-term effectiveness of SRCP as an input in PRISM to produce estimates of the impact of SRCP on per capita health and economic outcomes through 2025 and 2040, including quality-adjusted life-years (QALYs), premature deaths, and medical costs (medical expenditures). PRISM simulates the relationships between risk factors (e.g. high sodium intake), chronic disease (e.g. hypertension), and health outcomes (e.g. cardiovascular disease events, deaths, and medical costs) annually and cumulatively through 2025 and 2040. Because the model has been described in detail elsewhere[10–12, 15], we only focus on the aspects related to sodium in this paper. The model tracks average daily sodium consumption at the population level for a nationally representative population over time and simulates the impact of changes in sodium consumption on hypertension rates in the population. The model then simulates the impact of hypertension on cardiovascular disease and medical costs, including costs related to hypertension management, cardiovascular disease, and event hospitalization and care. Costs are all discounted by 3% annually to account for time preference (i.e. that the present is valued more than the future). Key model parameters related to hypertension and sodium are shown in Table 3. The impact of hypertension on cardiovascular disease events are modeled using a modified version of the Framingham equation[16]. The original Framingham equation was modified for PRISM to 1) include additional risk factors such as secondhand smoke, fruit and vegetable intake, sodium intake, psychological distress, and physical activity; 2) include risk adjustments for control of high blood pressure, high blood cholesterol, and diabetes; 3) calibrate the cardiovascular disease event and death rates by age, sex, and event type (stroke, coronary heart disease, and overall) to reported surveillance data; and 4) differentiate rates for first-time and subsequent cardiovascular disease events. The model simulates changes in risk factors and outcomes over time with and without any intervention and compares the scenarios to estimate the impact of the intervention. PRISM has been validated over the course of its development[17] and has been used to estimate the potential long-term impact and cost-effectiveness of several other community prevention programs, such as the Communities Putting Prevention to Work program[18, 19] and the Community Transformation Grants program[20]. Specific to the present paper, PRISM includes the ability to model interventions for reducing average sodium consumption in the population.

(3) Estimate the long-term costs of sustaining sodium reduction strategies: PRISM uses the costs per capita for start-up and for ongoing maintenance as inputs. The costs measured in the cost study represent per capita implementation costs for the first 36 months of the program from recipients and food service organizations. We assumed that this represents the start-up period of the program. We also assumed that the average cost per capita for the included food service organizations is representative of food service organizations across the program. Because we only collected implementation cost data during the start-up period, we assumed that the ongoing maintenance costs would be 95% of start-up costs. This is based on subject matter expert opinion that policy and systems interventions such as these have minimal ongoing maintenance costs,10% of start-up, (M. Farrelly, personal communication, June 2012). Annual start-up costs used in the model were $2.02 per capita, including costs of recipients and food service organizations. Ongoing maintenance costs were $0.20.

(4) Compute the cost-effectiveness ratio: To assess the long-term cost-effectiveness, we computed

$$Cost\text{-}effectiveness\ ratio = \frac{(Program\ Costs - Medical\ Cost\ Savings)}{Health\ Impact} \quad (5)$$

This ratio represents the cost per health impact achieved. It can be thought of as measuring the program’s return on investment. We measured health impact both in terms of premature deaths averted and QALYs gained. To draw conclusions from the cost-effectiveness ratio, it is necessary to compare it with estimates of societal willingness to pay for health gains. If the cost-effectiveness ratio is lower than societal willingness to pay, then it can be considered cost-effective. If the cost-effectiveness ratio is greater than societal willingness to pay, then the program is considered not cost-effective. A conservative and common threshold of willingness to pay in the United States is $50,000 per QALY saved[21]. We conducted a probabilistic sensitivity analysis to generate 95% confidence intervals for the estimates.

(5) Conduct sensitivity analysis of key assumptions: We conducted one-way sensitivity analysis to test the sensitivity of results to two key assumptions in the model: (1) program effectiveness and (2) the ongoing implementation costs to maintain the intervention.

Specifically, we examined the change in net costs if effectiveness was reduced by 50% and if maintenance costs was 50% or 100% of startup implementation cost.

RESULTS

The average total implementation cost of SRCP recipients was $1,264,609, with low variation (standard deviation = $204,819) (Table 4). The most cost-intensive activity for recipients on average was conducting evaluation but implementing sodium reduction interventions was nearly as costly. There was low variation across all cost categories for recipients with all standard deviations being less than half of the mean. Total monthly costs incurred by SRCP food service organizations averaged $4,282 but varied substantially, ranging from $88 to $28,747 (Table 5). Most of this variation was eliminated when considering the cost per person served at the food service organization. After constructing this measure, only one outlier (more than 3 standard deviations above the mean) remained, and the rest of the values were within a consistent range. This organization was implementing major recipe changes. The most cost-intensive activity for food service organizations on average was additional food preparation, but only six of the food service organizations reported conducting this activity, and their costs varied widely ($27 to $7,886). The next most-costly activities were nutritional analysis and recipe development ($1,648) and healthy food promotion ($1,126), both of which were common activities among partners (conducted by 15 and 12 partners, respectively).

Table 6 shows estimates of the cost of implementation achievements at both the recipient and food service organization levels. At the recipient level, cost per person reached averaged $10, and cost per food service organization reached averaged $42,917. Both metrics had moderate variation, with standard deviations near the mean estimates. Median values were $6 and $36,623, respectively. At the food service organization level, monthly cost per item affected by recipe modification or product substitution averaged $22,869, but this average was driven by one outlier ($183,979); the median was only $684. This outlier was an organization that had incurred substantial implementation costs but had not yet impacted many menu items.

Table 7 presents estimates of the potential long-term cost-effectiveness of SRCP through 2025 and 2040. If changes made are sustained through 2025, the activities implemented under SRCP are projected to decrease premature deaths by 0.17% and medical costs by 0.12% and increase QALYs by 0.77% cumulatively over the entire period among the populations targeted by SRCP recipients. When examining the cost-effectiveness of these impacts, the program is cost saving, indicating that cumulative medical cost savings through 2025 are greater than cumulative program costs. If sustained through 2040, the activities implemented under SRCP are projected to decrease deaths by 0.19% and medical costs by 0.14% and increase QALYs by 0.91% cumulatively over the entire period among the populations targeted by SRCP recipients. When examining the cost-effectiveness of these impacts, the program is cost saving, indicating that cumulative medical cost savings through 2040 are greater than cumulative program costs.

Table 8 presents one way sensitivity analysis testing the impact of changes in assumptions on the projected impact on per capita net costs through 2025 and 2040. A 50% reduction in program effectiveness was estimated to reduce the cost savings of the program, but net costs were still negative indicating the program is still projected to be cost saving. After increasing maintenance cost of the program to 50% and 100% of startup implementation cost, the program is still projected to be cost saving, although the amount saved per capita was reduced.

DISCUSSION

We evaluated the costs and outcomes of the first three years of the 2016–2021 round of SRCP (September 2016 – September 2019). We estimated the costs of achieving program implementation goals and found that at the recipient level, cost per person reached averaged $10, and cost per food service organization reached averaged $42,917. At the food service organization level, monthly cost per item affected by recipe modification or product substitution had a median of $684. We also estimated the cost-effectiveness of SRCP through 2025 and 2040. Results demonstrate that SRCP strategies are projected to be cost saving through 2025 and 2040 if the sodium reduction observed in program performance measures are sustained. The health impacts were not large, but the program costs are projected to be offset by medical cost savings over time. Furthermore, the health impact could be greater if scaled across a larger population (e.g. the population reached by SRCP was 3.9 million and 20% reduced sodium consumption). The simulated reduction in sodium intake represented 6% of the reduction needed to reach the recommended daily intake of 2300 mg(5). This average population level reduction is in line with the average reduction across studies identified in a recent systematic review.(14) Understanding the cost of public health programs and the long-term impacts are key to include in a larger framework for public health decisions and chronic disease prevention(22). The results highlight how sodium reduction strategies can impact health and healthcare cost over time. Program implementation costs are primarily incurred at the outset, and once changes are in place (e.g., lower-sodium options available), the impact can compound over time with potential cost savings by 2025. However, it is important to note that program costs are born by public health agencies while the medical cost savings accrue to individuals, payers, and health systems.

Previous studies have used simulation models to examine the potential impact of hypothetical changes in sodium intake with no consideration of strategies to achieve the hypothetical changes(23–26). One study examined hypothetical strategies for achieving sodium reduction in the United States, estimating that a government-led collaboration with food manufacturers to reduce sodium content would increase life-years by 1.3 million and save $32.1 billion in lifetime medical costs and a sodium tax would increase life-years by 840,113 and save $22.4 billion in lifetime medical costs(27). However, the assumptions about the efficacy of strategies used in the study are not drawn from practice-based evidence in the United States and implementation costs are not considered. Other studies have simulated the cost-effectiveness of strategies implemented in other countries, such as the United Kingdom and New Zealand, and estimated approaches to be either cost-effective or cost-saving(28, 29). The results of this study add to the evidence base by demonstrating what a public health intervention can achieve and incorporating implementation costs for a small set of sodium reduction strategies.

Analysis of the cost of achieving implementation outcomes provides insight into the return on program inputs, demonstrating how much was achieved for investments, and assists in planning for other organizations seeking to implement similar sodium reduction strategies. There was moderate variation in the recipient cost per person and food service organization reached, which may be driven by differences in venues that may be more likely to serve more people less frequently (e.g., hospitals) or fewer people more frequently (e.g., congregate meals). This variation is an important consideration for planners seeking to budget sufficiently to achieve program goals in targeted venues.

Results also highlight the important contributions of partner food service organizations. Past studies have assumed that food service organizations would not incur any additional costs to make recipe modifications or product substitutions because it is part of normal reformulation operations[27]. However, the results of this study provide contradictory evidence, demonstrating that food service organizations do incur costs on a range of activities, including recipe modification, procurement changes, and overall coordination. This finding is important when considering the feasibility of these sodium reduction strategies because food service organizations may be reluctant to partner given the costs. Other studies of SRCP have shown the importance of external and internal factors to generate buy-in for sodium reduction efforts[30], which are important for overcoming potential cost concerns. Cost per menu item affected was relatively consistent across food service organizations after accounting for one large outlier that had incurred substantial cost but had yet to achieve any impact, indicating that results may be useful across a range of organizations implementing sodium reduction strategies. Partners from 7 of the 8 venues submitted cost data, but the highest participation rate was from congregate meals and there was not a clear pattern across the other venues. This may impact results if the probability of response was correlated with lower or higher costs.

This study has several limitations. First, we assumed that we are reducing sodium consumption daily in a consistent population, meaning all of the consumers frequenting these food service organizations eat at these venues daily. We tested this assumption in sensitivity analysis where we reduced the effectiveness measure by 50%. In this analysis, the impact was reduced, but the net effect was still cost saving. Simulations were cost saving up to a 75% reduction in the effectiveness input. This assumption allows us to estimate a population-level effect. However, we know that at least some of these food service organizations do not have consistent patrons. Similarly, reach is likely not representative of community populations, and we do not have information on how populations at a higher risk for cardiovascular disease (e.g. those with high blood pressure or other risk factors) were affected. Second, we assume that changes are sustained through 2025 and 2040, which may not be reasonable because organizations might revert to using higher-sodium recipes or products. Third, PRISM uses a nationally representative population to produce estimates of percentage changes in outcomes. The SRCP target population may not reflect this same population mix, which would impact results. implementation and effectiveness measures reported by recipients were not reported by all organizations for all venues, so we assumed that measures of the percentage of people reducing sodium intake and the average sodium content of foods was generalizable to all organizations and venues. Further they are only performance measures and may not represent the causal impact of the program. Fourth, cost data were collected retrospectively and may be subject to recall bias. Fifth, the partner food service organizations that participated in the cost study were a convenience sample, subject to non-response, and our findings may not be generalizable to all SRCP partner food service organizations. Finally, simulation modeling results are limited by the availability and quality of evidence in the literature. PRISM is based on the latest evidence and has been tested and validated extensively but it is subject to these standard model limitations.

By providing evidence of the cost-effectiveness of a public health sodium reduction initiative, this study is an important advance in the literature on the cost-effectiveness of sodium reduction strategies. Community-level nutrition interventions that augment the amounts of micro- and macro-nutrients in foods that people consume without having to change their behavior have been show to play a key role in improving population health (e.g., folic acid fortification of foods[31]). Community-level change is not easy to achieve, but the success can be substantial and takes the onus off consumers who may not be tracking the nutrient content or who may have constrained options. In food fortification examples, success happened after food fortification policies and standards were set by the U.S. Food and Drug Administration. However, similar to SRCP, food fortification started as a voluntary opt-in by food producers. Sodium reduction strategies at the food service organization level provide an opportunity to make changes to the amount of a nutrient the population consumes and can affect real health outcomes.[32] The findings here represent the current state of implementation but if these efforts could be scaled up, the average daily amount of sodium consumed by U.S. adults could be brought closer to the recommended amount in the dietary guidelines. The results of this study demonstrate the long-term cost-effectiveness of SRCP, which can catalyze future work in sodium reduction and promote scale-up to achieve this impact. Furthermore, the results demonstrate the costs of achieving implementation goals that can support effective planning for future programs, ensuring that budgets are sufficient to achieve impact.

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REFERENCES

1. Zhang Z, Cogswell ME, Gillespie C et al. (2013) Association between usual sodium and potassium intake and blood pressure and hypertension among US adults: NHANES 2005–2010. PloS One 8, e75289. [PubMed: 24130700]
2. Cook NR, Appel LJ Whelton PK (2014) Lower levels of sodium intake and reduced cardiovascular risk. Circulation 129, 981–989. [PubMed: 24415713]

3. Cogswell ME, Loria CM, Terry AL et al. (2018) Estimated 24-hour urinary sodium and potassium excretion in US adults. JAMA 319, 1209–1220. [PubMed: 29516104]
4. Services USDoAaUSDoHaH (2020) Dietary Guidelines for Americans, 2020–2025. 9th Edition.
5. National Academies of Sciences E, and Medicine. (2019) Dietary reference intakes for sodium and potassium.
6. Boon CS, Taylor CL Henney JE (2010) Strategies to Reduce Sodium Intake in the United States. Washington, DC: National Academies Press.
7. Food and Drug Administration (2016) Draft Guidance for Industry: Voluntary Sodium Reduction Goals: Target Mean and Upper Bound Concentrations for Sodium in Commercially Processed, Packaged, and Prepared Foods. Silver Spring, MD: Food and Drug Administration.
8. regulations.gov (2016) Comment from Grocery Manufacturers Association. no. FDA-2014-D-0055–0425. Washington, DC: Grocery Manufacturers Association.
9. Jordan J, Hickner H, Whitehill J et al. (2020) Peer Reviewed: CDC's Sodium Reduction in Communities Program: Evaluating Differential Effects in Food Service Settings, 2013–2016. Preventing Chronic Disease 17.
10. Homer J, Milstein B, Labarthe D et al. (2010) Peer reviewed: simulating and evaluating local interventions to improve cardiovascular health. Preventing Chronic Disease 7.
11. Hirsch G, Homer J, Trogdon J et al. (2014) Using simulation to compare 4 categories of intervention for reducing cardiovascular disease risks. American journal of public health 104, 1187–1195. [PubMed: 24832142]
12. Hirsch G, Homer J, Evans E et al. (2010) A system dynamics model for planning cardiovascular disease interventions. American Journal of Public Health 100, 616–622. [PubMed: 20167899]
13. Canby JB (1995) Applying activity-based costing to healthcare settings. Healthcare Financial Management: Journal of the Healthcare Financial Management Association 49, 50.
14. Barberio AM, Sumar N, Trieu K et al. (2017) Population-level interventions in government jurisdictions for dietary sodium reduction: a Cochrane Review. International journal of epidemiology 46, 1551–1405. [PubMed: 28204481]
15. Orenstein DR, Homer J, Milstein B et al. (2008) Modeling the local dynamics of cardiovascular health: risk factors, context, and capacity. Preventing Chronic Disease 5.
16. Anderson KM, Odell PM, Wilson PWF et al. (1991) Cardiovascular disease risk profiles. American Heart Journal 121, 293–298. [PubMed: 1985385]
17. Honeycutt A, Yarnoff B, Khavjou O et al. (2019) Validation of the prevention impact simulation model. Under Review.
18. Soler R, Orenstein D, Honeycutt A et al. (2016) Community-based interventions to decrease obesity and tobacco exposure and reduce health care costs: outcome estimates from communities putting prevention to work for 2010–2020. Preventing Chronic Disease 13, E47–E47. [PubMed: 27055264]
19. Honeycutt A, Bradley C, Khavjou O et al. (2019) Simulated impacts and potential cost effectiveness of Communities Putting Prevention to Work: Tobacco control interventions in 21 US communities, 2010–2020. Preventive medicine 120, 100–106. [PubMed: 30659909]
20. Yarnoff B, Bradley C, Honeycutt AA et al. (2019) Peer Reviewed: Estimating the Relative Impact of Clinical and Preventive Community-Based Interventions: An Example Based on the Community Transformation Grant Program. Preventing Chronic Disease 16.
21. Neumann PJ, Cohen JT Weinstein MC (2014) Updating cost-effectiveness—the curious resilience of the $50,000-per-QALY threshold. New England Journal of Medicine 371, 796–797.
22. Frieden TR (2010) A framework for public health action: the health impact pyramid. American Journal of Public Health 100, 590–595. [PubMed: 20167880]
23. Bibbins-Domingo K, Chertow GM, Coxson PG et al. (2010) Projected effect of dietary salt reductions on future cardiovascular disease. New England Journal of Medicine 362, 590–599.
24. Polar K & Sturm R (2009) Potential societal savings from reduced sodium consumption in the US adult population. American Journal of Health Promotion 24, 49–57. [PubMed: 19750962]

25. Doll TM, Fulgoni VL III, Zhang Y et al. (2009) Potential health benefits and medical cost savings from calorie, sodium, and saturated fat reductions in the American diet. American Journal of Health Promotion 23, 412–422. [PubMed: 19601481]
26. Coxson PG, Cook NR, Joffres M et al. (2013) Mortality benefits from US population-wide reduction in sodium consumption: projections from 3 modeling approaches. Hypertension 61, 564–570. [PubMed: 23399718]
27. Smith-Spangler CM, Juusola JL, Enns EA et al. (2010) Population strategies to decrease sodium intake and the burden of cardiovascular disease: a cost-effectiveness analysis. Annals of Internal Medicine 152, 481–487. [PubMed: 20194225]
28. Nghiem N, Blakely T, Cobiac LJ et al. (2015) Health and economic impacts of eight different dietary salt reduction interventions. PLoS One 10, e0123915. [PubMed: 25910259]
29. Wilson N, Nghiem N, Eyles H et al. (2015) Modeling health gains and cost savings for ten dietary salt reduction targets. Nutrition Journal 15, 44.
30. Strazza K, Whitehill J, Jordan J et al. (2019) Implementing strategies to address health equity in the context of limited resources? Examples from charitable food organizations participating in the Sodium Reduction in Communities Program. Under Review.
31. Honein MA, Paulozzi LJ, Mathews TJ et al. (2001) Impact of folic acid fortification of the US food supply on the occurrence of neural tube defects. JAMA 285, 2981–2986. [PubMed: 11410096]
32. Io Medicine (2010) Strategies to Reduce Sodium Intake in the United States. Washington, DC.
33. Midgley JP, Matthew AG, Greenwood CMT et al. (1996) Effect of reduced dietary sodium on blood pressure: a meta-analysis of randomized controlled trials. JAMA 275, 1590–1597. [PubMed: 8622251]
34. Cutler JA, Follmann D Allender PS (1997) Randomized trials of sodium reduction: an overview. American Journal of Clinical Nutrition 65, 643S–651S.
35. He FJ & MacGregor GA (2002) Effect of modest salt reduction on blood pressure: a meta-analysis of randomized trials. Implications for public health. Journal of Human Hypertension 16, 761–770. [PubMed: 12444537]
36. He FJ & MacGregor GA (2004) Effect of longer-term modest salt reduction on blood pressure. Cochrane Database of Systematic Reviews.
37. Yang Q, Zhang Z, Kuklina EV et al. (2012) Sodium intake and blood pressure among US children and adolescents. Pediatrics 130, 611–619. [PubMed: 22987869]
38. He FJ, Marrero NM MacGregor GA (2008) Salt and blood pressure in children and adolescents. Journal of Human Hypertension 22, 4–11. [PubMed: 17823599]
39. Aburto NJ, Ziolkovska A, Hooper L et al. (2013) Effect of lower sodium intake on health: systematic review and meta-analyses. Bmj 346, f1326. [PubMed: 23558163]
40. Shi L, Krupp D Remer T (2014) Salt, fruit and vegetable consumption and blood pressure development: a longitudinal investigation in healthy children. British Journal of Nutrition 111, 662–671.
41. Caldeira D, Vaz-Carneiro A Costa J (2013) [What is the benefit of salt reduction on blood pressure? Assessment of the Cochrane Review: Effect of longer-term modest salt reduction on blood pressure. He FJ, Li J, Macgregor GA. Cochrane Database Syst Rev. 2013 Apr 30;4:CD004937]. Acta medica portuguesa 26, 490–492. [PubMed: 24192084]
42. Russell MW, Huse DM, Drowns S et al. (1998) Direct medical costs of coronary artery disease in the United States. American Journal of Cardiology 81, 1110–1115.
43. Carlson JJ, Johnson JA, Franklin BA et al. (2000) Program participation, exercise adherence, cardiovascular outcomes, and program cost of traditional versus modified cardiac rehabilitation. American Journal of Cardiology 86, 17–23.
44. Fox KM, Wang L, Gandra SR et al. (2016) Clinical and economic burden associated with cardiovascular events among patients with hyperlipidemia: a retrospective cohort study. Bmc Cardiovasc Disor 16, 13.

Table 1.

Example Implementation Activities for each Sodium Reduction Strategy

Sodium Reduction Strategy	Example Activities
Implementation of food service guidelines and nutritional standards that include sodium	• Using environmental scans to inform recommendations for sodium reduction improvements in the food service organizations • Convening meetings with key partners like registered dietitians and food service personnel to provide unified guidance for nutrition guidelines and other sodium reduction strategies • Setting feasible sodium reduction goals by targeting the food categories that offer the greatest opportunity for reducing sodium (e.g. high sodium ingredients that affect many menu items)
Introduction of meal and menu item modifications	• Developing a culinary food preparation program where an external chef educated food service staff on culinary techniques and food preparation practices to reduce sodium in meals • Distributing lower sodium cooking materials including recipes, tool kits, and measuring spoons to enable chefs to make lower sodium meals from scratch • Conducting skills-based training to enable food service staff to feel more confident using lower sodium and healthier alternatives while cooking
Integration of lower-sodium food procurement practices	• Embedding sodium standards within existing and new food services contracts for cafeterias • Reviewing product lists and provided food service organizations with a list of similar products with lower sodium content • Developing new procurement relationships with vendors and manufacturers who carry lower sodium food items
Implementation of behavioral economic strategies to promote lower-sodium items	• Redesigning spaces by repainting and hanging photos of healthy foods • Discounting purchases that are part of healthy foods program • Removing salt packets from trays and salt shakers from tables so that patrons must request them

Table 2.

Summary of Implementation in Each Setting, September 1, 2016–December 31, 2018

Settings	Number of Recipients Working in the Setting	Number of Food Service Organizations Reached	Number of People Reached[a]
Worksites	1	5	16,000
Hospitals	2	19	2,246,000
Schools	3	218	626,000
Early childhood education centers	1	57	5,000
Higher-learning institutions	3	22	373,000
Restaurants	1	15	5,000
Emergency food services	1	5	228,000
Distributive/congregate meals	5	188	403,000
Total	17	529	3,902,000

Notes:

[a]Estimated based on the average number of people served each day in participating food service organizations. Rounded to the nearest thousand.

Table 3.

Key PRISM Parameters Related to Sodium Consumption, Hypertension, and Cardiovascular Disease

Model Parameter	Value	Source
Reduction in SBP among the population without hypertension per 1,000 mg sodium reduction	1.0 mm Hg	Synthesis of Midgley et al. (1996)[33], Cutler et al. (1997)[34], He and MacGregor (2002[35] and 2004[36]), Yang et al. (2012)[37], He et al. (2008)[38], Aburto et al. (2013)[39], Shi et al. (2014)[40], Caldiera et al. (2013)[41]
Reduction in SBP among the population with hypertension per 1,000 mg sodium reduction	2.75 mm Hg	Synthesis of Midgley et al. (1996)[33], Cutler et al. (1997)[34], He and MacGregor (2002[35] and 2004[36]), Yang et al. (2012)[37], He et al. (2008)[38], Aburto et al. (2013)[39], Shi et al. (2014)[40], Caldiera et al. (2013)[41]
Reduction in CVD Events[a] and Deaths from changes in hypertension	Framingham equation	Anderson et al. (1991)[16]
Annual per person cost of hypertension management (2018 $)	$564	MEPS 2003–05 (regression analysis)
Annual acute care and rehab costs of a survived CVD event[a] (2018 $)	$32,640	Russell et al. (1998)[42], Carlson et al. (2000)[43], expert opinion of Stroke subject matter experts at Veterans Health Administration, Fox et al. (2016)[44]
Annual acute care costs of a nonsudden death from a CVD event[a] (2018 $)	$34,643	Russell et al. (1998)[42]
Annual acute care costs of a sudden death from a CVD event[a] (2018 $)	$1,409	Russell et al. (1998)[42]
Average hospitalization cost of non-CVD[b] complications of hypertension (2018 $)	$11,910	Average hospitalization cost of hypertension: HCUP, 2016. ICD-10: I10 (Primary Hypertension), and I12 (Hypertensive CKD)

Abbreviations: SBP = Systolic Blood Pressure; PRISM = Prevention Impacts Simulation Model; CVD = Cardiovascular Disease; CKD = Chronic Kidney Disease; HCUP = Healthcare Cost and Utilization Project; ICD-10 = International Classification of Diseases, 10th Revision; MEPS = Medical Expenditure Panel Survey.

Notes:

[a]CVD events include coronary heart disease, heart failure, and stroke.

[b]Non-CVD complications of hypertension include primary hypertension and kidney disease.

Table 4.

Average SRCP Recipient Implementation Cost (September 30, 2016–September 29, 2019), by Activity

Activity	N	Mean	SD	Min	Max
Building and maintaining partnerships	8	$201,401	$45,743	$116,265	$263,584
Designing sodium reduction interventions	8	$183,180	$52,091	$109,586	$243,625
Implementing sodium reduction interventions	8	$292,040	$80,905	$198,849	$450,409
Conducting evaluation	8	$311,628	$103,480	$182,895	$533,654
Performing administrative activities	8	$276,359	$88,875	$135,493	$380,532
Total	8	$1,264,609	$204,819	$1,008,240	$1,603,550

Table 5.

Average Monthly Implementation Cost to Food Service Organizations by Activity

Activity	N	Mean	SD	Min	Max
Total cost	**20**	**$4,282**	**$6,790**	**$88**	**$28,747**
Total cost per person served	**17**	**$2**	**$4**	**$1**	**$19**
Cooking for new product offerings	6	$1,964	$2,990	$27	$7,886
Nutritional analysis and recipe development	15	$1,648	$3,370	$39	$13,047
Healthy food promotion, including environmental and behavioral economic interventions	12	$1,126	$2,325	$19	$8,062
Other activities related to development	7	$1,061	$1,326	$15	$3,341
Find new lower-sodium ingredients	14	$941	$2,342	$11	$8,933
Meetings	12	$596	$787	$11	$2,399
Other activities	3	$494	$404	$169	$947
Nutrition guideline implementation	13	$432	$952	$5	$3,563
Trainings for new recipes or techniques	12	$64	$81	$3	$296

Table 6.

Implementation Cost-Effectiveness Measures

Cost-Effectiveness Metric	N[1]	Mean	SD	Median	Min	Max
Recipient Level						
Cost per person reached	8	$10	$10	$6	$1	$28
Cost per food service organization reached	8	$42,917	$37,343	$36,623	$5,308	$122,316
Food Service Organization Level						
Monthly cost per item affected by recipe modification or product substitution	13	$22,869	$54,290	$684	$3	$183,979

Notes:

[1] At the recipient level, N represents the number of recipients that reported both cost data and the performance measure data. At the food services organization level, N represents the number of food service organizations that reported both cost data and performance measure data.

Table 7.

Long-Term Cost-Effectiveness of SRCP Through 2025 and 2040

Metric	2025	2040
Percent change in premature deaths in the target population	−0.17% (−0.14%, −0.29%)	−0.19% (−0.16%, −0.31%)
Percent change in average annual QALYs per capita in the target population	0.77% (0.64%, 1.25%)	0.91% (0.75%, 1.45%)
Percent change in medical costs in the target population	−0.12% (−0.09%, −0.21%)	−0.14% (−0.11%, −0.24%)
Net cost per capita in the target population (2018 $)	−$1.82 (−$1.69, −$1.88)	−$2.09 (−$1.97, −$2.23)
Cost-effectiveness ratio per premature death averted	*Cost Saving*	*Cost Saving*
Cost-effectiveness ratio per quality-adjusted life-year gained	*Cost Saving*	*Cost Saving*

Notes:

1. Target population is the total population in the food service organizations targeted by SRCP.

2. Estimates were generated using PRISM’s nationally representative model and measures of SRCP program implementation and costs.

3. Estimates are for the entire population age 2+.

4. 95% confidence intervals are in parentheses.

Table 8.

One-Way Sensitivity Analysis of Change Key Assumptions on Net-Cost per Capita of SRCP Through 2025 and 2040

Change in Assumption	2025	2040
50% reduction in program effectiveness	−$0.61	−$0.41
Maintenance costs are 50% of start-up implementation costs	−$1.27	−$1.24
Maintenance costs are 100% of start-up implementation costs	−$0.58	−$0.19

Notes:

1. Target population is the total population in the food service organizations targeted by SRCP.

2. Estimates were generated using PRISM’s nationally representative model and measures of SRCP program implementation and costs.

3. Estimates are for the entire population age 2+.