(IM) PROVING THE CSA MODEL

EXPLORING THE CSA MODEL AS A HEALTH INTERVENTION

A RESEARCH PROJECT FUNDED BY THE BLUE CROSS BLUE SHIELD FOUNDATION OF MASSACHUSETTS AND THE UNITED STATES DEPARTMENT OF AGRICULTURE

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Just Roots is a social justice organization that builds equity, connection, health, pride and empowerment in its community through food-based programs and systems change. Its farm, programming and advocacy efforts connect people to food and one another. They approach their work by growing food; connecting people of all ages and life experiences with the land; running an all-income CSA; cooking community meals; developing partnerships with schools, health insurance companies, legislators, health clinics and other resource agencies; researching the health outcomes of CSA participation and more. They build direct access, models, momentum and evidence for change in agricultural policy, food policy and social justice.

The Community Health Center of Franklin County

The CHCFC is a 501c3 Federally Qualified Community Health Center serving the community of Franklin County by providing full primary care Medical and Dental services.

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ABSTRACT

OBJECTIVE

Socioeconomically vulnerable individuals often face poor access to nutritious food and bear a disproportionate burden of diet-related chronic illness. Therefore, two key objectives drove this research:

1. To test whether a subsidized community supported agriculture (CSA) intervention could improve diet quality.
2. estimate the population-level effectiveness and cost-effectiveness of a subsidized community supported agriculture (CSA) intervention.

METHODS

From May 2017 to December 2018, we conducted a randomized clinical trial (clinicaltrials.gov registration number NCT03231592) to explore the health outcome impacts of CSA participation. Adults with a BMI > 25 kg/m2, primarily but not exclusively patients of a community health center in western Massachusetts, were eligible to participate. Health-related eligibility requirements beyond BMI were limited, aiming to study the impact of the CSA model on a broad demographic of health rather than on people experiencing specific health challenges. Individuals were randomized to one of two study groups: One group received a subsidized CSA membership for two years, which provided weekly farm produce pickups each year from June to November. The other group received healthy eating information produced by the United States Department of Agriculture, www.choosemyplate.gov, and functioned as the control group. Each group received $300/year for participation. The CSA intervention participants were then required to purchase a CSA share from Just Roots, the money from the study stipend serving as a subsidy or rebate for their CSA purchase. The control group was provided the same level of funding, but in the form of unrestricted funds. The primary outcome was the Healthy Eating Index 2010 (HEI) Total score (range: 0-100, higher indicates better diet quality, minimum clinically meaningful difference: 3). HEI, participant-reported metrics on health and well-being, participant-reported metrics on food security and finance-related medication underuse, anthropometrics and biomarkers were assessed. Following the study, we developed a microsimulation model from nationally-representative demographic, biomedical, and dietary data (National Health and Nutrition Examination Survey, 2013-2016), and the data resulting from the previously mentioned study. We modeled 2 interventions: unconditional cash transfer ($300/year) and subsidized CSA ($300/year subsidy).

RESULTS

Demographics of the study:

- 122 participants
- Mean age of 50.3
- 82% women
- 88% non-Hispanic white
- Control and intervention groups shared similar distribution of baseline characteristics.

Baseline data:

- HEI Total score
  Control group = 53.9
  Intervention group = 55.1

Change in HEI:

- Intervention group increased 4.3 points relative to the control group

Change in food Insecurity:

- Intervention group proved a reduction in food insecurity.

Microsimulation:

- Disability-Adjusted Life Years (DALY)
  - Total discounted DALY lost over life-course reduction:
    - Cardiovascular disease and diabetes complications
    - Baseline: 24,797 per 10,000 people
      - Reduced to:
        - 23,463 per 10,000 people under cash intervention
        - 22,304 per 10,000 people under CSA intervention
  - Societal Perspective over life-course horizon
    - Cost savings to society (expressed as negative incremental cost-effectiveness ratios)
      - -$191,000/DALY averted for cash intervention
      - -$93,182/DALY averted for CSA intervention

CONCLUSIONS

A subsidized CSA intervention resulted in clinically meaningful improvements in diet quality. Further, the study pointed to subsidized community supported agriculture as well as a cash intervention as both potential important public health/socioeconomic interventions for low-income, vulnerable individuals. As no one health intervention can treat a whole population and the benefits of the interventions lead to both public health and societal benefit, a cross-sectoral approach that bundles private resources with those from multiple programs (food programs designed in part to boost agriculture, low-income programs designed to address inequities in food access, health programs designed to improve nutrition, and housing programs intended to improve the quality of life and stability of low-income families) may generate broad health and social benefit while reducing the burden carried by any single stakeholder/payer.

OBJECTIVE

Socioeconomically vulnerable individuals often face poor access to nutritious food and bear a disproportionate burden of diet-related chronic illness. Therefore, two key objectives drove this research:

1. To test whether a subsidized community supported agriculture (CSA) intervention could improve diet quality.
2. estimate the population-level effectiveness and cost-effectiveness of a subsidized community supported agriculture (CSA) intervention.

CONTEXT

Why the research was conducted

SUMMARY

The CSA (Community Supported Agriculture) farm share approach is a widely utilized model to get farm fresh food direct from farm to customer. In Massachusetts alone, there are over 400 CSAs according to the USDA census data. CSAs however, have been relatively inaccessible to low-income populations due in large part to the economic model it is premised on: pay the full CSA fee (avg $600 - $800) months in advance of the harvest season and collect a weekly allotment of produce during the harvest season. However, Just Roots believed that the "membership structure" and repetitive nature of a CSA offered a powerful opportunity to build healthy eating habits for those who participated, distinct from a decision to visit a grocer, market or farm stand. Just Roots aimed to challenge the status quo of the CSA and reinvent it as a health intervention model, accessible to all people regardless of economic circumstance. Following four years of success with its accessible CSA farm share program which regularly demonstrated member data indicating improved health measures, Just Roots aimed to model its accessible CSA farm share program as a health intervention broadly. To that end, Just Roots partnered with Dr. Seth Berkowitz and the Community Health Center of Franklin County to run a research study to understand the potential of the CSA to improve health and save healthcare dollars. For two CSA seasons, the study researched CSA participants and non-participants in Franklin County, MA. If the findings proved the CSA effective, they would be used to attract stakeholder investment to expand CSA access to low-income populations, improve health for participants and save healthcare dollars.

BACKGROUND

Since its inception Just Roots has worked to increase access to healthy, local food by connecting people, land, resources and know-how (the mission of Just Roots). In 2011, Just Roots gained access to a piece of municipally owned agricultural land through a long term lease, which they helped place into Agricultural Preservation Restriction (APR). Just Roots grows roughly sixty types of vegetables, small fruits and herbs on approximately 5-7 acres of land, using organic practices. Just Roots made the decision to adopt the CSA model as their primary method to distribute their produce from farm to table. However, the organization dedicated itself to reinventing the CSA model as an accessible health intervention by addressing key barriers inherent in the model which disproportionately limited access for those with lesser socioeconomic means from participating. Just Roots understood the important role repetition and support services played in the formation of habits of health, and the CSA offered this unique opportunity to connect with the customer regularly over the course of a 20-24 week harvest season, offering local produce and wrap around support services to promote health (physical, mental and social). Just Roots began distributing CSAs in 2013 and within four years became the largest provider of farm-based "low-income" CSAs in the Commonwealth of Massachusetts.

Committed to understanding the health impacts of the CSA program, Just Roots surveys its CSA participants bi-annually and the results have been both obvious and astounding (see full results of the mid and end of year 2018 CSA survey in the appendices.) Note that while 2018 results include members of the (Im) Proving the CSA Study, these surveys were produced independently of the methodology used in the study and are conducted on a bi-annual basis by Just Roots to its entire CSA membership (inclusive of low-, moderate- and high-income individuals. Data specific to low-income members are specified in the Mid Season [https://tinyurl.com/ybm5hlhu] and End of Season [https://tinyurl.com/y4q5ac5b] reports).

Survey Snapshot:

CSA program impact on member health/habits in 2018:

- 93% of Just Roots CSA members reported increasing their vegetable consumption by at least half a cup/day, and for the members receiving the subsidized share, the impact was even more significant reaching 100%,
- 54% reported improvement in household attitude toward vegetables,
- 72% reported an increase in their general willingness to try new veggies/dishes.

The Just Roots CSA is set up like a farmers market stand, with a wide variety of vegetables to choose from. Participants have full autonomy to choose what vegetables they take home. Even so:

- 83% reported trying a new vegetable this year
- 70% also reported expanding their cooking repertoire by utilizing recipes offered by the CSA program, with 31% reporting cooking together with family/friends at home more frequently.

Social and physical outcomes related to participation

- 55% reported creating at least one new meaningful connection in the community as a result.

- 35% of members reported increased energy levels;
- 19% reported an improvement in weight (loss for those overweight and gain for those underweight);
- 47% reported an improvement in general well-being,
- 35% reported an improvement in mental well-being.

Results such as those listed above reinforced Just Roots' conviction that the CSA model might prove a powerful health intervention that could improve the health and wellbeing of those who participated. Just Roots began to explore opportunities to model its program regionally, even nationally. Two initial key components would be needed to move from a program offered by a single organization to a program broadly adopted/implemented: research and stakeholder investment.

Historically, research has proven to drive public policy and stakeholder investment. Building the case for stakeholder investment in CSAs is a critical next step in beginning to convert a recognized model of healthy food distribution from an exclusive model to an accessible one.

However, research was and continues to be lacking specific to the health intervention power of a CSA. While we understand and can point to research associated with incorporating more fruits and vegetables into the diet, the CSA specifically had not been well-researched, especially not within a clinical trial environment. Just Roots approached Dr. Seth Berkowitz, with extensive experience in research on nutrition's impact on health outcomes, about his interest in conducting a study to research health outcomes associated with CSA participation targeting low income individuals. He agreed to design and complete the analysis of the research. Just Roots then sought out the Community Health Center of Franklin County (a federally qualified community health center, FQHCH) due to its potential to serve as a model for the more than 1,400 Health Center Organizations and 11,000 locations in urban, suburban and rural communities across the United States. Together, this team secured funding from the USDA, followed by Blue Cross Blue Shield Foundation of Massachusetts to fund a three-year research project, including two years of data collection. The project began in the fall of 2016, published the findings of its two primary research questions in November of 2019, and is now employing a dissemination strategy to utilize the results to influence systems thinking and policy change.

EVIDENCE OF SIMILAR EFFECTIVE INITIATIVES

While evidence proving the health outcomes associated with the CSA is lacking, there is a body of work on which this now completed research builds upon:

1. A prior randomized study found improvements in diet quality for a 30% subsidy on the purchase of fruit and vegetables via SNAP (the Supplemental Nutrition Assistance Program).[1]
2. Prior modeling studies of this type of intervention have estimated positive effects on health and healthcare spending.[2, 3]
3. A recent cost effectiveness analysis of economic incentive programs offered through Medicaid and/or Medicare found these programs could be highly cost-effective.[4] A recent study conducted by University of Kentucky analyzed medical claims from UK employees who participated in pilot CSA voucher programs in 2015 and 2016 to see if behavior change is reflected in billed medical expenses. Findings indicate scientifically significant reduction in diet-related medical claims and pharmacy expenses in the High Expenditure cohort. The low-expenditure cohort did not see scientifically significant changes. [5]

METHODOLOGIES

To provide a thorough understanding of how the research team came to the recommendations offered later in this report, a description of the study design as well as the microsimulation model used to expand the conclusions to a nationwide scope is described here. More thorough descriptions can be found in the complete manuscripts. Please also reference tables and figures at the end of this document.

STUDY

Design

From May 2017 to December 2018, we conducted a randomized clinical trial (clinicaltrials.gov registration number NCT03231592) to explore the health outcome impacts of CSA participation (see Figure 1). Adults with a BMI > 25 kg/m2, primarily but not exclusively patients of a community health center in western Massachusetts, were eligible to participate. Health-related eligibility requirements beyond BMI were limited, aiming to study the impact of the CSA model on a broad demographic of health rather than on people experiencing specific health challenges. Individuals were randomized to one of two study groups: One group received a subsidized CSA membership for two years, which provided weekly farm produce pickups each year from June to November. The other group received healthy eating information produced by the United States Department of Agriculture, www.choosemyplate.gov[6], and functioned as the control group. Each group received $300/year for participation. The CSA intervention participants were then required to purchase a CSA share from Just Roots, the money from the study stipend serving as the subsidy or rebate for their CSA purchase. The control group, was provided the same level of funding, but in the form of unrestricted funds. This approach, known as cash-benchmarking[7], allowed the study to specifically explore the impact and influence on health outcomes specific to the CSA model in comparison to the impacts resulting from in comparison to the impacts resulting from an annual influx of $300.

Participants were assigned to their group (CSA recipient or control group) during their first of five research visits. These research visits took place at the beginning and end of each of the 2017 and 2018 growing seasons as well as one during the winter of early 2018. Each research visit captured participant-reported data on their state of mental and physical health, participant-reported data on their state of food security and cost-related medical underuse, and a detailed report on the food the participant consumed in the previous 24 hours. The tools used were

- the PROMIS Global Health 10-item questionnaire and the 4-item PROMIS assessments of depressive and anxiety symptoms
- 4 items from the Medical Expenditure Panel Survey
- 6 items from the USDA Food Security moduleThe ASA 24-hour dietary recall platform, https://asa24.nci.nih.gov/[8]

Research staff was trained to follow standardized protocol for data collection, and all surveying was completed orally to eliminate inaccuracies resulting from improper or inconsistent use of the data collection tools. Additionally, utilizing calibrated instruments and following a standardized protocol for all participants, height, weight, and systolic and diastolic blood pressure were measured at each research visit, allowing for the tracking of any shifts. Following four of the five research visits, participants had blood drawn and levels of serum lipids, serum glucose and hemoglobin A1c were tracked over time. In addition to the research visits, participants also completed an additional 5 telephone-based 24-hour dietary recalls using the ASA24 system throughout the 20 months of data collection. In total, the 10 24-hour recalls included a baseline recall at each participant's initial research visit followed by three dietary recalls during each harvest season and three occurring during the non-harvest season. To provide an accurate reflection of participants' food consumption, recalls were completed without advanced notice as much as possible, minimizing the impacts often seen on diet when people are aware they are being observed. The data from the recalls were used to calculate Healthy Eating Index (HEI) 2010[9] scores and analyze the impact of the CSA on dietary habits. The HEI is a scoring system used to analyze food consumption and its adherence to the USDA-recommended diet across 12 sub-scores (table 1 and 2). HEI 2010 ranges from 0-100. A higher HEI score indicates healthier habits.

In order to appropriately power the study, we estimated we needed 100 participants, 50 in each group. We therefore aimed to enroll 120 participants prior to the 2017 harvest season to protect the study against attrition typical to research of this nature. We succeeded in enrolling 101 participants for the 2017 harvest season and elected to proactively secure additional participants (adding 21 new participants) for the 2018 harvest season (table 1). This created 2 cohorts: Cohort A was enrolled for the entirety of the study, both the 2017 and 2018 harvest seasons and the time in between. Cohort B was enrolled solely for the 2018 harvest season.

The Intervention and Control

The intervention tested was participation in a Just Roots CSA farm share. The participants in the intervention group were required to purchase the farm share with cash, credit or Supplemental Nutrition Assistance Program benefits (SNAP) each year, and received a $300/year subsidy for their annual purchases (the study participation stipend). Membership in the CSA entitled participants to fresh produce from the farm each week throughout the harvest seasons, June through November each year. Participants could go to the farm to get their produce, or pick it up in downtown Greenfield. At each pickup, Just Roots prepared and provided sample dishes featuring the in-season vegetables, and recipes and tips were available for people to take home. Members could also visit the farm to pick a small amount of additional vegetables from a Pick-Your-Own Garden. Meanwhile, the control group received suggestions on healthy eating prepared by the USDA at the first research visit, as well as an equivalent amount of cash to the intervention group but with no restrictions on its use. The control group was not permitted to participate in the Just Roots CSA. Both Cohort A (2017 and 2018) and Cohort B (2018 only) study procedures and participation were identical apart from the duration of their participation.

Adherence

To understand the impact of the intervention, we conducted both analyses based on participation as it occurred, as well as analyses that specifically estimated the "per-protocol" effect, or the difference in the diet quality between the intervention and control group that would have been realized should all participants have adequately adhered to the intervention, and no participants lost to follow-up. Adequate adherence was defined as picking up produce from the CSA program for at least 70% of the weeks of the harvest season.

MICROSIMULATION

Design

Given the known benefits of long-term healthy diets and the length of time required for the benefits of sustainable dietary interventions to be fully appreciated, Dr. Seth Berkowitz and Dr. Sanjay Basu designed a microsimulation model to expand upon the learnings able to be drawn from the study data. We elected to use a microsimulation model because it can identify impacts of an intervention on populations affected by a variety of concurrent risk factors/chronic illnesses.[10,11] The complexities of correlation between demographics, nutrition profile, health biomarkers and disease incidence are therefore accounted for in this type of modeling. This microsimulation model examined the 10-year and life-course impact the CSA intervention has on health outcomes on a nationally-representative population and the cost-effectiveness of this intervention.

- The nationally-representative population was narrowed to examine a population with a BMI > 25 kg/m2 and who either had a household income <200% of the federal poverty level or were Medicaid beneficiaries (or both).
- The CSA intervention was examined in comparison to a $300 unrestricted cash influx as well as a baseline (no intervention).
- A simulated U.S. population was created considering age, sex and race and generated data by simulating the typical distribution of health variables for the current American population which matched the criteria listed in bullet point one above, as this population is the primary intended beneficiary of the subsidized CSA intervention model.
- The input dietary data was drawn from the National Health and Nutrition Examination Survey, 2013-2016[12].

The effect estimates were extrapolated from the study defined above, and were then applied to the simulated population in order to model the diet change, health outcomes and associated costs over time for the two interventions in comparison to an intervention-free baseline. Again, the interventions under scrutiny were provision of unrestricted funds at the level of $300/year, and a $300 subsidy/year for a CSA share. Detailed data sources, input parameters and characteristics of the simulated population are summarized in Tables 5 and 6.

For each intervention as well as for the baseline, 10-year and life-course impacts, validated risk equation data particular to an array of specific chronic illnesses including cardiovascular, and metabolic disease[13,14,15], all-cause morbidity, stroke risk and diabetes-contingent complications, were used to assess how much change could be expected from the baseline rates. See Table 8.

To evaluate cost-effectiveness, we calculated Disability Adjusted Life Years (DALYs) lost and funds expended over 10 years and over the life-course under the following three interventions. We defined DALYs as the years of life lost from the disease plus the years of life lived with disability (years weighted by a disutility weight reflecting the degree of loss of life quality from the disease).

1. subsidized CSA intervention,
2. unrestricted cash infusion intervention, and
3. no intervention

DALYs lost were estimated using previously published health state utility values[16]. See Figure 2.

When calculating cost-effectiveness from the healthcare perspective, we included the $300/person/year intervention cost, plus the overhead rates for both interventions, 16.7% ($50) for cash and 90.3% ($271) for CSA. The OH rate for the CSA intervention was based on the rate utilized in the study. Healthcare costs including payments to providers and out of pocket costs associated with disease outcomes were included, and were based on estimates from the Optum Clinformatics Database of low-income Americans nationwide.

When calculating cost-effectiveness from a societal perspective, two additional costs were considered:

1. economic benefit to farms resulting from the interventions[17,18] (The CSA model in particular provides reliable funds to farmers, often early on in the season when other revenue streams like market sales are yet to be realized).
2. work productivity impact due to health outcomes[19,20].

For both the healthcare and societal cost effectiveness perspectives, the Incremental Cost-Effectiveness Ratio (ICER) was calculated as the change in dollars expended from baseline (no intervention) to either the cash influx or subsidized CSA interventions divided by the change in DALYs lost from baseline to the interventions.

Sensitivity analysis included

1. identifying the degree to which the ICER changed at varying intervention participation levels

1. how much more effective the CSA intervention would need to be at changing diet quality than the cash intervention given its higher overhead rate.
2. how much less expensive the CSA intervention would need to be than the cash intervention given its greater impact.
3. estimating the ICER if the intervention only produced behavior change for the initial year of intervention, followed by a return to baseline (pre-intervention) dietary quality.
4. performing probabilistic sensitivity analysis to estimate the distribution around each outcome metric and to plot the cost-effectiveness plane. Input data and statistical code for reproduction of the analyses are available at https://github.com/sanjaybasu/CSA.

The microsimulation model diagram can be seen in Figure 3.

KEY FINDINGS

STUDY

The Study Population

128 individuals enrolled in the study, with six individuals withdrawing prior to the start of the intervention, resulting in an analysis group of 122 (figure 1). Participation as well as adherence to the intervention for those receiving the CSA (successfully picking up their shares of fruits of vegetables) were both considered good - 100 participants (82%) completed the study, and of those receiving the CSA share intervention, the median percentage of CSA shares an individual picked up was 79% (25th percentile: 49%; 75th percentile: 92%). 81% of participants were women; the mean age was 50.2; and the mean income was 146% of the federal poverty line.

The Study Outcomes

The study explored the impact on 3 outcome categories: Diet quality; Participant-Reporting on Food Security and Mental and Physical Well-Being; and anthropometric and biomarker outcomes. See tables 2, 3 and 4 for results.

Diet Quality

Both the cash transfer and CSA interventions saw improvement in HEI score. The cash transfer intervention saw an increase of 7% (95% CI: 3%, 11%) in HEI score, landing at 55.9. Meanwhile, the CSA intervention saw an increase of 13% (95% CI: 9%, 17%) in HEI score, landing at 60.2. A clinically meaningful difference in HEI is 3, and difference found between the CSA and the cash transfer was 4.3. Data used to calculate the HEI total was collected both during the CSA season and between the two CSA seasons encompassed in the study, suggesting that eating habits practiced during the growing season did have staying power beyond the weeks of intervention. The shift in HEI scores could be primarily pointed to two key subscores: the HEI subscore specific to an increase in total vegetables, total fruit and whole fruit, as well as the HEI subscore that reflects a decrease in "empty calories" like sugar-sweetened beverages.

Food Security

CSA intervention participants also experienced a significant decrease in food insecurity with odds ratio: 0.68, 95%CI 0.48 to 0.96. This translates to a 30% reduction in food security odds. Regarding food insecurity, the CSA intervention group once again realized a greater degree of improvement compared to the cash/control group: the CSA saw a 20 point reduction of food insecurity, from 31% to 11%. Meanwhile the cash intervention group saw a reduction of 10 points, from 42% to 32%.

Mental and Physical Well-Being reported by participants, Anthropometrics and biomarkers

CSA intervention participants trended in positive directions for a wide range of self-reporting health and wellness data points as well as for weight, blood pressure and hemoglobin A1c, however apart from diastolic blood pressure which also trended in the right direction, the statistically significant data was limited to the improvement in HEI score and the reduction in food insecurity.

These results support a number of previous bodies of research:

- A "substitution" hypothesis explored why individuals with lower socioeconomic status often purchase food with lesser dietary qualities, concluding these habits were built on the basis of unhealthy foods being less costly than fruits and vegetables.[21]
- A recent randomized trial of food pantry clients with diabetes found that a healthy food box could increase fruit and vegetable consumption.[22]
- The Healthy Incentives Pilot, examining the impact of the state-funded SNAP-matching Healthy Incentives Program, found a similar improvement in the HEI score to the study at hand.[1]

MICROSIMULATION

Key Metrics

Results were reported utilizing four key metrics: first, the change in disability adjusted life years (DALY), second, change in health care costs, third the cost in dollars of each DALY averted, from the healthcare system perspective, and fourth cost in dollars of each DALY averted, from the perspective of society overall (i.e., including factors like worker productivity and agriculture sector benefits). Measurements considered both a 10-year time horizon and a full life-course horizon. See Figure 4a and 4b for negative health outcomes averted over 10 years and life-course.

Broadly speaking and as noted above, both interventions improved HEI, but the CSA intervention proved to have a greater impact on HEI. Further, the CSA intervention resulted in more DALYs averted than the cash intervention, but at a higher cost. Healthcare costs increased by approximately $23,000,000 per 10,000 people over 10 years in the cash intervention and by approximately $50,000,000 per 10,000 people over 10 years in the CSA intervention primarily due to the cost to administer the CSA health intervention (ie: the cost borne by Just Roots of the CSA).

At nearly $63,000 per DALY averted, the CSA intervention healthcare cost is 7% higher than the cash intervention over a 10-year horizon, although the healthcare cost of the two are nearly equal over a life-course horizon. In order to have the same impact as a straight cash intervention, the CSA would have to boost HEI by 20% (as opposed to the 13% measured in the study) or the CSA would have to cost $198 less.

From a societal perspective however, both interventions had a negative incremental cost effectiveness ratio, meaning they saved money for society on a net basis, $155,719 per DALY averted for the cash intervention and $69,570 per DALY averted for the CSA intervention, again the difference due to higher CSA overhead. Breaking the economic benefits of the CSA down on a per CSA basis we found that an annual investment of $600 in the CSA resulted in about $1,000 in cost savings each year to society. These savings take the form of local economic development through farm sustainability, and improved quality of life and ability to remain an active member of the workforce and community due to reduction in disabilities of participants thanks to healthier eating on the part of the CSA participants.

Implications

- The study evaluated the all-inclusive costs of the interventions. As the CSA benefits a wider range of stakeholders, there is more opportunity for the cost of the CSA intervention to be distributed amongst a number of stakeholders (health centers, health insurers, farms, municipalities, private employers, municipalities, etc.). With this cost sharing, the cost to any particular stakeholder may prove a cost savings. Further research or a simulation would need to be completed to verify this.
- This point becomes particularly salient in light of Just Roots efforts to bridge gaps between food programs, health programs

from each segment of social service provision can collectively have a significant impact on feasibility and resulting social benefit. This cross-sectoral approach helps to address the "wrong pocket" problem, where an intervention creates considerable societal benefit but the benefits do not accrue to the intervener or payer (in this case insurance companies). Results demonstrate that the health benefits of the CSA intervention may save society money in the long-run. A cross-sectoral approach that bundles private resources with those from multiple programs (food programs designed in part to boost agriculture, low-income programs designed to address inequities in food access, health programs designed to improve nutrition, and housing programs intended to improve the quality of life and stability of low-income families) can generate broad health and social benefit and reduce the burden to a single payer.

KEY CHALLENGES & LIMITATIONS

STUDY

Primary challenges and limitations revolved around participant enrollment and participation. A predominantly non-hispanic and white, female population was studied as a result of their primary interest in participating. The study was also single-site, limiting the analyses to a small, relatively rural population. Additionally, while study group assignment was masked for outcome assessors, this was not possible for the study participants themselves as the research team met with participants in person. Next, attrition and lower than expected initial recruitment led to the addition of a second cohort of participants, who participated for only one growing season. After analysis, we saw no meaningful differences between the two cohorts, and interaction testing did not suggest effect modification by cohort. Finally, the study was not powered to directly detect differences in outcomes beyond the Healthy Eating Index scores. The additional outcomes being assessed were intended to be inputted into a previously built microsimulation model, but the results were not sufficient to do so, so a new model was built to complete the secondary analyses.

MICROSIMULATION

First and foremost it is important to recognize the limitations of a modeling-based assessment which is subject to the specific data imported. There are three key limitations associated with the micro-simulation model:

- State to national projection: the data from the study we conducted (in Massachusetts) was projected to the whole of the United States.
- Single composite index selected: the simulation exercise uses the Health Eating Index (HEI) to mediate the key health and economic benefits of the intervention. There are alternative composite indices related to long-term cardio-metabolic disease incidence and mortality. [23]
- Intangible societal benefit data lacking: The secondary impacts from a CSA were not surveyed through the study and are not well known/readily quantified. However these benefits are an important component of the true impact results of the CSA intervention, especially from a societal perspective. Results from the Just Roots internal surveying over the years point to such impact, ie: community and relationship building impact.

In addition, neither the study nor the micro-simulation consider the household benefit associated with the CSA intervention as rarely does a CSA impact only one individual. Just Roots internal survey information indicates two and a half persons are impacted per CSA share. Therefore, the impact and cost effectiveness may be far greater than is reflected in our findings and suggests that the resulting cost saving #s may be conservative. Further research would need to be completed to test this hypothesis.

The cost to produce the CSA intervention (OH) was based on one year of fixed and variable cost associated with the Just Roots CSA. Because CSAs are not standardized from farm to farm, we were not able to collect data that helped us to understand whether these costs could be considered an industry standard. Further, costs and efficiencies differ on an annual basis due to a myriad of reasons (ie: weather, fixed costs fluctuations, etc.) and therefore it is difficult to conclude what the average cost of the CSA intervention is in the state or other regions and certainly in the nation.

Finally, it is important to consider, when referencing other research specific to the health impact of the CSA, that at least two key considerations be noted: barriers (affordability, transportation, know-how, etc.) have in large measure prevented socioeconomically disadvantaged populations from participating in CSAs and consequently people who are already healthy and of sound economic means have been the predominant participant in CSAs. Until now, both factors have limited the body of research and our understanding of the CSAs potential health impact.

RECOMMENDATIONS

Given the study and microsimulation both resulted in the conclusion that a subsidized Community Supported Agriculture intervention was effective in improving diet quality and reducing food insecurity among health center patients with BMI > 25 kg/m2, further research should be completed to study the health outcomes associated with the CSA model when utilized in different communities with different populations, as explored to-date only by microsimulation.

With the positive conclusions coming out of the microsimulation, it is recommended that the study be replicated in such a way that offers generalization of the data to other demographics and parts of the country. If future work replicates these findings that show significant improvement to healthy eating, and point to substantial long-term health impacts and societal cost savings, subsidized community supported agriculture may be an important intervention to improve the diet quality, and ultimately the health of socioeconomically vulnerable adults. Finding that the results are robust and have substantial long-term health impacts would have clear implications for health and public policy as well as strong recommendations for investment from local public health and small business groups that could support healthier eating in a community, with subsequent public health benefits and support of the local economy. A number of healthcare plans are experimenting with 'wellness' benefits for beneficiaries, and, in certain circumstances, subsidized CSA membership may fit into this approach.[24–26] As a subsidized CSA intervention could both support healthier eating in a community, with consequent public health and socioeconomic benefits, where the cost savings demonstrated in the microsimulation study currently reside, it is recommended that further research be conducted to better understand the full breadth of potential impact and cost savings associated with the CSA across multiple stakeholders, both public and private.

To that end, during a future phase of research, Just Roots plans to study the marginal cost and benefit to multiple stakeholders in a CSA approach. Given that its farm share program can include cash resources from low-income members, SNAP dollars, private donations, and direct government support, it may be effective to consider the policy case for ongoing partial contributions from various stakeholders and demonstrate to each the marginal benefit of those contributions relative to the policy, business or philanthropic goals of each.

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CONFLICTS OF INTEREST

Jessica O'Neill and Rochelle Belin are employees of Just Roots. Sophie Schouboe and Megan Saraceno were TerraCorps members serving at Just Roots during the time of the study. All other authors declare that they have no conflicts to report.

FOOTNOTES/REFERENCES

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APPENDICES

Table 1: **Baseline Characteristics of Participants**			
	N=122	N=66	N=56
	N (%) or mean (SD)	N (%) or mean (SD)	N (%) or mean (SD)
Cohort B	21 (17.2)	10 (15.2)	11 (19.6)
Age	50.16 (13.77)	51.09 (12.61)	49.07 (15.07)
Female	99 (81.1)	51 (77.3)	48 (85.7)
Race/Ethnicity			
Non-Hispanic white	110 (90.2)	60 (90.9)	50 (89.3)
Non-Hispanic black	3 (2.5)	2 (3.0)	1 (1.8)
Hispanic	2 (1.6)	0 (0.0)	2 (3.6)
Asian/Multi-/Other	7 (5.7)	4 (6.1)	3 (5.4)
Education			
< HS Diploma	7 (7.1)	5 (9.1)	2 (4.5)
HS Diploma	19 (19.2)	10 (18.2)	9 (20.5)
> HS Diploma	73 (73.7)	40 (72.7)	33 (75.0)
Ratio of Income to	1.46 [0.92, 2.45]	1.32 [1.03, 2.26]	1.48 [0.86, 2.48]
Born in US	96 (97.0)	53 (96.4)	43 (97.7)
Receiving SNAP Benefits	47 (39.2)	27 (41.5)	20 (36.4)
Food Insecure	44 (36.7)	27 (41.5)	17 (30.9)
Cost-Related Medication	23 (19.2)	15 (23.1)	8 (14.5)
Put off Buying	18 (15.0)	10 (15.4)	8 (14.5)
PROMIS-10 Global Raw	32.19 (6.51)	32.17 (6.68)	32.22 (6.36)
PROMIS 4-item	7.76 (3.33)	7.88 (3.60)	7.62 (3.03)
PROMIS 4-item Anxiety	7.51 (3.00)	7.66 (3.04)	7.33 (2.97)

Table 1 Cont.

HEI Total Score	54.93 (15.29)	53.96 (15.48)	56.07 (15.12)
HEI 1 Score	3.29 (1.73)	3.22 (1.84)	3.36 (1.61)
HEI 2 Score	2.04 (2.32)	2.20 (2.36)	1.85 (2.29)
HEI 3 Score	2.54 (2.13)	2.17 (2.08)	2.98 (2.12)
HEI 4 Score	2.82 (2.29)	2.44 (2.28)	3.27 (2.23)
HEI 5 Score	2.98 (3.84)	3.16 (3.83)	2.77 (3.87)
HEI 6 Score	5.53 (3.51)	5.89 (3.30)	5.12 (3.74)
HEI 7 Score	4.01 (1.52)	3.88 (1.67)	4.17 (1.32)
HEI 8 Score	2.60 (2.31)	2.60 (2.26)	2.62 (2.39)
HEI 9 Score	4.76 (3.53)	4.91 (3.50)	4.59 (3.60)
HEI 10 Score	4.61 (3.62)	4.34 (3.57)	4.94 (3.68)
HEI 11 Score	6.68 (3.59)	6.39 (3.98)	7.04 (3.07)
HEI 12 Score	13.05 (6.15)	12.77 (6.47)	13.38 (5.80)
Weight, kg	92.02 (20.86)	94.22 (23.97)	89.42 (16.29)
BMI, kg/m2	33.91 (7.91)	34.50 (7.83)	33.21 (8.02)
Systolic Blood Pressure,	127.79 (19.82)	124.67 (17.87)	131.55 (21.53)
Diastolic Blood Pressure,	77.99 (12.48)	75.62 (11.35)	80.85 (13.28)
Serum Glucose, mg/dL	110.92 (46.82)	107.96 (48.37)	114.79 (44.99)
Hemoglobin A1c, %	5.72 (1.22)	5.68 (1.25)	5.78 (1.18)
High-density Lipoprotein	56.76 (16.48)	58.11 (18.20)	54.93 (13.82)
Low-density Lipoprotein	109.70 (41.84)	110.65 (43.86)	108.39 (39.44)
Total Cholesterol, mg/dL	197.07 (44.36)	197.91 (46.53)	195.93 (41.75)
Triglycerides, mg/dL	168.82 (154.38)	152.55 (78.94)	190.92 (218.36)

Table 2: HEI Results			
Score range in			
	Intervention	Control	P for difference
HEI Total (0-100)	60.2	55.9	0.03
Adequacy Scores (higher score indicates greater consumption)			
HEI 1: TOTAL	4.2	3.7	0.008
HEI 2: GREENS AND	2.7	2.3	0.16
HEI 3: TOTAL FRUIT	3.2	2.2	<.0001
HEI 4: WHOLE FRUIT	3.1	2.4	0.007
HEI 5: WHOLEGRAIN	2.9	3.0	0.99
HEI 6: TOTAL DAIRY	5.1	5.6	0.23
HEI 7: TOTAL	4.2	4.2	0.95
HEI 8: SEAFOOD	3.0	2.6	0.19
Moderation Scores (higher score indicates lower consumption)			
HEI 9: FATTY ACIDS	5.4	5.0	0.27
HEI 10: SODIUM	3.5	3.9	0.23
HEI 11: REFINED	7.7	7.6	0.61
HEI 12: 'EMPTY'	15.1	13.4	0.01

Score range in parentheses. Higher score always represents 'better' consumption (e.g., a higher Empty Calories score represents lower consumption of 'empty' calories)

Table 3: Anthropometrics and Biomarkers				
	Difference in Means*	Lower 95% Confidence Interval	Upper 95% Confidence Interval	p-value for difference
Weight, kg	-1.56	-3.79	0.67	0.17
BMI, kg/m²	-0.43	-1.52	0.66	0.44
Systolic Blood Pressure, mm Hg	-1.68	-6.08	2.72	0.45
Diastolic Blood Pressure, mm Hg	-3.66	-6.27	-1.05	0.01
Serum Glucose, mg/dL	1.45	-12.81	15.71	0.84
Hemoglobin A1c, %**	-0.25	-1.10	0.59	0.55
High-density Lipoprotein Cholesterol, mg/dL	-0.86	-2.30	0.58	0.24
Low-density Lipoprotein Cholesterol, mg/dL	2.28	-3.93	8.49	0.47
Total Cholesterol, mg/dL	3.55	-3.83	10.92	0.35
Triglycerides, mg/dL	13.11	-5.30	31.52	0.16

*Control group is reference category for all comparisons
**Among participants with Hemoglobin A1c > 6.5% at baseline

Table 4: Participant Reported Outcomes				
	Difference in Means	Lower 95%	Upper 95%	p-value for
Food Insecurity	0.68	0.48	0.96	0.03
PROMIS-10 Global	0.19	-0.72	1.11	0.68
PROMIS 4-item	-0.57	-1.31	0.18	0.13
PROMIS 4-item	-0.53	-1.21	0.16	0.13
Cost-Related	1.01	0.66	1.53	0.97
Put off Buying	0.73	0.48	1.11	0.14

*Control group is reference category for all comparisons. Food insecurity, cost-related medication underuse, and putting off buying medications to afford food are presented as odds ratios. PROMIS (patient reported outcome measurement information system) scores are presented as differences in means.

Table 5: Data Sources and Input Parameters		
Baseline Risk		
Data type	*Parameters*	*Sources*
Demographics	Age	NHANES (2013-2016)[12]
Nutrition profile	Macronutrients, micronutrients in Healthy Eating Index: Total fruit, Whole fruit, Total vegetables, Greens and beans, Whole grains, Dairy, Total protein foods, Seafood and plant proteins, Fatty acids, Refined grains, Sodium, Added sugars, Saturated fats	NHANES (2013-2016)[12], USDA (for Healthy Eating Index) [27,28]
Biomedical profile	Body mass index, blood pressure, lipid profile, diabetes status, hemoglobin A1c, renal biomarkers, tobacco smoking status, cardiovascular disease history, cardiovascular and diabetes medications	NHANES (2013-2016)[12]
Atherosclerotic cardio-vascular disease risk	Revised pooled cohort equations	Yadlowsky et al.[13]
Diabetes incidence	Incidence by age, sex, and race/ethnicity	Centers for Disease Control and Prevention[29]
Diabetes complication risk	Risk Equations for Complications of type 2 Diabetes (RECODe) for: end-stage renal disease, neuropathy, and retinopathy	Basu et al.[14,15]
All-cause mortality risk	Risk Equations for Complications of type 2 Diabetes (RECODe)	Basu et al.[14,15]
Life-course years remaining	Years remaining by age, sex, and race/ethnicity	Centers for Disease Control and Prevention[30]
Effectiveness Analyses: change in outcome per 10% increase in diet quality		
Outcome	*Hazard Ratio*	*Sources*
Atherosclerotic cardio-vascular disease incidence	0.96 (95% CI: 0.92, 0.99)	Sotos-Prieto et al.[31]
Type 2 diabetes incidence	0.84 (95% CI: 0.78, 0.90)	Ley et al.[32]
All-cause mortality	0.92 (95% CI: 0.89, 0.94)	Sotos-Prieto et al.[23]
Change in hemoglobin A1c	-0.32 percentage points (95% CI: -0.41, -0.23)	Schwingshackl et al.[33]
--end-stage renal disease, conditional on type 2 diabetes	0.98 (95% CI: 0.97, 0.99) per 1% decrease in hemoglobin A1c	UKPDS Group[34] Vijan et al.[35]
--Neuropathy, conditional on type 2 diabetes	0.93 (95% CI: 0.90, 0.96) per 1% decrease in hemoglobin A1c	UKPDS Group[34] Vijan et al.[35]
--Retinopathy, conditional on type 2 diabetes	0.86 (95% CI: 0.79, 0.93) per 1% decrease in hemoglobin A1c	UKPDS Group[34] Vijan et al.[35]

Table 5 Cont.

Cost-effectiveness		
Input	*Value*	*Source*
Incident atherosclerotic cardiovascular disease event	Disutility: 0.28 (95% CI: 0.06, 0.57)	Global Burden of Disease[16]
Incident uncomplicated case of type 2 diabetes	Disutility: 0.01 (95% CI: 0.00, 0.02)	Global Burden of Disease[16]
Incident renal failure/end-stage renal disease	Disutility: 0.57 (95% CI: 0.40, 0.75)	Global Burden of Disease[16]
Incident neuropathy	Disutility: 0.10 (95% CI: 0.05, 0.20)	Global Burden of Disease[16]
Incident retinopathy	Disutility: 0.20 (95% CI: 0.10, 0.40)	Global Burden of Disease[16]
Subsidized CSA intervention	Cost: $300 + $271 (90.3%) overhead rate, per annum, healthcare and societal perspective	Just Roots Randomized Clinical Trial[36]
Unconditional cash transfer	Cost: $300 + $50 (16.7%) overhead rate, per annum, healthcare and societal perspective	Just Roots Randomized Clinical Trial[36]
Incident atherosclerotic cardiovascular disease event	Cost: $61,614 (95% CI: $61,095, $62,132) per event, healthcare and societal perspective	Optum Clinformatics Database
Incident uncomplicated case of type 2 diabetes	Cost: $22,526 (95% CI: $21,919, $23,132) per event, healthcare and societal perspective	Optum Clinformatics Database
Incident renal failure/end-stage renal disease	Cost: $293,490 95% CI: $290,584, $296,396) per annum, healthcare and societal perspective	Optum Clinformatics Database
Incident neuropathy	Cost: $48,432 (95% CI: $46,470, $50,393) per annum, healthcare and societal perspective	Optum Clinformatics Database
Incident retinopathy	Cost: $26,174 (95% CI: $25,578, $26,769) per annum, healthcare and societal perspective	Optum Clinformatics Database
Economic benefit to farms	Benefit: $426/person/year for unconditional cash transfer (95% CI: $396, $570), societal perspective only Benefit: $558/person/year for subsidized CSA (95% CI: $519, $747), societal perspective only	Hardesty et al.[17] NCSU[18]
Lost productivity	Cost: $1,085 for each cardiovascular disease event (95% CI: $521, $1,649), societal perspective only Cost: $5,811 for each complication of diabetes (95% CI: $2,571, $9,052), societal perspective only	Song et al.[19] Ng et al.[20]

Table 6: Descriptive statistics on the study sample. Statistics describe properties of the unweighted NHANES study sample (2013-2016) after applying the inclusion criteria of: household income <200% of the federal poverty level or enrollment in Medicaid health insurance, and a body mass index of 25 kg/m^2 or greater (N=73,248).

Characteristic	**Mean (interquartile range)**
Age, yrs	58.1 (47.0, 71.0)
Female, %	55.9
Black, %	19.7
Hispanic, %	12.8
Income, % of federal poverty level	113.4 (73.0, 148.0)
Healthy Eating Index, score (0 to 100)	51.2 (40.4, 61.0)
Body mass index (kg/m^2)	33.2 (28.1, 36.2)
Systolic blood pressure, mmHg	128.2 (116.0, 138.0)
Total cholesterol, mg/dL	184.0 (156.0, 207.0)
High-density lipoprotein cholesterol, mg/dL	50.4 (41.0, 58.0)
Diabetes, %	39.3
Hemoglobin A1c, %	6.3 (5.5, 6.5)
Serum creatinine, mg/dL	1.0 (0.7, 1.0)
Urine microalbumin:creatinine ratio	105.0 (5.6, 24.9)
Current tobacco smoker, %	21.8
Cardiovascular disease history, %	9.0
Blood pressure treatment, %	62.4
Statin treatment, %	7.1
Diabetes treatment, %	4.4
Anticoagulation treatment, %	0.6

Table 7: Cost-effectiveness analysis. Discounted disability-adjusted life-years (DALYs) and costs, from a healthcare and societal perspective, estimated under the baseline (pre-intervention), cash intervention, and community-supported agriculture (CSA) intervention scenarios over 10-year and life-course time horizons. DALYs and costs were discounted at a 3% annual rate. The societal perspective includes cost-savings due to increased agricultural economic sector profits and workplace productivity attributable to lower disease events.						
Time horizon:	**10-year**			**Life-course**		
Simulation:	**Baseline**	**Cash**	**CSA**	**Baseline**	**Cash**	**CSA**
DALYS lost, mean (95% CI) per 10,000 population						
Atherosclerotic cardiovascular disease events	2,256 (2,244, 2,273)	2,138 (2,215, 2,158)	2,039 (2,027, 2,058)	6,469 (6,434, 6,511)	6,122 (6,083, 6,163)	5,829 (5,788, 5,871)
Incident diabetes	214 (205, 222)	179 (172, 188)	153 (145, 161)	1,344 (1,316, 1,374)	1,141 (1,115, 1,167)	972 (947, 992)
End-stage renal disease	512 (503, 522)	504 (493, 515)	495 (485, 505)	2,524 (2,498, 2,548)	2,431 (2,397, 2,455)	2,355 (2,322, 2,383)
Diabetic neuropathy	1,253 (1,237, 1,269)	1,181 (1,170, 1,197)	1,121 (1,107, 1,134)	4,428 (4,391, 4,459)	4,148 (4,112, 4,182)	3,907 (3,872, 3,937)
Diabetic retinopathy	957 (947, 968)	895 (883, 908)	845 (833, 855)	3,457 (3,420, 3,490)	3,217 (3,188, 3,345)	3,010 (2,980, 3,038)
All-cause mortality	3,085 (3,059, 3,112)	2,955 (2,925, 2,983)	2,837 (2,808, 2,868)	6,574 (6,526, 6,620)	6,404 (6,346, 6,454)	6,231 (3,872, 3,937)
Total	8,277 (8,195, 8,366)	7,854 (7,768, 7,950)	7,490 (7,405, 7,580)	24,797 (24,584, 25,001)	23,463 (23,241, 23,666)	22,304 (22,084, 22,510)
Healthcare costs (economic losses), mean $ (95% CI) per 10,000 population						
Intervention costs, including overhead	-	$33078562 (33066714, 33090188)	$53785489 (53767247, 53804471)	-	$88943154 (88906685, 88978752)	$144488911 (14438151, 144546524)
Atherosclerotic cardiovascular disease events	$63700963 (63286801, 64070267)	$59932729 (59523066, 60298161)	$61672426 (61288116, 6202919)	$87975145 (87539516, 88380198)	$82811501, 82455648, 83168305)	$85201361 (84764298, 85596195)
Incident diabetes	$8677620 (8568758, 8789768)	$6867224 (6772852, 6957762)	$7694248 (7606733, 7803294)	$15679192 (15595512, 15776491)	$12614572 (12523485, 12701533)	$14051013 (13969713, 14140246)
End-stage renal disease	$42842078 (42162598, 43544550)	$42264501 (41340557, 43040046)	$42638875 (41740179, 43502642)	$76204249 (75324273, 77144071)	$73140934 (72239092, 74051752)	$74440930 (73536997, 75357744)

Table 7 Cont.

Diabetic neuropathy	$37359456 (37096981, 37660528)	$36099172 (35816906, 36370305)	$36691082 (36354594, 36967804)	$55039850 (54794722, 44315650)	$52634453 (52329595, 52943611)	$53743086 (53450491, 54059025)
Diabetic retinopathy	$12050585 (11953704, 12142211)	$11270420 (11155492, 11372047)	$11630054 (115116153, 11731171)	$18447844 (18297081, 18600935)	$17084975 (16965593, 17201551)	$17716022 (17597382, 17830793)
Total	$164630701 (157779143, 166207324)	$189512608 (187675587, 191128508)	$214112174 (212273022, 215830300)	$253346281 (251551103, 255217345)	$327229589 (235420098, 329044504)	$389641323 (387757033, 391530526)
Societal savings						
Agricultural sector net profit gains	-	$40261324 (40246904, 40275474)	$52560960 (52543134, 52579509)	-	$108256494 (108212106, 108299821)	$141199345 (141149742, 141255647)
Disease-related economic productivity gains	-	$50586911 (50336678, 50856308)	$51680227 (51441253, 51938814)	-	$220580312 (219435117, 221590145)	$227440648 (226355132, 228542270)
Total	-	$90848235	$104241187	-	$328836805	$368639993

Table 8: Revised Pooled Cohort Equations for atherosclerotic cardiovascular disease to predict risk of myocardial infarction or stroke.27 Displayed are risk equations for a 10-year time horizon, which were scaled using an exponential decay function to estimate life-course risk. Example is shown for a nonsmoking black adult aged 55 y without diabetes who has a total cholesterol level of 5.52 mmol/L (213 mg/dL), high-density lipoprotein cholesterol level of 1.29 mmol/L (50 mg/dL), and untreated systolic blood pressure of 120 mm Hg. An online calculator is available at https://sanjaybasu.shinyapps.io/ascvd.

Variable	Coefficient	Example	Coefficient
Women			
(Intercept)	−12.823110	–	−12.823110
Age	0.106501	55	5.857555
Black race (1/0 for black/white)	0.432440	1	0.432440
Systolic blood pressure (mm Hg) squared	0.000056	14 400	0.806400
Systolic blood pressure	0.017666	120	2.119920
Taking blood pressure medication (1/0 for yes/no)	0.731678	–	0.000000
Diabetes mellitus (1/0 for yes/no)	0.943970	–	0.000000
Current smoker (1/0 for yes/no)	1.009790	–	0.000000
Ratio of total cholesterol (mg/dL) to high-density lipoprotein cholesterol (mg/dL)	0.151318	4.26	0.644615
Age if black (0 if not)	−0.008580	55	−0.471900
Systolic blood pressure if taking blood pressure medication (0 if not)	−0.003647	–	0.000000
Systolic blood pressure if black (0 if not)	0.006208	120	0.744960
Black race and taking blood pressure medication (1/0 for yes/no)	0.152968	–	0.000000
Age × systolic blood pressure	−0.000153	6600	−1.009800
Black race and diabetes mellitus (1/0 for yes/no)	0.115232	–	0.000000
Black race and current smoker (1/0 for yes/no)	–0.092231	–	0.000000
Ratio of total cholesterol to high-density lipoprotein cholesterol if black	0.070498	4.26	0.300321
Systolic blood pressure if black and taking blood pressure medication	−0.000173	–	0.000000
Age × systolic blood pressure if black (0 if not)	−0.000094	6600	−0.620400
Sum of terms	–	–	−4.018999
10-y probability of ASCVD event =	–	–	0.017654

Table 8 Cont.

Men			
(Intercept)	−11.679980	–	−11.679980
Age	0.064200	55	3.531000
Black race (1/0 for black/white)	0.482835	1	0.482835
Systolic blood pressure (mm Hg) squared	−0.000061	14 400	−0.878400
Systolic blood pressure	0.038950	120	4.674000
Taking blood pressure medication (1/0 for yes/no)	2.055533	–	0.000000
Diabetes mellitus (1/0 for yes/no)	0.842209	–	0.000000
Current smoker (1/0 for yes/no)	0.895589	–	0.000000
Ratio of total cholesterol (mg/dL) to high-density lipoprotein cholesterol (mg/dL)	0.193307	4	0.773228
Systolic blood pressure if taking blood pressure medication (0 if not)	−0.014207	–	0.000000
Systolic blood pressure if black (0 if not)	0.011609	120	1.393080
Black race and taking blood pressure medication (1/0 for yes/no)	−0.119460	–	0.000000
Age × systolic blood pressure	0.000025	6600	0.165000
Black race and diabetes mellitus (1/0 for yes/no)	−0.077214	–	0.000000
Black race and current smoker (1/0 for yes/no)	−0.226771	–	0.000000
Ratio of total cholesterol to high-density lipoprotein cholesterol if black	−0.117749	4.26	−0.501611
Systolic blood pressure if black and taking blood pressure medication (0 if not)	0.004190	–	0.000000
Age × systolic blood pressure if black (0 if not)	−0.000199	6600	−1.313400
Sum of terms	–	–	−3.354248
10-y probability of ASCVD event =	–	–	0.033756 (3.4%)

Table 9: RECODe equations (Risk Equations for Complications of type 2 Diabetes) to estimate risk of diabetes-contingent end-stage renal disease/renal failure, neuropathy as defined by pressure sensation loss by 10g monofilament testing, retinopathy as defined by severe vision loss (<20/200 visual acuity by Snellen chart), and all-cause mortality.28,29 Displayed are risk equations for a 10-year time horizon, which were scaled using an exponential decay function to estimate life-course risk. Blank cells indicate that the particular covariate is not included in the given equation.

Covariate	Renal	Severe vision loss	Pressure sensation loss	All-cause mortality
Age, years	−0.01938	0.02285	0.03022	0.06703
Women	−0.01129	0.2264	−0.18680	-0.15290
Black	0.08812	−0.16770	−0.09448	-0.02393
Hispanic or Latino	0.2338	-	-	
Tobacco smoking, current	0.1483	-	-	0.53990
Systolic blood pressure, mm Hg	0.00303	0.00824	0.00456	-0.00299
Cardiovascular disease history	−0.02164	0.1127	0.26672	0.58880
Blood pressure- lowering drugs	−0.07952	0.06393	0.18192	0.08776
Statins				-0.26810
Oral diabetes drugs	−0.12560	−0.23490	−0.25747	
Anticoagulants	0.03199			0.40360
HbA1c, %	0.1369	0.1449	0.18866	0.16590
Total cholesterol, mg/dL	−0.00111	−0.00017	0.00219	-0.00095
HDL cholesterol, mg/dL	0.00629	0.00545	−0.00539	-0.00438
Serum creatinine, mg/dL	0.8609	0.6947	0.60442	0.35970
Urine albumin:creatinine ratio, mg/g	0.00036	0.0002	-	0.00039

Figure 1: Study Design

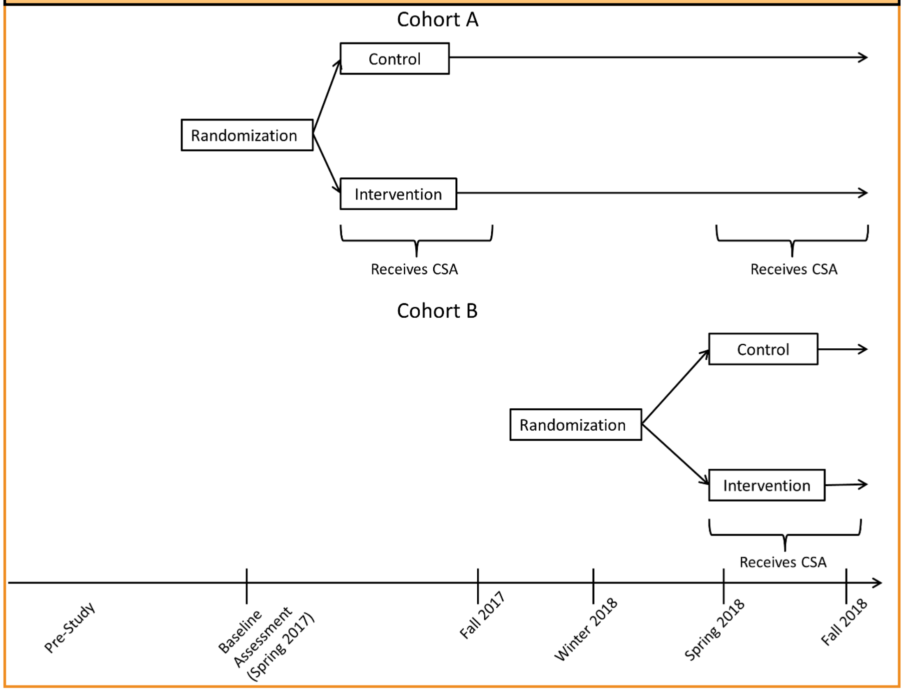


Figure 2: Calculating DALYs (figure from wikipedia)

Figure 3: Model Diagram

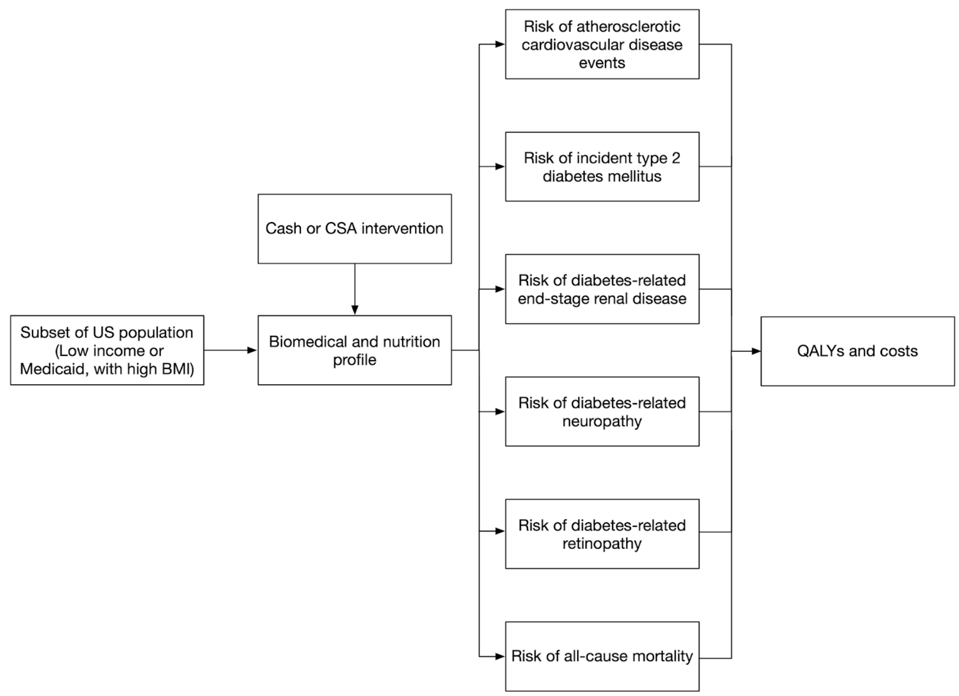
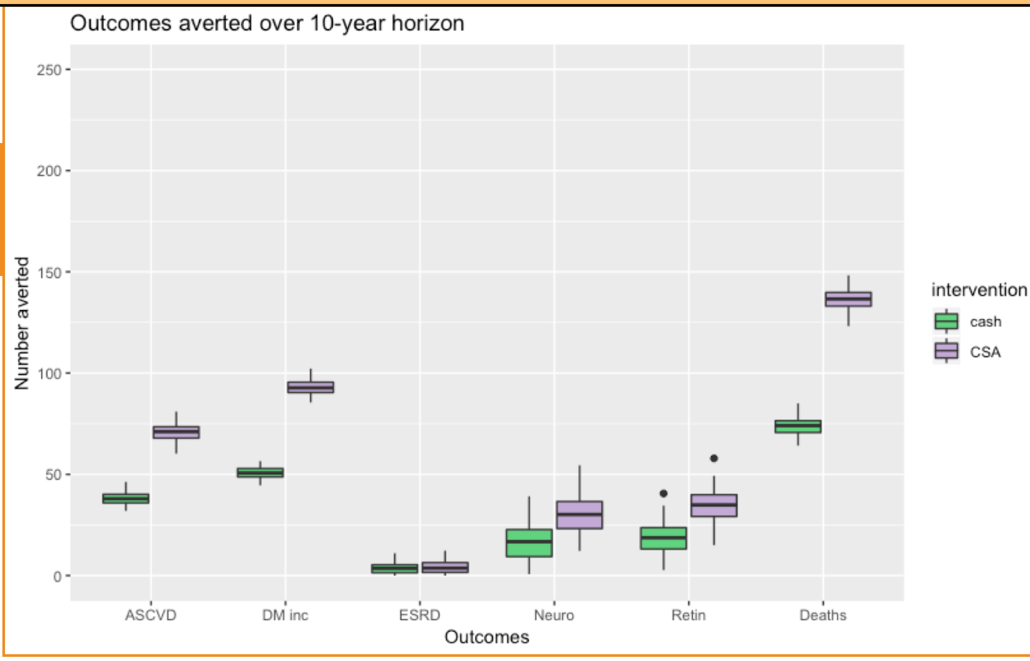


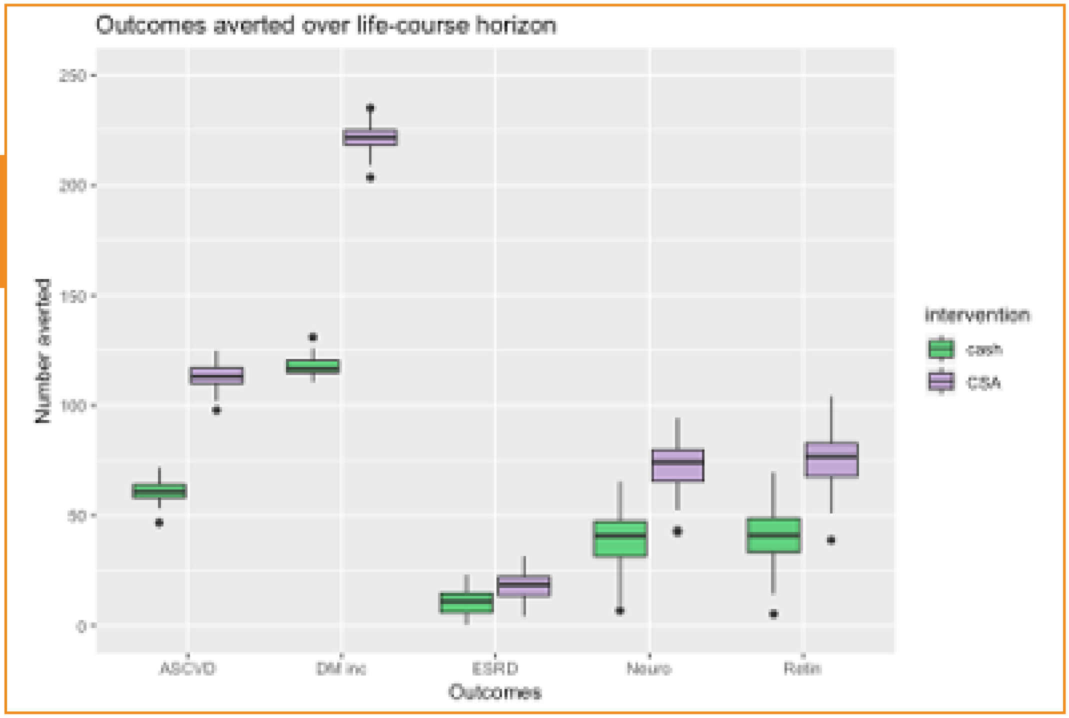
Figure 4: Averted disease outcomes. Reduction in disease outcomes from cash and community supported agriculture (CSA) interventions over (A) 10-year and (B) life-course time horizons. Boxplots display the interquartile range (box), median (bold horizontal line), 1.5 times the interquartile range (whiskers), and outliers (points).

Legend: ASCVD = atherosclerotic cardiovascular disease events (myocardial infarctions and strokes), DM inc = incident type 2 diabetes mellitus, ESRD = diabetes-related end-stage renal disease/renal failure; Neuro = diabetes-related neuropathy; Retin = diabetes-related retinopathy; Death = all-cause mortality.

A



B


Outcomes averted over life-course horizon
250
200
150
100
50
0
Number averted
ASCVD
DM inc
ESRD
Neuro
Retin
Outcomes
intervention
cash
CSA