Nutrition Education and Obesity Prevention in Los Angeles County

Final Report for the Evaluation of the Local Supplemental Nutrition Assistance Program Education (SNAP-Ed) Efforts

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UCLA CENTER FOR HEALTH POLICY RESEARCH

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Executive Summary

Nutrition Education and Obesity Prevention in Los Angeles County: The Local Supplemental Nutrition Assistance Program Education (SNAP-Ed) Efforts

The Los Angeles County Department of Public Health (LACDPH), Division of Chronic Disease and Injury Prevention receives United States Department of Agriculture (USDA) funding through the California Department of Public Health to implement the Supplemental Nutrition Assistance Program Education (SNAP-Ed) project in Los Angeles County. SNAP-Ed, formerly known as the Nutrition Education and Obesity Prevention (NEOP) program, supports strategies that promote healthy eating, active living, and healthy and safe environments. Alongside traditional nutrition education services, recent SNAP-Ed efforts have sought to identify complementary ways to improve health, through policy, systems, and environmental (PSE) change strategies that promote healthy behaviors among adults and children who have limited access to nutritious foods. Interventions are tailored to these strategies with the intent to empower and enable underserved residents with limited resources to select healthy foods and beverages, and to increase their physical activity levels.

Evaluation Approach

SNAP-Ed involves the implementation of traditional nutrition education services and a series of policy, systems, and environmental (PSE) change strategies. These PSE strategies are achieved through community-based interventions that were implemented in Los Angeles County during the Federal Fiscal Year 2014-2016 grant cycle. They include: establishing childcare policies, implementing school wellness policies, entering into shared use agreements, creating healthy retail or restaurant environments, building community gardens, establishing farmers' markets, developing healthy worksite programs, creating structured physical activity programs, promoting active transportation, and establishing healthy food and beverage standards in large food venues. In the present program evaluation, five strategies were examined: nutrition education, farmers' markets, healthy retail, community gardens, and healthy food and beverage standards. LACDPH contracted with the UCLA Center for Health Policy Research (CHPR) to conduct this evaluation. The evaluation assessment focuses on two of the high needs Service Planning Areas (SPAs) in Los Angeles County, SPA 4 and SPA 6. It addresses the following questions:

1. What is the prevalence of chronic health conditions, including obesity and related health behaviors in Los Angeles County by SPA, especially in the two selected high needs areas?

2. What are the size, scope, investment and estimated reach of the SNAP-Ed strategies implemented to date in SPA 4 and SPA 6?
3. What is the estimated impact of these strategies in SPAs 4 and 6 if they were sustained over the next 25 years?
4. What, if any, economic gains are expected from the investment in these strategies in SPA 4 and SPA 6?

To answer these questions, CHPR analyzed population-based survey data, synthesized program data provided by LACDPH, developed agent-based models (ABM) to simulate impacts, and conducted a return of investment analysis of SNAP-Ed. CHPR's final report to LACDPH describes the methods and results of these analyses.

Key Findings

- In overall county comparisons, the prevalence of obesity is highest in SPA 6 where 40% of adults are obese, as compared to the lowest prevalence in SPA 5 (18% of adults are obese).
- SPAs 4 and 6 have the highest poverty rates in Los Angeles County (both around 28 percent) as well as the highest rates of SNAP eligibility (46 and 51 percent, respectively).
- One hundred eight sites in SPAs 4 and 6 provided direct nutrition education services, reaching more than 12,000 program participants.
- A total of seven farmers' markets implemented farmers' market strategies in SPAs 4 and 6.
- Healthy corner store makeovers were implemented at 18 stores in the two SPAs (4 and 6).
- Seventeen community gardens were developed in SPAs 4 and 6.
- Healthy food and beverage standards were established at 23 organizations in SPAs 4 and 6
- In SPA 4, the estimated prevalence of obesity in 2040 is 50% in the control scenario, as compared to 45% in the SNAP-Ed intervention scenario.
- In SPA 6, the estimated prevalence of obesity in 2040 is 58% in the control scenario, as compared to 54% in the SNAP-Ed intervention scenario.
- Cost analyses estimate a return on investment (ROI) of 29.75 for strategy interventions implemented in SPA 4 and 8.37 for strategy interventions implemented in SPA 6.

Conclusions and Implications

The SNAP-Ed project in Los Angeles County has the overarching goal of reducing obesity and other diet-related chronic diseases among Supplemental Nutrition Assistance Program (SNAP) participants and SNAP-eligible populations. The ABM results suggest that the SNAP-Ed strategy interventions that were examined would result in lower rates of obesity by 2040 relative to the control scenarios in which these strategy interventions were not implemented. Specifically, the estimated prevalence of obesity in 2040 for the two high needs, low-income areas of Los Angeles County (SPAs 4 and 6) was 50% and 58%, respectively, in the control scenarios, but

were 45% and 54%, respectively, in the SNAP-Ed intervention scenarios. These results also suggest that the interventions implemented in SPAs 4 and 6 would result in savings relative to program costs. Combined with traditional evaluation methods, ABM was used in these analyses. In general, ABM provides a useful tool for understanding interactions and outcomes of these multi-faceted interventions within complex dynamic systems. Estimating impacts of these complex interventions, especially over the long term, is an important endeavor and can help inform existing and future prevention program planning and investments.

Table of Acronyms

ABM – Agent-Based Model
CDPH – California Department of Public Health
CHIS – California Health Interview Survey
FPL – Federal Poverty Level
LACDPH – Los Angeles County Department of Public Health
PSE – Policy, Systems, and Environmental Change(s)
SNAP – Supplemental Nutrition Assistance Program
SNAP-Ed – Supplemental Nutrition Assistance Program Education
SPA – Service Planning Area
USDA – United States Department of Agriculture

Supplemental Nutrition Assistance Program Education (SNAP-Ed): Context and Overview

In response to the national obesity epidemic and its broad impact on population health and health care expenditures, the Los Angeles County Department of Public Health (LACDPH), Division of Chronic Disease and Injury Prevention received USDA funding through the California Department of Public Health to support the Supplemental Nutrition Assistance Program Education (SNAP-Ed) project in Los Angeles County. SNAP-Ed supports local partners to implement strategies that promote healthy eating, active living, and healthy and safe environments. Alongside traditional nutrition education services, recent SNAP-Ed efforts have sought to identify complementary ways to improve health, through policy, systems, and environmental (PSE) change strategies that promote healthy behaviors among adults and children who have limited access to nutritious foods. Interventions are tailored to these strategies with the intent to empower and enable underserved residents with limited resources to select healthy foods and beverages, and to increase their physical activity levels.

Obesity Prevalence and Trends in the U.S., California, and Los Angeles County

Over the past 30 years, obesity prevalence among both adults and youth in the United States has increased significantly.[1] In the 1970s, approximately 15 percent of adults were obese; by 2004, the rate had increased to 32 percent.[1] Although the prevalence of obesity among youth is lower than among adults, children and adolescents have experienced considerably larger increases in obesity prevalence. Between the early 1970s and 2003-2004, the prevalence of obesity nearly tripled among youth ages 12 to 19, from 6 percent to 17 percent, and more than quadrupled among children ages 6 to 11, rising from 4 percent to 19 percent.[1-4] Nationally, the prevalence of obesity among adults and youth has not changed significantly since 2004, but rates remain high.[5] The most recent data from the National Health and Nutrition Examination Survey indicated that among adults, approximately 38 percent were obese in 2013-14. Among youth, 18 percent of those ages 6 to 11 were obese in 2013-14, as were 21 percent of those ages 12 to 19.

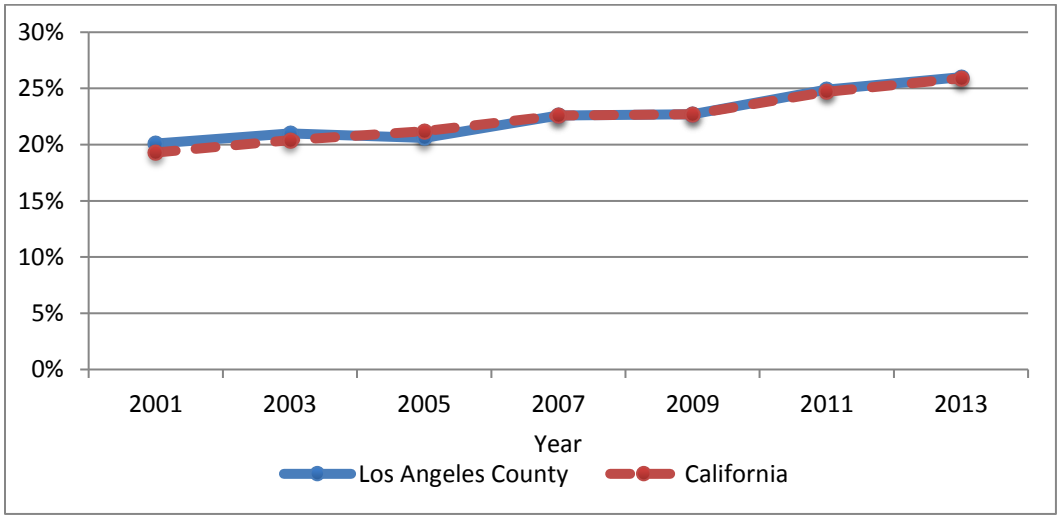
Obesity is a significant risk factor for serious health conditions, including type 2 diabetes, heart disease, stroke, and some cancers. In addition to increasing the risk for serious health conditions, obesity is costly. In 2008, the Centers for Disease Control and Prevention estimated

the annual medical costs of obesity in the United States at $147 billion.[6] In California alone, overweight and obesity are estimated to cost more than $21 billion each year.[7]

In California, the prevalence of obesity among adults increased by more than 34 percent between 2001 and 2014 (

Exhibit 1). In 2013-14, more than one quarter of adults (26 percent) were obese, significantly higher than in 2001 (19 percent). A similar pattern is seen in Los Angeles County, where 26 percent of adults were obese in 2013-14 compared to one-fifth of adults (20 percent) in 2001.

Exhibit 1. Prevalence of Obesity in Los Angeles County and California, Adults age 18 and over, 2001-2014

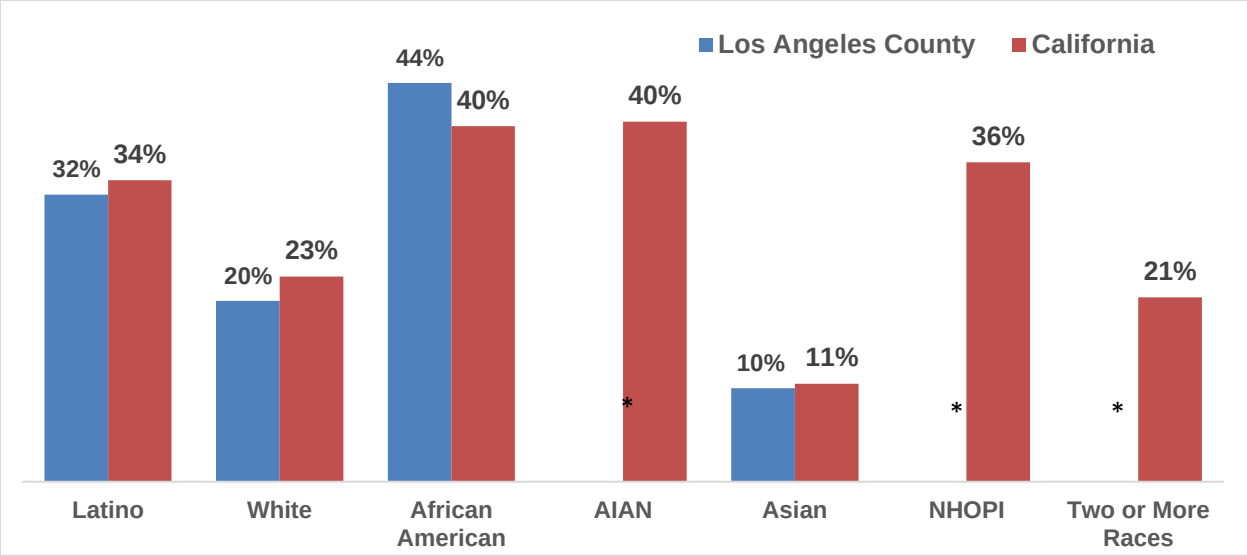


Source: California Health Interview Survey, 2001-2014.

Variation by Race/ethnicity

Nationally, obesity disproportionately affects African Americans and Latinos.[8] Among California adults, the prevalence of obesity was higher among American Indians, African Americans, and Latinos than among whites, and the prevalence was lower among Asians than whites (Exhibit 2). Similar disparities are observed in Los Angeles County. Specifically, African-American and Latino adults had higher obesity prevalence than white adults.

Exhibit 2 Prevalence of Obesity by Race and Ethnicity, Adults age 18 and over, Los Angeles County and California, 2013-14



Source: 2013-14 California Health Interview Survey.
Note: * Indicates the estimate was not statistically reliable. AIAN refers to American Indian or Alaska Native. NHOPI refers to Native Hawaiian or Pacific Islander.

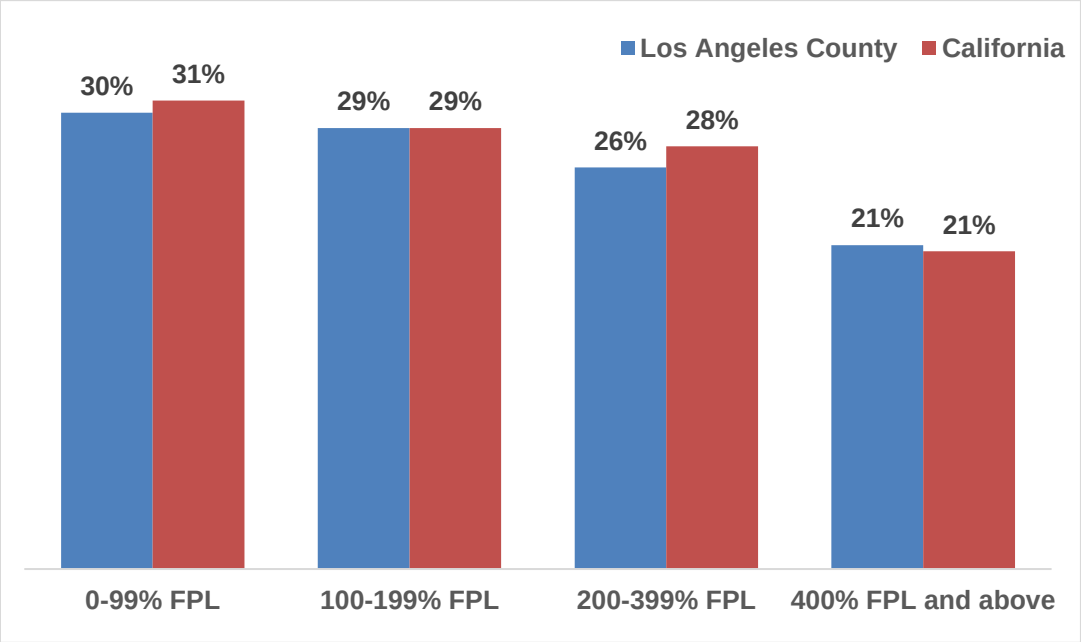
Variation by Income

Obesity disproportionately affects California's poorest individuals. Adults living below 100% FPL had a higher prevalence of obesity (31 percent) than their higher income counterparts (21 percent). A similar pattern is seen in Los Angeles County (Exhibit 3).

Access to Healthy Food Options

Some of these disparities in obesity may be related to differences in the availability of healthy food options in the neighborhood.[9] Poor dietary behaviors are associated with higher rates of obesity, and a number of research studies have found that access to healthy food options is associated with healthier eating behaviors.[10-16] For example, studies have found that the presence of supermarkets, grocery stores, and produce markets is associated with greater consumption of fresh fruits and vegetables.[13,16] Research has also shown that availability of farmer's markets is positively associated with consumption of fruits and vegetables.[15] Moreover, availability of stores that regularly offer fresh produce varies with neighborhood income and racial/ethnic composition.[17-19] Research suggests that residents of low-income neighborhoods or those living in communities of color have fewer options for purchasing healthy foods.[17-19] These findings suggest that residents of low-income neighborhoods may be at greater risk for obesity in part because they lack access to healthier food options.

Exhibit 3. Prevalence of Obesity by Income as Percent of Federal Poverty Level, Adults age 18 and over, Los Angeles County and California, 2013-14



Source: 2013-14 California Health Interview Survey.

Note: Income is presented as percent of Federal Poverty Level (FPL).

Overview of SNAP-Ed Strategy Intervention Efforts

Nutrition Education

LACDPH has implemented community-based Nutrition Education with the goal of improving food and physical activity choices by delivering evidence-based nutrition education to participants where they live, learn, work, play, pray and shop.[20] LACDPH partners with schools, public agencies, faith-based and community organizations, and grocery stores to provide effective obesity prevention programming. Educating community members about new health resources, including new access points to healthy foods, is an important step in establishing sustainability. In addition to increasing awareness about new resources, formal education about how to prepare a healthy meal and the importance of eating healthy foods can increase the likelihood of changing eating habits.[21-23] Research suggests that class-based nutrition education can be a cost-effective means of increasing consumption of fresh fruits and vegetables,[22,24] and that these types of community-based education interventions can be effective among low-income populations.[24,25]

Farmers' Markets

The USDA defines a farmers' market as a space where at least two farmer-producers "sell their own agricultural products directly to the general public at a fixed location, which includes fruits and vegetables, meat, fish, poultry, dairy products, and grains".[26] In the U.S., there has been a 383% increase in farmers' markets from 1994 to 2015, primarily concentrated in densely

populated areas of the country.[27] Farmers' markets have been shown to increase access to fresh fruits and vegetables, as well as to increase the purchase[28] and consumption[29] of fresh fruits and vegetables. People who participate in incentive programs designed to help defray costs of produce for low-income shoppers are more likely to increase fruit and vegetable consumption and are more likely to return to a farmers' market.[28,30]

The focus of SNAP-Ed farmers' market strategies in Los Angeles County is threefold: 1) establish new Certified Farmers' Markets or produce stands, 2) actively promote and accept electronic benefit transfer (EBT)/Women, Infants, Children (WIC) food and nutrition service, and 3) offer a Market Match healthy food incentive. While the acceptance of EBT is becoming more widespread with new policies at the state, county, and city levels, fresh fruits and vegetables can often still be cost prohibitive at farmers' markets. Market Match is a program that incentivizes the purchase of fresh fruits and vegetables by offering matching funds to EBT users at a farmers' market. This effectively doubles the purchasing power of low income shoppers, allowing them both physical and financial access to locally produced fresh produce.

Healthy Retail

The SNAP-Ed strategies portfolio also includes healthy retail interventions. These interventions entail improving the availability of healthy foods sold as well as signage promoting healthy options at traditional corner stores and supermarkets in underserved areas. Transforming traditional corner stores and supermarkets into healthy retailers typically involves three steps: 1) increasing access to fresh fruits and vegetable, 2) training store owners on the purchase, storage, maintenance, and sale of fresh fruits and vegetables, and 3) introducing new marketing to educate consumers about healthier options such as fresh fruit instead of candy, or water instead of sugar sweetened beverages. These interventions, often called corner store conversions or market makeovers, can be as simple as the introduction of less perishable fresh fruits and vegetables such as onions, garlic, bananas, and apples, or as elaborate as a total store transformation including the addition of new refrigeration for fresh fruits and vegetables, and the rearranging of unhealthy items as a focal point of the store. Corner store conversions are an intervention born from the observation that there is a lack of full-service grocery stores in many low income, urban communities. Transforming corner stores into healthy retailers provides an opportunity to improve the food environment while leveraging existing resources in a community.

Most people shopping at corner stores purchase beverages or snacks, making these two items the most likely to impact health behaviors.[31] Although corner store conversions are a relatively new intervention, there is some evidence that they can change the health behaviors of people shopping at the stores. For example, small store interventions lead to increased sales of healthy food items and greater availability of fruits and vegetables in small neighborhood stores is associated with higher consumption of fruits and vegetables.[32-34] In addition, research suggests that in-store marketing strategies including availability, price, placement and promotion can increase purchase and consumption of healthy items including fruits and vegetables.[35]

Community Gardens

Another strategy employed as part of SNAP-Ed is identifying and providing opportunities to develop and sustain edible gardens in schools and communities. An edible garden is a parcel of land where a group of people grows plants for food. These garden interventions can include shared, individual, or mixed plots. The land can be privately or publicly owned and is often leased to a group of gardeners. Edible gardens can range greatly in size and scale. Often edible gardens exist for a defined group of people (defined through membership, living in an affordable housing complex, etc.), but some edible gardens are planted in public spaces such as city owned parks.

There is limited research evaluating the impact of community gardens on nutrition-related outcomes.[36] However, a handful of studies suggest that community gardens may impact consumption of fresh fruits and vegetables.[37-39] For example, participation in a community garden is associated with higher fresh fruit and vegetable consumption,[38,40] including in one study among low-income Californians.[39] Furthermore, other adults living in the same household as a community garden participant are likely to consume more fresh fruits and vegetables than adults who are not living with a community gardener.[37] Community ("edible") gardens also provide a space and opportunity for nutrition and gardening education.

Food and Beverage Standards

The final strategy examined in this report is the use of healthy food and beverage standards. This strategy involves promoting standards within public housing units, city parks and recreation facilities, vending machines, and Los Angeles County department facilities. Creating healthy food and beverage standards or policies in workplaces and other gathering locations such as faith-based organizations can help increase access to healthy options and shape behavior and choices about nutrition. Research suggests that establishment of healthy food and beverage standards in schools are associated with greater availability of healthy food options and better dietary behaviors.[41] In addition, healthy food procurement policies in worksites, health care settings and government organizations are usually effective interventions for increasing availability of healthy food options and decreasing availability of unhealthy options.[42]

SNAP-Ed Evaluation Approach

LACDPH contracted with the UCLA Center for Health Policy Research (CHPR) to conduct an evaluation of specific components of the SNAP-Ed program. The evaluation focuses in particular on two Service Planning Areas (SPAs) in Los Angeles County, SPA 4 and SPA 6. The evaluation addresses the following questions:

1. What is the prevalence of chronic health conditions, including obesity and related health behaviors in Los Angeles County by SPA, especially in the two selected high needs areas?
2. What are the size, scope, investment, and estimated reach of the SNAP-Ed strategies implemented to date in SPA 4 and SPA 6?
3. What is the estimated impact of these strategies in SPAs 4 and 6 if they were sustained over the next 25 years?
4. What, if any, economic gains are expected from the investment in these strategies in SPA 4 and SPA 6?

Methodology to Assess SNAP-Ed Impact

As a first step in assessing the impact of SNAP-Ed strategy interventions, we synthesized program data provided by LACDPH to describe progress indicators for the nutrition education services and four of the PSE strategies (farmers' markets, healthy retail, community gardens, and healthy food and beverage standards) implemented as part of SNAP-Ed in SPA 4 and SPA 6. These progress indicators include the size, scope, investments and estimated reach of these services and strategy interventions.

To estimate the potential population health impact of the SNAP-Ed strategy interventions that are implemented in Los Angeles County in SPA 4 and SPA 6, we use agent-based modeling (ABM) to simulate scenarios about the lasting effects of the strategy interventions singularly and in combination. ABM has been widely used in different research and evaluation fields including health care policy research. This method allows evaluators to model the interaction of individuals with their environments and provides a platform to integrate information from multiple sources in one model to simulate the effects of individuals' interactions with their environments on outcomes. The approach serves as an effective means for evaluating various strategy interventions based on the specific implementation factors within each target area.

Finally, to assess whether the Los Angeles County SNAP-Ed project would likely result in economic gains over the long-term, we conduct a return on investment analysis. This analysis draws on LACDPH program data covering investments made in each SPA along with the results estimating the prevalence of obesity from the ABM. A more detailed description of the methods and data sources are provided in the Appendix.

Progress Indicators

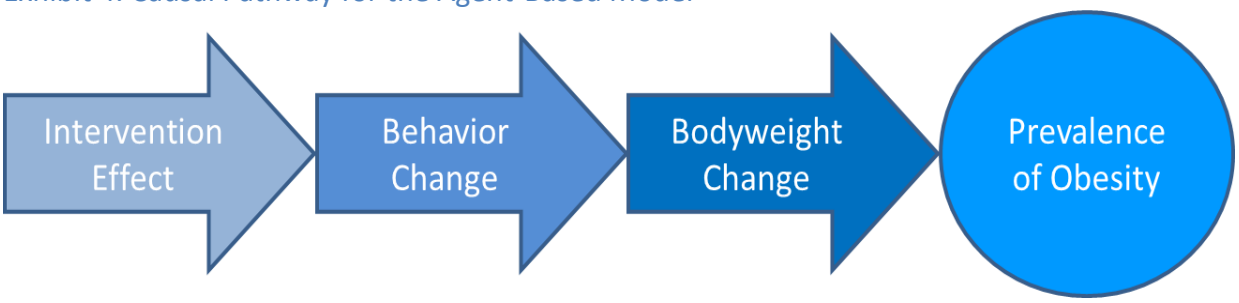
The strategy interventions examined in this evaluation have the potential to reach the existing SNAP-eligible population living nearby. For instance, the opening of a new farmer's market may attract people to shop there. However, program data do not tell us how many of the program participants were SNAP-eligible. This information should be estimated. We estimated potential reach (beyond SNAP recipients) based on geographic proximity to the programs and interventions. Based on the CDC recommendations of *DCH programs: An Introduction to Estimating Reach*, a buffer was drawn around the location of each intervention: farmers' market has a 5 mile buffer, all other interventions have 1 mile buffer.[43] We used the estimated SNAP-eligible population within the buffer as the numerator and the total estimated SNAP-eligible population within the SPA as the denominator provided by the Los Angeles Department of Public Health. Thus, the potential reach for a healthy retail intervention in SPA 4 was calculated as the estimated number of SNAP-eligible within a 1 mile buffer of the retail location divided by the estimated total number of SNAP-eligible in SPA 4.

Agent-Based Modeling Approach

Public health issues like the obesity epidemic are the result of complex, multifaceted processes in which environmental and biological factors interact and create feedback to one another. One simple example of these dynamic interactions is how a community's consumption of fresh fruits and vegetables is both influenced by the availability of such food and a factor in determining its availability, as retailers tend to stock the products that sell best. Traditional regression-based analyses have difficulty in adequately accounting for problems that involve several dynamic interactions. In addition, the lack of available data on the impact of specific health interventions on health behaviors and health outcomes over time make it even more difficult to evaluate using traditional regression-based modeling. Because of these methodological and data issues, this evaluation uses computational modeling to simulate the impact of health behavior interventions on the prevalence of adult obesity. ABM in particular is used in order to allow persons - represented as agents - to operate autonomously in the model.

ABM allows evaluators to integrate information from multiple sources into one model that simulates the effect of individuals' interactions with their environments on outcomes. In this way, ABM may be able to more accurately illustrate the complexities of real world problems that are bi-directionally influenced by social, environmental and biological factors. It provides a conceptualization of the real world with an intervention in place as well as the counter-factual scenario without intervention. In particular, for evaluating the effect of SNAP-Ed, the ABM developed here attempts to simulate the impact of the interventions through their effect on health-related behaviors, which in turn affect body weight, which in turn leads to a change in the prevalence of obesity (Exhibit 4).

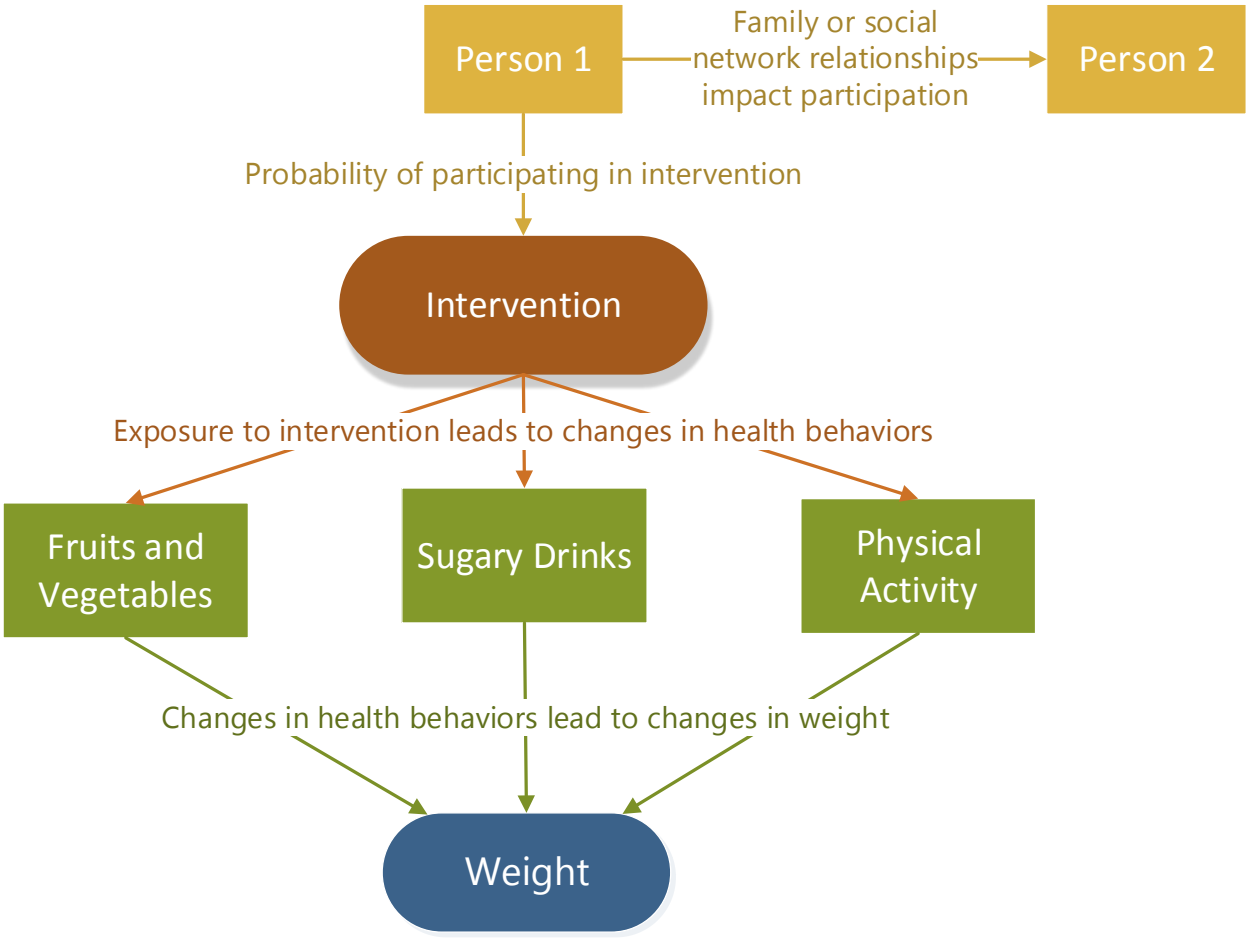
Exhibit 4. Causal Pathway for the Agent-Based Model



Overview of Models

The models developed for this evaluation examine five strategy interventions that have been implemented as part of SNAP-Ed in Los Angeles County: nutrition education, farmer's markets, healthy retail, community gardens, and healthy food and beverage standards. This analysis focused on two geographical areas within the county, SPA 4 and SPA 6. These two SPAs have high rates of poverty, SNAP eligibility, and obesity, and as a result, there has been a high level of investment to address the high obesity rates in these areas. We developed a model intended to simulate the effects of each intervention in isolation or in combination. Exhibit 5 displays the general approach used in the ABM developed for this project. Very broadly, individual residents of Los Angeles County have a probability of participating in the interventions within their SPA. Participation in an intervention can lead to change in three health behaviors: consumption of fruits and vegetables, consumption of sugar-sweetened beverages (SSB), and physical activity. Changes in these health behaviors lead to changes in weight. Changes in weight are then reflected in population-level prevalence of obesity. Although separate simulations are conducted for each SPA, the same underlying models are applied. As both models are identical except for the population and interventions used, this section covers the standard model developed for both SPAs.

Exhibit 5. General Approach Utilized for the SNAP-Ed Agent-Based Model

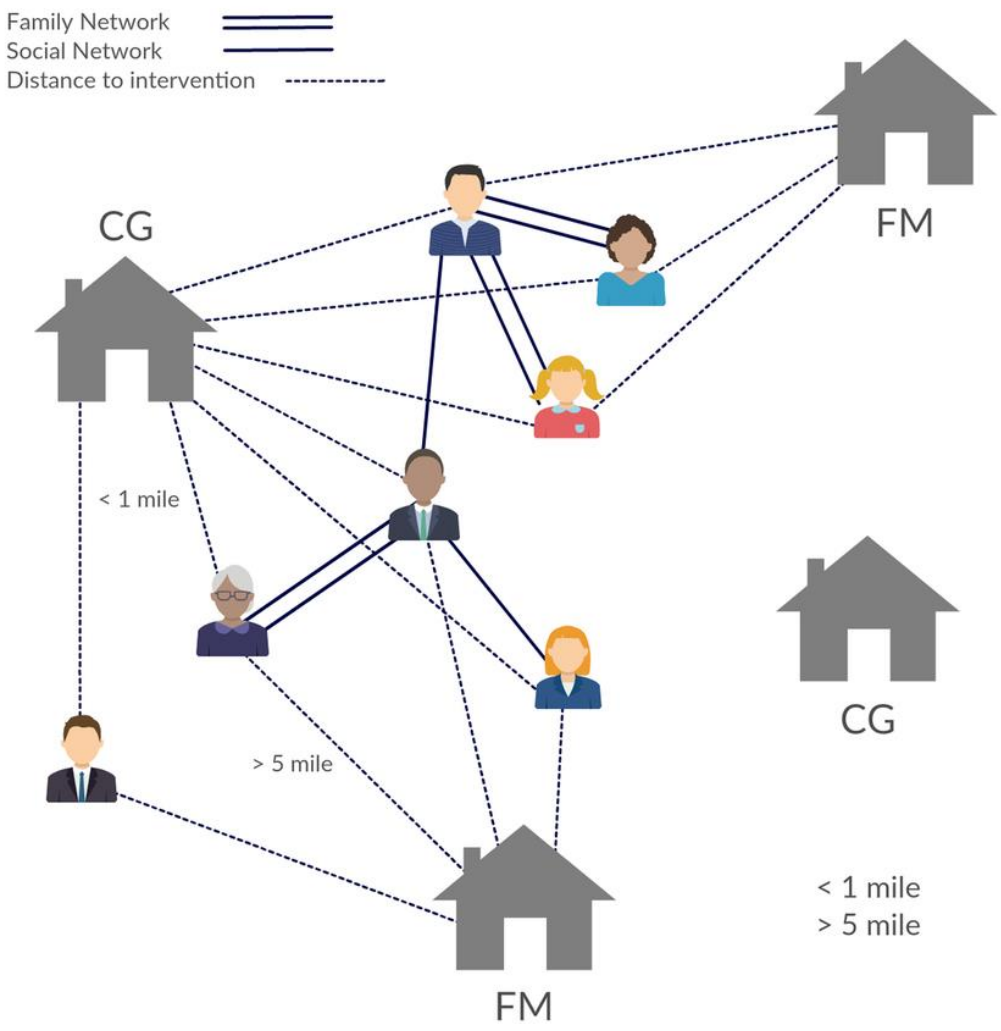


Each arrow in Exhibit 5 represents a parameter in the model that describes the effect. These parameters provide a platform for evaluators to test different scenarios and different assumptions. The team performed literature reviews of the available research to estimate feasible values for these parameters. For example, let's assume the intervention being modeled is farmer's markets. The arrow from the intervention (farmer's market) to consumption of fresh fruits and vegetables (FV) representing the effect of the farmer's market interventions on FV consumption needs to be operationalized. Whenever possible, these parameters are defined based on published peer-reviewed literature. However, some of the necessary parameters are not available in the published literature (e.g., the effect of farmer's markets on physical activity). In these cases, parameters are defined based on information available in the gray literature and consultation with program experts. Parameters that lacked evidence in the published literature are included as sliders on the model parameter page (described below). This is done to allow for the adjustment of these parameters as new information becomes available. The specific parameters used for the model results in this report are shown in the Appendix.

Data Source

A synthetic data set of adults (age ≥18) was created for each of the two SPAs being modeled, SPA 4 and SPA 6. The data are at the individual (agent) level and are based on 2012 CHIS public data, which provides health behavior measures, body weight, height and calculated body mass index (BMI) as well as demographic variables. We overlaid geographical information on the individuals to match with 2010 Census block level population data. The sampling weights were ranked to match with 2015 SPA-specific distributions of key demographic variables, including race/ethnicity, age, gender, poverty level and population totals. In addition, two social network structures were created for modeling families and general social connections and interactions. The family network is generated based on the household size. The social network structure is generated as a random network overlaying on the participants with an average size of 5 members. Exhibit 6 illustrates these two social networks and how they impact the interaction of agents with interventions.

Exhibit 6. Interaction of Family Network and Social Network with Interventions



CG = Community ("Edible") Garden Intervention
FM = Farmer's Market Intervention

Analyses

The ABM simulation model is conducted as a cohort analysis. Adults, ages 18 and older, in 2015 were followed for 25 years from 2015 to 2040. We evaluated a closed population that assumes persons did not change residency and were only removed from the simulated system upon death. Population totals for the 2015 adult cohort are calculated at each simulation year and the final results are reweighted each year to reflect the initial population demographics and

population change due to death over time. Population growth is taken into consideration based on the Los Angeles County population projection provided by the Department of Finance of California. The annual sampling weight variables were generated to modify the sample so that it reflects the population for the year. Based on this reconstructed sample, annual population level obesity rates are calculated and reported in the results. This allows us to infer population-level effects based on the results of the cohort analysis conducted by the ABM.

Persons - represented as agents - operate in a GIS environment defined by each SPA. On this level, many person variables are established and updated according to what is around them. At the agent level, which is unique for each person, the agents move through interventions, gain and lose exposure to interventions, have changes made to their health behaviors and changes made to their bodyweight based on their health behavior change. Agents also have model-defined family and social networks that influence how they interact with the interventions and how their health behaviors change due to their exposure to the interventions. Variables for agents are created twice in order to allow two states of the same agent - one set of variables is modifiable according to the effects of the intervention, and another is not. The second set serves as a control. These two states allow for the evaluation to use a true counterfactual, where the only difference between the intervention and control scenario populations is the presence of the intervention.

Interventions are also operationalized in the model as agents and interact with the person agents to modify their participation and behavior. However, intervention agents behave differently than person agents, as their characteristics do not change over time and intervention agents do not interact with each other, meaning the interaction between interventions are not modeled explicitly. Each intervention is read into the model as a separate population of agents with their own unique parameters. Interventions with multiple sites are represented in the model as separate locations.

Probability for Participating in a SNAP-Ed Intervention

Most of the interventions are location-based. The probability for participating in an intervention for an individual depends on three factors: 1) distance to the location of the intervention, 2) if the individual has been exposed to the intervention or the members of the social networks have been exposed to the intervention, and 3) very importantly, the actual participation rates data collected by Los Angeles County (see SNAP-Ed Implementation section for detail). Roughly speaking, the probability for participating in an intervention is inversely proportional to the distance from the geographic location of the individual to the geographic location of the intervention and positively correlated with exposure to the intervention.

While participation probabilities are used to expose persons to each intervention, one key aspect of the models uses participation data to create caps on the number of persons able to participate in an intervention each year. For example, participation data may indicate that a retail store had an average of 50 visitors per day during the last week. In order to create a cap on unique individuals exposed to the retail store on a year timescale we use research on the frequency of retail store visits to produce an estimate which is then used as the intervention

cap. Participation data for each intervention undergoes similar transformations, except for healthy food and beverage standards where it is assumed that the entire membership for the church or community center is exposed to the intervention.

SNAP-Ed Implementation

This section provides an overview of health conditions and the burden of obesity in Los Angeles County Service Planning Areas (SPAs) along with detailed information about the specific SNAP-Ed strategy interventions implemented in SPA 4 and SPA 6. The first section describes the prevalence of SNAP status, obesity and other health conditions, and health behaviors by SPA. The second section provides descriptive information about nutrition education services and policy, systems and environmental (PSE) change strategies implemented in SPA 4 and SPA 6. This information includes the number and type of programs and services implemented, as well as information about their locations, and their estimated reach.

Prevalence of Health Conditions and Burden of Obesity in Los Angeles County Service Planning Areas

Using data from the 2013-14 California Health Interview Survey (CHIS) we examined population health indicators for adults living in Los Angeles County and each of the eight Service Planning Areas (SPAs).

SNAP Eligibility and Poverty Rates

Exhibit 7 displays the estimated proportion eligible for SNAP benefits and the percent with incomes below the Federal Poverty Level (FPL) by SPA. SNAP-eligible residents were identified based on income (below 185% FPL) and receipt of Medicaid. SPAs 4 and 6 have the highest poverty rates in Los Angeles County (both around 28 percent) as well as the highest rates of SNAP eligibility (46 and 51 percent, respectively).

Exhibit 7. Percent Eligible for SNAP and Percent Below the Federal Poverty Line, Adults age 18 and over, Los Angeles County, California, 2013-14

	SNAP eligible		Below Federal Poverty Line	
	%	95% CI	%	95% CI
Los Angeles County	35.9	34 - 37.8	18.4	16.8 - 20.0
SPA 1 - Antelope Valley	22.7	15 - 30.3	20.0	10.5 - 29.6
SPA 2 - San Fernando	34.8	30.2 - 39.3	14.5	11.1 - 17.9
SPA 3 - San Gabriel	35.6	30.4 - 40.7	14.5	11.5 - 17.5
SPA 4 - Metro	45.7	39.1 - 52.3	28.6	22.9 - 34.3
SPA 5 - West	14.4	10.2 - 18.6	4.1*	1.6 - 6.5
SPA 6 - South	50.6	43.9 - 57.4	28.4	22.1 - 34.8
SPA 7 - East	38.0	31.1 - 44.8	21.7	16.2 - 27.3
SPA 8 - South Bay	32.9	27.8 - 37.9	17.7	13.2 - 22.3

Source: 2013-14 California Health Interview Survey

Note: * Statistically unreliable. SNAP-eligible defined as income below 185% FPL or on Medicaid and does not include those who reported receiving SNAP

Overall, approximately 8% of adults in Los Angeles County reported receiving SNAP benefits and 36% met the eligibility requirements based on income and receipt of Medi-Cal (Medicaid), but did not report receiving SNAP benefits. However, these rates varied considerably by SPA. Exhibit 8 shows that the percent reporting receiving SNAP benefits ranged from less than 2% in SPA 5 to 19% in SPA 1 and was 11% and 13% in SPAs 4 and 6, respectively. SNAP eligibility rates ranged from 14% in SPA 5 to 51% in SPA 6. SPA 4 had the second highest rate of eligibility at 46%.

Exhibit 8. SNAP status by Service Planning Area (SPA), Adults age 18 and over, Los Angeles County, California, 2013-14

	SNAP recipient		SNAP eligible		Not eligible	
	%	95% CI	%	95% CI	%	95% CI
Los Angeles County	7.7	6.7 - 8.6	35.9	34 - 37.8	56.4	54.7 - 58.1
SPA 1 - Antelope Valley	19.1	9.9 - 28.3	22.7	15 - 30.3	58.3	48.1 - 68.4
SPA 2 - San Fernando	5.4	3.4 - 7.5	34.8	30.2 - 39.3	59.8	55.3 - 64.4
SPA 3 - San Gabriel	5.1	2.5 - 7.8	35.6	30.4 - 40.7	59.3	54.2 - 64.4
SPA 4 - Metro	11.1	7.0 - 15.2	45.7	39.1 - 52.3	43.2	36.5 - 50.0
SPA 5 - West	1.8*	0 - 3.6	14.4	10.2 - 18.6	83.8	79.5 - 88.2
SPA 6 - South	13.1	8.1 - 18.0	50.6	43.9 - 57.4	36.3	30.5 - 42.1
SPA 7 - East	10.6	6.3 - 15.0	38.0	31.1 - 44.8	51.4	45.2 - 57.6
SPA 8 - South Bay	5.1	2.3 - 7.9	32.9	27.8 - 37.9	62.0	57.5 - 66.5

Source: 2013-14 California Health Interview Survey.
Note: The SNAP-eligible population was defined as having income below 185% FPL or receiving Medi-Cal benefits and does not include those who reported receiving SNAP benefits. Receiving SNAP benefits was only asked of adults with household incomes below 300% FPL. Adults with incomes above 300% FPL were coded as not eligible for SNAP.

Health Conditions

The prevalence of obesity and related health conditions also vary considerably within Los Angeles County (Exhibit 9). The prevalence of obesity is highest in SPA 6 where 40% of adults are obese and lowest in SPA 5 where 18% of adults are obese. SPAs 3, 6, and 8 all have diabetes rates over 12%. SPA 5 has the lowest diabetes prevalence at 7%. The pattern for hypertension is slightly different. In SPAs 4, 6, and 8 the prevalence of hypertension is above 30% and SPA 2 has the lowest prevalence at 23%.

Exhibit 9. Health Outcomes by Service Planning Area (SPA), Adults age 18 and over, Los Angeles County, California, 2013-14

	Diabetes		Hypertension		Overweight		Obese	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Los Angeles County	10.4	9.2 - 11.6	27.4	25.7 - 29.0	35.7	33.7 - 37.7	26.3	24.3 - 28.4
SPA 1 - Antelope Valley	7.9	4.7 - 11.2	27.8	18.4 - 37.3	33.7	24.1 - 43.3	27.1	18.0 - 36.1
SPA 2 - San Fernando	8.1	5.8 - 10.3	22.9	19.1 - 26.7	36.7	32.3 - 41.1	23.6	19.3 - 27.8
SPA 3 - San Gabriel	12.1	8.7 - 15.6	25.9	22.1 - 29.7	37.3	32.7 - 42.0	22.4	18.8 - 26.0
SPA 4 - Metro	9.7	5.9 - 13.6	31.3	26.0 - 36.6	37.7	30.9 - 44.4	22.5	16.6 - 28.3
SPA 5 - West	7.2	3.9 - 10.4	25.3	19.5 - 31.0	29.5	22.7 - 36.2	17.7	12.5 - 22.8
SPA 6 - South	12.3	7.5 - 17.1	30.3	23.0 - 37.6	38.5	30.3 - 46.8	40.2	31.7 - 48.6
SPA 7 - East	11.2	7.2 - 15.3	25.5	19.8 - 31.2	33.8	28.1 - 39.6	32.7	26.7 - 38.6
SPA 8 - South Bay	12.4	8.4 - 16.3	32.9	27.9 - 38.0	34.0	28.6 - 39.5	27.7	22.7 - 32.7

Source: 2013-14 California Health Interview Survey.
Note: Diabetes and hypertension are based on self-report responses to ever being diagnosed with the condition. Overweight and obesity are based on body mass index (BMI) which is calculated from self-reported height and weight. Overweight has BMI of 25.0 to 25.99 and obese has BMI of 30 or above.

Exhibit 10 displays the prevalence of four related health behaviors: walking for transportation, walking for leisure, consumption of sugar-sweetened beverages, and fast food consumption. In Los Angeles County, more than half of adults (56%) reported walking for transportation and 65% reported walking for fun or exercise. The prevalence of walking for transportation ranged from 41% in SPA 1 to 72% in SPA 4 and the prevalence of walking for leisure ranged from 63% in SPA 4 to 71% in SPA 5. Overall, 15% of adults in Los Angeles County consumed at least one sugar sweetened beverage (SSB) per day and 44% had fast food at least twice a week. The percent consuming at least on SSB per day ranged from 9% in SPA 5 to 24% in SPA 6; and the percent eating fast food at least twice per week ranged from 29% in SPA 5 to 54% in SPA 6.
In summary, SPA 4 and SPA 6 have the highest rates of SNAP-eligibility among the SPAs in Los Angeles County and they have the second and third highest rates of SNAP participation. In addition, SPA 4 and SPA 6 have high rates of obesity and chronic conditions as well as high rates of poor dietary behaviors that can contribute to obesity and chronic conditions.

Exhibit 10. Health-related Behaviors by Service Planning Area (SPA), Adults age 18 and over, Los Angeles County, California, 2013-14

	Walked for Transport		Walked for Leisure		One or more SSB per day		Fast food 2 or more times per week	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Los Angeles County	55.7	53.3 - 58.0	64.9	62.7 - 67.0	15.2	13.5 - 17.0	43.6	41.5 - 45.7
SPA 1 - Antelope Valley	41.4	30.9 - 51.9	67.6	58.7 - 76.5	21.3	12.2 - 30.4	48.9	38.7 - 59.1
SPA 2 - San Fernando	52.8	47.8 - 57.9	65.8	60.6 - 70.9	13.2	9.5 - 17.0	42.1	36.7 - 47.5
SPA 3 - San Gabriel	48.6	43.3 - 53.9	64.7	60.3 - 69.2	13.5	10.2 - 16.8	42.5	37.1 - 48.0
SPA 4 - Metro	71.5	65.3 - 77.6	62.9	56.6 - 69.1	12.6	8.3 - 16.8	34.8	28.4 - 41.1

SPA 5 - West	60.3	53.6 - 67.0	71.4	64.0 - 78.8	8.7	4.6 - 12.8	29.0	22.2 - 35.9
SPA 6 - South	62.2	53.8 - 70.6	64.3	56.6 - 72.1	23.9	18.0 - 29.8	53.9	46.4 - 61.3
SPA 7 - East	54.8	48.3 - 61.4	63.6	56.8 - 70.4	18.4	13.4 - 23.5	51.2	44.3 - 58.2
SPA 8 - South Bay	54.3	49.5 - 59.2	63.1	58.5 - 67.7	15.6	11.0 - 20.2	46.0	40.1 - 51.9

Source: 2013-14 California Health Interview Survey.
Note: Walked for transport includes adults who reported walking to get someplace in the past week. Walked for leisure includes adults who reported walking for fun, relaxation, or exercise in the past week. Sugar-Sweetened Beverages (SSB) include soda, sports drinks, energy drinks, and sweetened fruit drinks, but does not include diet drinks.

SNAP-Ed Implementation in SPA 4 and SPA 6

Through the Los Angeles County SNAP-Ed efforts, LACDPH funded local partners to implement PSE strategies and provide nutrition education services to community residents to promote healthy eating and prevent obesity. Because of their high number of SNAP-Ed eligible census tracts, a high concentration of interventions has been implemented in SPA 4 and SPA 6, and these two SPAs are the focus of this evaluation report.

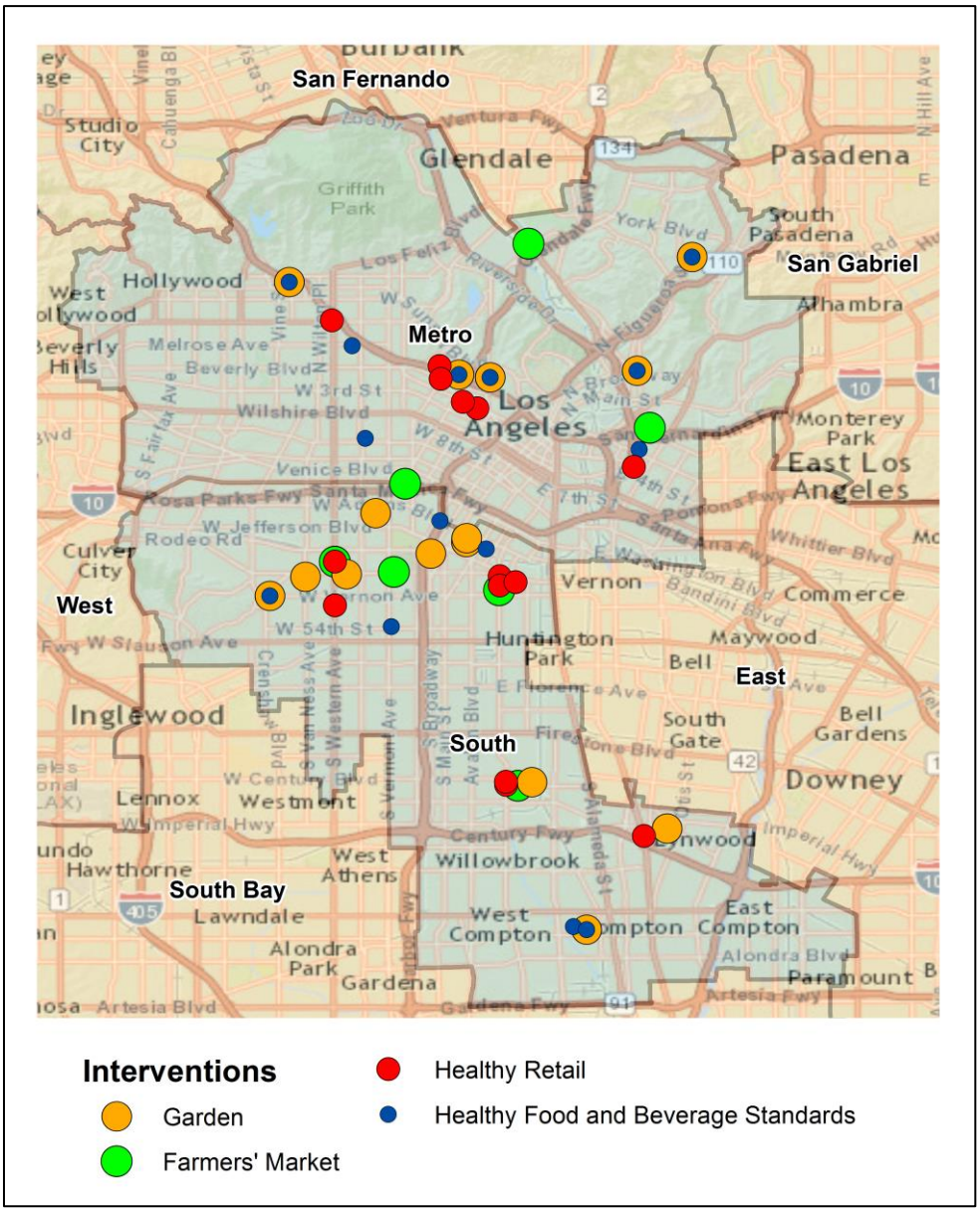
Service Planning Area 4, or SPA 4, services the communities of Boyle Heights, Central City, Downtown LA, Echo Park, El Sereno, Hollywood, Mid-City Wilshire, Monterey Hills, Mount Washington, Silverlake, West Hollywood, and Westlake.

Service Planning Area 6, or SPA 6, services the communities of Athens, Compton, Crenshaw, Florence, Hyde Park, Lynwood, Paramount, and Watts.

Implementation of Policy, Systems, and Environmental (PSE) Change Strategies

This evaluation focuses on the following four PSE strategies that were implemented in SPA 4 and SPA 6: farmers' markets, healthy retail, community ("edible") gardens, and healthy food and beverage standards. Exhibit 11 provides a map displaying the locations of these PSE interventions in SPA 4 (Metro) and SPA 6 (South). More PSE strategies were implemented in SPA 6 than SPA 4. Details for each of the PSE strategies are described below and displayed in Exhibit 12.

Exhibit 11. SNAP-Ed PSE Intervention Sites in SPA 4 (Metro) and SPA 6 (South), Los Angeles County



Farmers' Markets

As one of the obesity prevention strategies, SNAP-Ed sought to increase access to farmers' markets. This was accomplished through increasing CalFresh/EBT and WIC coupon acceptance at existing farmers' markets as well as supporting new market locations. In some cases, incentive programs to subsidize the cost of fresh fruits and vegetables were also established. A total of seven farmers' markets were involved in these strategies within SPA 4 and SPA 6.
In SPA 4, a new Certified Farmers' Market in a low-income neighborhood was established in spring 2014. The farmers' market has been accepting and promoting use of CalFresh/ Electronic Benefit Transfer (EBT) card, WIC Farmers' Market Nutrition Program (FMNP), WIC Fruit and Vegetable Checks (FVC) since October 2014 with a "market match" healthy food incentive program. The market match incentivizes the purchase of fresh fruits and vegetables by offering matching funds to EBT users at a farmers' market. The farmers' market is estimated to have reached nearly 200 targeted people per month with a total of 5,000 visits in two years of the project.

In SPA 6, two existing Farmers' Markets in low-income neighborhoods started to accept and promote use of CalFresh/EBT, WIC FMNP, WIC FVC after October 2014. These farmers' markets also offer matching funds to EBT users at the market. The SNAP-Ed program also opened a new produce stand in 5 farmer's markets to increase access and consumption of fruits and vegetables. The farmers' market is estimated to have reached targeted populations ranging from 15 to 1,500 people per month with a total of 81,000 visits since the beginning two years of the project.

Community or "Edible" Gardens

A total of 17 community or "edible" gardens were established in SPA 4 and SPA 6 at various faith-based sites and affordable housing sites. Other edible gardens were established at school sites, but were not included in the agent-based model. Partners worked to create new edible gardens to increase the availability of fresh fruits and vegetables, as well as to provide a place for education about nutrition and growing practices. Some partners also provided the necessary land, water, and technical support to build and maintain new gardens.

Five community gardens were developed at faith-based sites and affordable housing sites in SPA 4. It is estimated over 1,000 people participated in or benefited from gardening activities (e.g., worked in, learned or ate from the gardens), although one of the gardens existed prior to the intervention but did not open to communities until the beginning of the project.

Twelve community gardens were developed at faith-based sites and affordable housing sites in SPA 6. It is estimated over 350 people participated in gardening activities. These gardens have increased the availability of fresh fruits and vegetables, as well as provided a place for nutrition education and growing practices.

Healthy Food and Beverage Standards

Healthy food and beverage standards were adopted at twenty-three locations in SPA 4 and SPA 6. The interventions included partnering with church leadership to develop and adopt policies that promote healthy food and beverage options at church sites, as well as to establish organization-wide nutrition policies for the food and beverage products that are sold or distributed.

Eight healthy food and beverage standards or policies were implemented in faith-based organizations in SPA 4 to increase access to healthy options for the food and beverage products that are sold or distributed in these organizations. These healthy food and beverage standards were implemented in June 2014, and have since then had a reach of nearly 2,000.
Fifteen healthy food and beverage standards or policies were adopted with 7 of the standards being implemented throughout 2014 and early 2015 in SPA 6. These policies help faith-based organizations, schools, institutions and City of Lynwood to increase access to healthy food and beverage products, which are sold or distributed in these places. In the City of Lynwood, they passed a healthy parks resolution for the entire city where all park facilities have "healthy vending" in February of 2016. These healthy food and beverage standards have had a reach of nearly 42,000 people.

Healthy Retail

Eighteen healthy retail interventions were implemented in SPA 4 and SPA 6 under the SNAP-Ed project. Intervention partners have worked to establish a healthy corner stores certification program to incentivize stores to sell fresh fruits and vegetables, as well as to promote healthier drink and snack options. Partners have also worked to create collaboration between farmers' markets and corner stores to provide fresh, local produce to stores in South Central Los Angeles.

In SPA 4, healthy corner store certification programs were implemented in five stores to improve grocery store options and increase consumption and purchase of healthy foods and beverages. In addition, one store worked with farmer's markets to implement a market makeover. The Healthy Retail programs have had the greatest reach of the four program types in SPA 4, with an estimated over 81,000 people exposed to community grocery stores with healthier options.

In SPA 6, healthy corner store certification programs were implemented in seven stores to improve grocery store options and increase clients' consumption and purchase of healthy foods and beverages. An additional 5 stores have worked to implement a market makeover with four sites still in progress to launch their healthier store fronts. Once again, healthy retail appears to have the greatest reach of the PSE strategies, reaching nearly 650,000 in SPA 6.

Exhibit 12. SNAP-Ed Policy, Systems, and Environmental (PSE) Change Strategies Implemented in SPA 4 and SPA 6

	SPA 4			SPA 6		
PSE Category	**N**	**Reach**	**Timeline**	**N**	**Reach**	**Timeline (Month Yr Initiated)**
Farmers' Market Example: *Certified Farmers' Markets established in low-income neighborhoods, accepting/promoting use of CalFresh/EBT, WIC FMNP, WIC FVC, and a "market match" healthy food incentive program*	1	4,968	▪ Spring 2014	6	83,912	▪ Pre-existing
Community Garden Example: *Increasing access to healthy foods and nutrition education with community gardens for church members*	5	1,005	▪ One pre-existing ▪ June 2014 – Present ▪ September 2014 – Present ▪ May 2015 - Present	12	354	▪ January 2014 ▪ September 2014 ▪ November 2014 ▪ January 2015 ▪ March 2015 ▪ July 2015 ▪ 4 in progress ▪ 1 not suited to host site
Healthy Food and Beverage Standards Example: *Universal Diocesan nutrition policies for foods sold at church sites or distributed through the church (food pantries, feeding programs, social gatherings)*	8	1,963	▪ Implemented June 2014	15	42,081	▪ June 2014 ▪ October 2014 ▪ January 2015 ▪ 1 in progress ▪ 7 changed focus
Healthy Retail Example: *Healthy corner store makeover and certification program to improve small grocery store options and increase consumption and purchase of healthy foods and beverages*	12	81,587	▪ December 2013 ▪ April 2014 ▪ August 2014	12	647,679	▪ June 2014 ▪ August 2014 ▪ September 2014 ▪ November 2014 ▪ 4 in progress

Nutrition Education Services

From October 2014 to August 2015, a total of 108 sites within SPA 4 and SPA 6 introduced various forms of nutrition education that included one-time direct education classes, a series of direct education classes, and indirect education including signage and marketing (Exhibit 13). Direct education included classes about: cooking, gardening, nutrition, creating a healthy menu and healthy snacks, preparing and enjoying vegetables, shopping on a budget, and macronutrients. Several direct education classes also included physical activity topics such as yoga, aerobics, or Zumba. Indirect education included brochures and information posted in public places, taste tests, and healthy food marketing at community events.

In SPA 4, direct education programs totaled a reach of over 3,000 with 64 single-session nutrition programs, 20 nutrition series programs, 1 single-session exercise program, 3 exercise series programs, 55 single-session nutrition and exercise programs, and 73 nutrition and exercise series programs. The nutrition programs had the greatest number of participants for single sessions (960), but combination nutrition and exercise series programs reported 784 participants. Indirect programs reported nearly 3,500 participants with 58 programs focusing on nutrition and healthy choices.

In SPA 6, there are 511 direct nutrition, exercise, and joint nutrition and exercise programs with 9,500 participants during the program period. In SPA 6, there are 136 single-session nutrition classes with a reach of over 3,000 community members and 276 nutrition series programs reached 4,200. SPA 6 had more exercise focused programs than SPA 4, with 23 single sessions and 36 series, reaching over 1,100 participants. Nutrition and exercise combination programs in SPA 6 reached over 500 (single sessions) and 450 (series programs). There are about 232 indirect programs with an estimated reach of nearly 11,000, primarily due to the indirect education being done in more community-accessible locations, such as community events and fairs and grocery stores.

Exhibit 13. Nutrition Education Programs Implemented in SPA 4 and SPA 6

	SPA 4			SPA 6		
	Number of programs	**Participants**	**Main topics**	**Number of Programs**	**Participants**	**Main topics**
Direct	216	3,049		511	9,500	
Nutrition (Single)	64	960	Fat Free & Low Fat Calcium Sources Fiber-rich Foods Food Safety Food Shopping/Preparation Fruits and Vegetables Lean Meat & Beans Limit Added Sugars or Caloric Sweeteners My Plate Sodium & Potassium Whole Grain	136	3,105	Fat Free & Low Fat Calcium Sources Fats & Oils Fiber-rich Foods Food Safety Food Shopping/Preparation Fruits and Vegetables Lean Meat & Beans Limit Added Sugars or Caloric Sweeteners My Plate Sodium & Potassium Whole Grain
Nutrition (Series)	20	680	Fat Free & Low Fat Milk or Equivalent (& Alternate Calcium Sources) Fats & Oils Food Shopping/Preparation Fruits and Vegetables Limit Added Sugars or Caloric Sweeteners My Plate Sodium & Potassium Whole Grain	276	4,268	Fat Free & Low Fat Calcium Sources Fats & Oils Fiber-rich Foods Food Safety Food Shopping/Preparation Fruits and Vegetables Lean Meat & Beans Limit Added Sugars or Caloric Sweeteners My Plate Sodium & Potassium Whole Grain
Exercise (Single)	1	21	Promote Healthy Weight	23	512	Promote Healthy Weight
Exercise (Series)	3	88	Promote Healthy Weight	36	613	Promote Healthy Weight
Nutrition and exercise (Single)	55	516	Physical Activity with Nutrition	24	527	Physical Activity with Fruits and Vegetables Physical Activity with Nutrition
Nutrition and exercise (Series)	73	784	Physical Activity with Fruits and Vegetables Physical Activity with Nutrition	16	475	Physical Activity with Fruits and Vegetables Physical Activity with Nutrition

Exhibit 13 continued: Nutrition Education Programs Implemented in SPA 4 and SPA 6

	SPA 4			SPA 6		
	Number of programs	**Participants**	**Main topics**	**Number of Programs**	**Participants**	**Main topics**
Indirect	58	3,466	Any Other Type of Activity Brief Performances/Demos Brochure Display/Bulletin Boards/ Posters Etc. Community Events/Fairs - Participated Community Events/Fairs - Only Sponsored Community Forum or Public Meeting Consumer Nutrition Education Class Farmers Market Other Farmers Market Taste Test/ Cooking Demo Grocery Store Taste Test/Cooking Demo Newsletters Other Taste Test/Cooking Demo Rethink Your Drink-Community Events / Fairs - Participated Rethink Your Drink-Community Events/Fairs - Only Sponsored	232	10,856	1-on-1 Nutrition Education Class Any Other Type of Activity Assemblies/Theater Presentations Brief Performances/Demos Brochure Display/ Bulletin Boards/ Posters Etc. Community Events/Fairs - Participated Community Events/Fairs - Only Sponsored Community Forum or Public Meeting Consumer Nutrition Class with PA Consumer Nutrition Education Class Farmers Market Other Farmers Market Taste Test/ Cooking Demo Grocery Store Other Grocery Store Taste Test/Cooking Demo Grocery Store Tour Newsletters Open Houses, Back to School Nights Organized Physical Activity Events Other Taste Test/Cooking Demo Rethink Your Drink-Community Events/Fairs - Participated Rethink Your Drink-Community Events/Fairs - Only Sponsored

Potential Reach Estimates

The strategy interventions described above have the potential to reach the existing SNAP-eligible population living nearby. For instance, the opening of a new farmer's market may attract people to shop there. However, program data do not tell us how many of the program participants were SNAP-eligible. Exhibit 14 and Exhibit 15 display the resulting reach estimates for SPA 4 and SPA 6, respectively. In SPA 4, healthy food and beverage standards had the highest estimated potential reach, followed by healthy retail. In SPA 6, farmers' markets had the highest reach, followed by healthy food and beverage standards. However, proximity to the intervention site may not appropriately estimate reach for healthy food and beverage standards, since those policy and standards may only impact the patrons, employees, or members of the organization implementing the standards. If congregant size or membership of an organization was used to estimate potential reach for the healthy food and beverage standards interventions, the estimated potential reach number for SPA 4 is 3,174 and for SPA 6 is 87,804, resulting in potential reach estimates of less than 1% for SPA 4 and 18% for SPA 6. Also, the appropriate numerator population for farmer's market should be recipients due to the match program. However, we used the estimated eligible population, which is developed by applying % of eligible population of the SPA to the population size in each census tract.

Exhibit 14. Potential Reach Estimates for SPA 4

SPA 4	Estimated SNAP-eligible Population Living Near Each PSE Intervention	Total SNAP-Eligible Population in SPA 4	Percent of SNAP-eligible Potentially Reached
Farmers' Market*	**64,044**	**354,351**	**18%**
Community Garden	**126,710**	**354,351**	**36%**
Healthy Food and Beverage Standards	**259,416**	**354,351**	**73%**
Healthy Retail	**190,111**	**354,351**	**54%**

Note: * Farmers' market has a 5-mile buffer, all other interventions have 1 mile buffer

Exhibit 15. Potential Reach Estimates for SPA 6

SPA6	Estimated SNAP-eligible Population Living Near Each PSE Intervention	Total SNAP-Eligible Population in SPA 6	Percent of SNAP-eligible Potentially Reached
Farmers' Market*	**466,741**	**479,219**	**97%**
Community Garden	**323,845**	**479,219**	**68%**
Healthy Food and Beverage Standards	**398,178**	**479,219**	**83%**
Healthy Retail	**386,291**	**479,219**	**81%**

Note: * Farmers' market has a 5-mile buffer, all other interventions have 1 mile buffer

SNAP-Ed Impact on Obesity and Costs

The first part of this section presents the results from the agent-based models and the return on investment for SPA 4 and SPA 6. Specifically, it presents estimated exposure rates for the five strategy interventions for each SPA, the estimated changes in weight and three health behaviors (fresh fruit and vegetable consumption, sugary beverage consumption, and physical activity) associated with each type of intervention, and finally the estimated obesity rates in each SPA for each year from 2015-2040 for two separate simulated scenarios: the SPA population that experienced the interventions (intervention scenario) and the SPA population in the absence of the interventions (control scenario). The second part of the section presents the estimated return on investment of the obesity prevention interventions implemented in SPA 4 and SPA 6.

SNAP-Ed Estimated Exposure Rates Over Time

Exposure rates are calculated from model output based on the number of agents participating in each intervention. Exhibit 16 displays the average overall estimated rate of exposure to each intervention in SPA 4. Farmers' markets and community gardens had relatively low average exposure rates (below 2%). Direct nutrition education programs that also focused on exercise (NEs) had the highest average exposure rates (over 15%). Exhibit 17 displays the average rate of exposure by intervention in SPA 4 from 2015 through 2040. Exposure rates increased for most interventions over the simulation timeframe.

Exhibit 16. Average Overall Estimated Rate of Exposure by Intervention, SPA 4

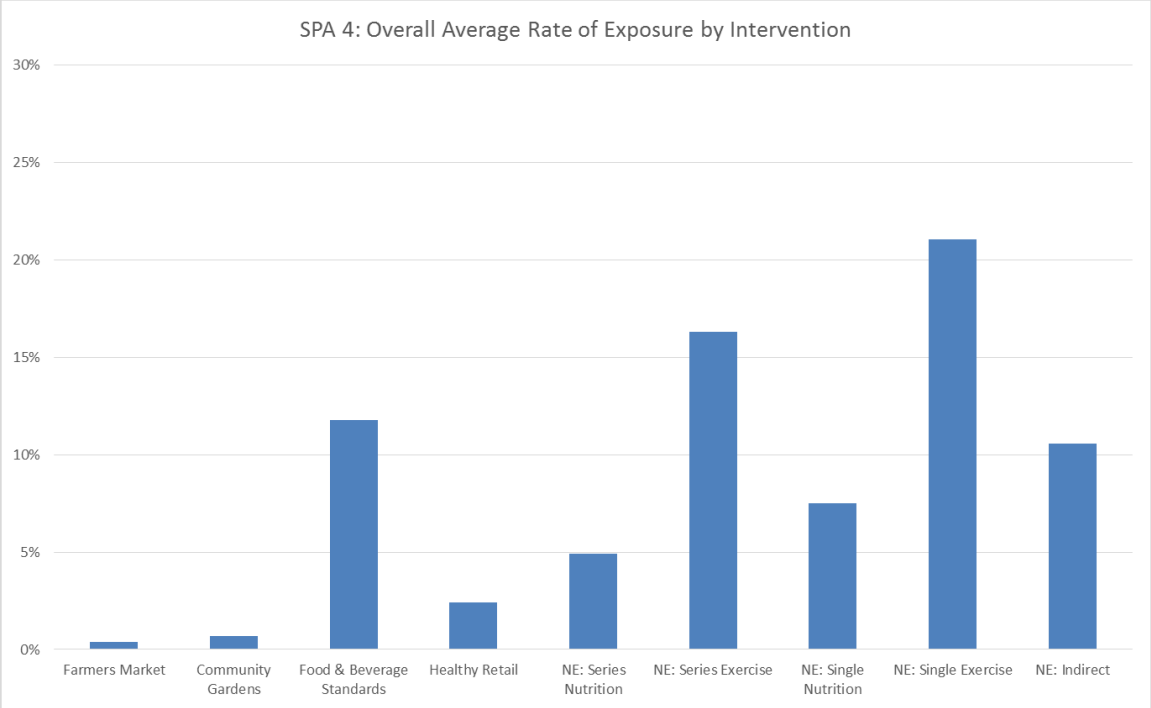
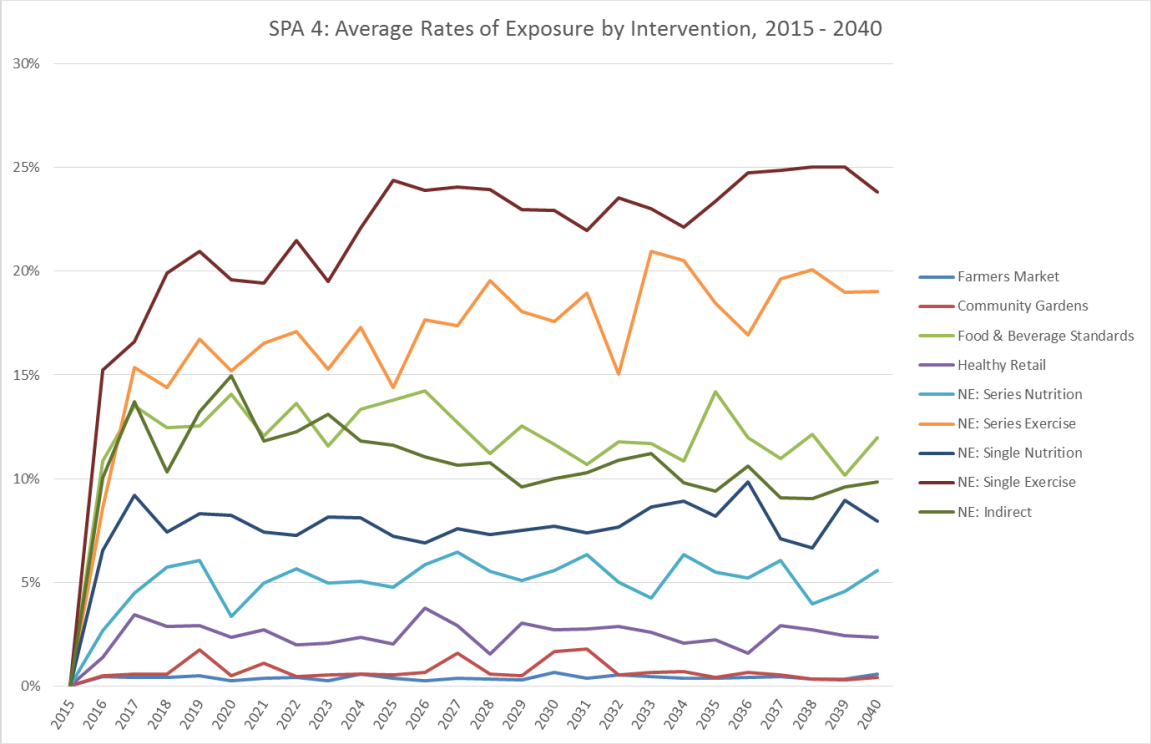


Exhibit 17. Average Estimated Rate of Exposure by Intervention Over Time, SPA 4, 2015-2040



The pattern of exposure rates in SPA 6 is somewhat different from SPA 4 (Exhibit 18). For example, healthy retail has the highest exposure rate (nearly 20%) and direct nutrition education and exercise classes (NEs) have relatively low exposure rates (below 5%). Similar to SPA 4, the exposure rates over time increased for most interventions over the simulation period (Exhibit 19).

Exhibit 18. Average Overall Estimated Rate of Exposure by Intervention, SPA 6

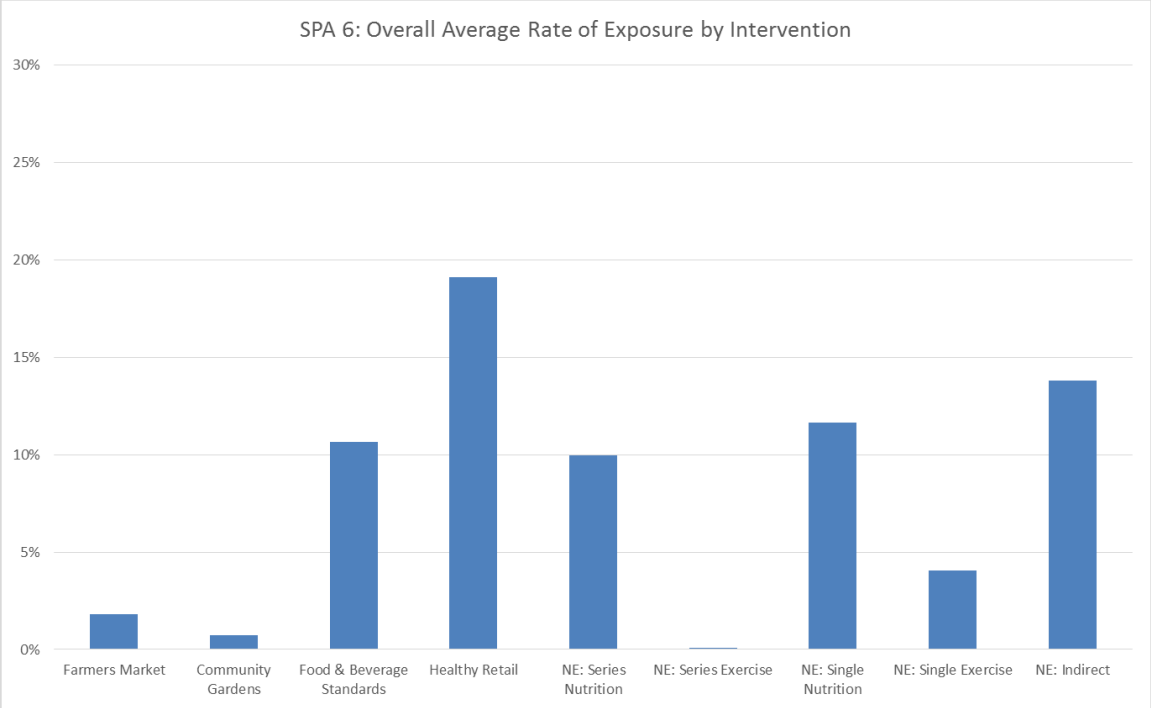
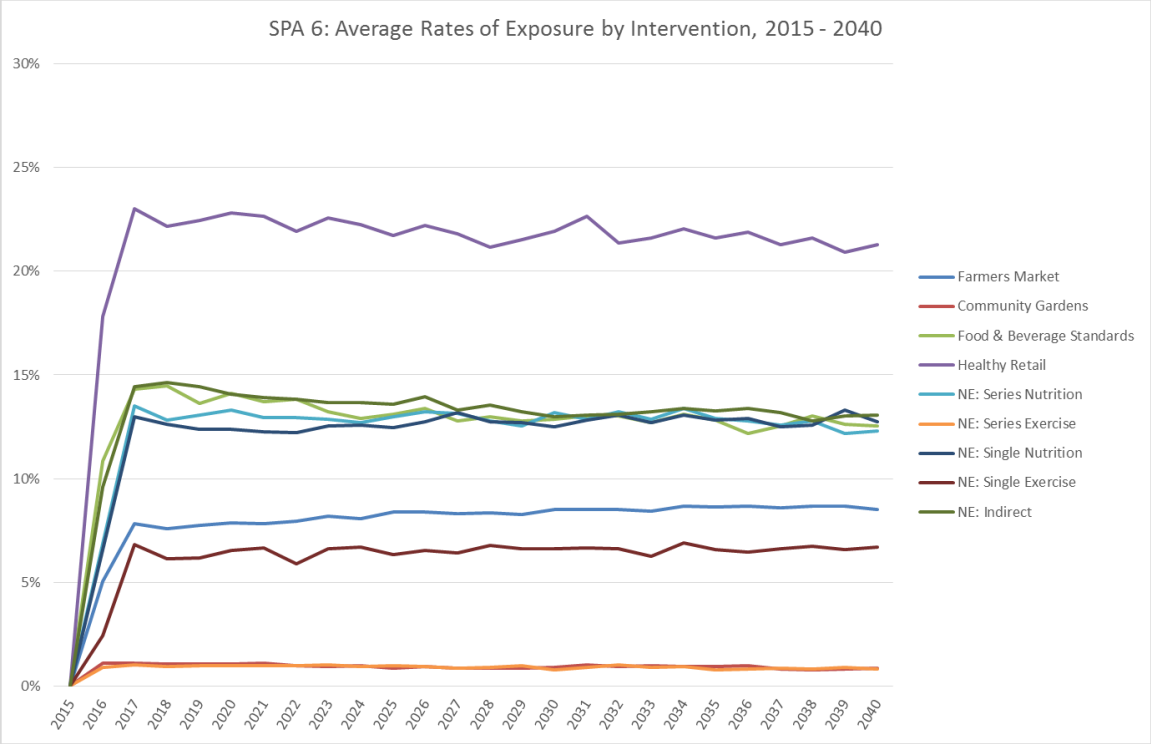


Exhibit 19. Average Estimated Rate of Exposure by Intervention over Time, SPA 6, 2015-2040



Estimated Changes in Health Behaviors and Weight

The average annual changes in the three health behaviors evaluated and weight as a function of each intervention for SPA 4 are displayed in Exhibit 20. Those for SPA 6 are displayed in Exhibit 21. In both SPAs, the largest average annual weight changes were associated with direct nutrition education class series focused on nutrition. This is due in part to their higher exposure rates. Among the PSE interventions, farmers' markets and community gardens were associated with greater changes in weight than interventions targeting healthy retail and food and beverage standards.

Exhibit 20. Average Annual Behavior and Bodyweight Estimated Changes in SPA 4

	Health Behavior Change			Weight (kg) Change			
	Fruits and Vegetables (FV) (servings/day)	Physical Activity (PA) (MET Mins/week)	Sugar-Sweetened Beverages (SSB) (Beverages/week)	FV	PA	SSB	Total*
Farmers Market	0.97	9.99	-0.10	-0.04	-0.08	-0.04	-0.07
Community Gardens	0.44	7.93	-0.10	-0.02	-0.07	-0.04	-0.06
Food & Beverage Standards	0.20		-0.09	-0.01		-0.04	-0.03
Healthy Retail	0.25		-0.17	-0.01		-0.07	-0.05
Nutrition Education: Nutrition Series	0.39		-0.39	-0.01		-0.16	-0.12
Nutrition Education: Exercise Series		19.78	0.13		-0.16	0.05	-0.06
Nutrition Education: Nutrition Single	0.29		-0.26	-0.01		-0.11	-0.08
Nutrition Education: Exercise Single		11.96	0.11		-0.10	0.05	-0.04
Nutrition Education: Indirect	0.16	3.99	-0.09	-0.01	-0.03	-0.04	-0.05

* Weight changes are raw and will not sum up to total, which is modeled using their current weight and their ideal weight.

Exhibit 21. Average Annual Behavior and Body Weight Estimated Changes, SPA 6

	Health Behavior Change			Weight (kg) Change			
	Fruits and Vegetables (FV) (servings/day)	Physical Activity (PA) (MET Mins/week)	Sugar-Sweetened Beverages (SSB) (Beverages/week)	FV	PA	SSB	Total*
Farmers Market	0.87	10.00	-0.10	-0.03	-0.08	-0.04	-0.06
Community Gardens	0.34	7.99	-0.08	-0.01	-0.07	-0.03	-0.07
Food & Beverage Standards	0.19	-	-0.09	-0.01	-	-0.04	-0.03
Healthy Retail	0.16	-	-0.17	-0.01	-	-0.07	-0.06
Nutrition Education: Nutrition Series	0.29	-	-0.32	-0.01	-	-0.13	-0.12
Nutrition Education: Exercise Series	-	19.06	0.19	-	-0.16	0.08	0.03
Nutrition Education: Nutrition Single	0.22	-	-0.28	-0.01	-	-0.12	-0.09
Nutrition Education: Exercise Single	-	11.92	0.11	-	-0.10	0.05	-0.05
Nutrition Education: Indirect	0.14	4.00	-0.09	-0.01	-0.03	-0.04	-0.05

* Weight changes are raw and will not sum up to total, which is modeled using their current weight and their ideal weight.

Estimated Changes in Obesity Rates Over Time

In the graphs below, the intervention gr refers to the scenario in which the population has the chance of being exposed to the SNAP-Ed interventions and the control group refers to the scenario without these interventions. In SPA 4, the ABM results predicted that obesity rates increased from 2015 to 2040, the period of the simulation (Exhibit 22). However, the prevalence of obesity among the intervention group(s) did not increase as much as the prevalence among the control group(s). A similar pattern is observed in SPA 6 (Exhibit 23).

Exhibit 22. Estimated Cohort Obesity Rates in SPA 4, Intervention vs. Control Scenario

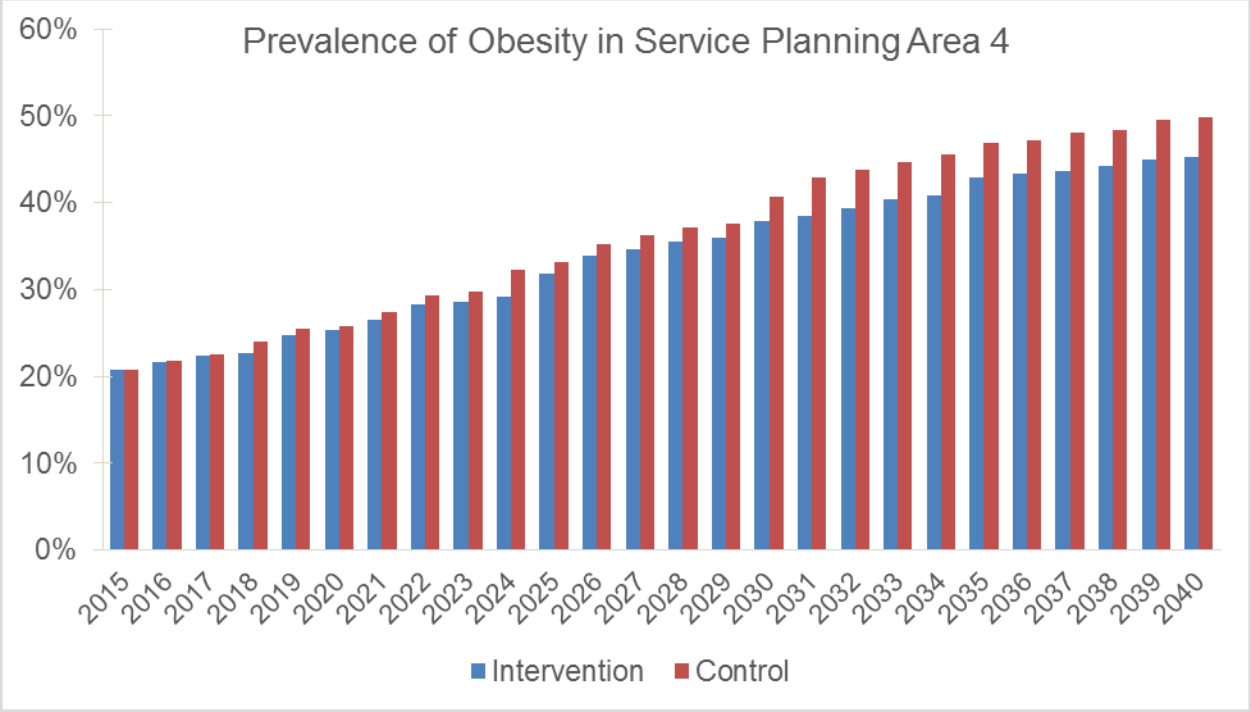
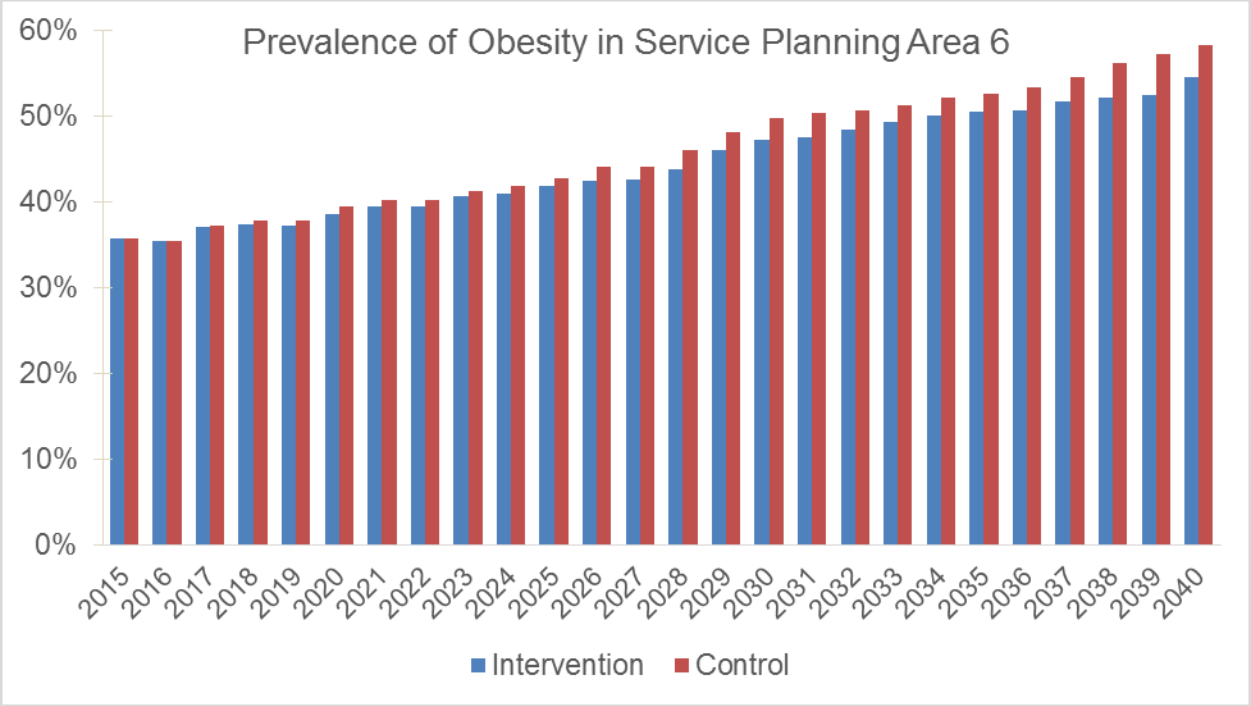


Exhibit 23. Estimated Cohort Obesity Rates in SPA 6, Intervention vs. Control Scenario



Return on Investment

Return on investment (ROI) analysis generally measures the economic gains related to investment in a particular program, where investments (costs) and gains (benefits) are both measured in dollar terms. Specifically, ROI is calculated as the following ratio: ***ROI = (benefits/costs).*** ROIs greater than 1.0 are said to produce a positive return on investment, because the benefits are greater than the costs. If these costs and benefits extended into future time periods, it is necessary to discount those future costs and benefits into present value (PV) terms.

To determine the ROI of the SNAP-Ed strategies in SPAs 4 and 6, we obtained the total annual investment costs in the 5 SNAP-Ed strategies for 2015. For each of the 5 strategies in each SPA, Los Angeles County staff provided a detailed breakdown of annual costs for each of the following expense categories:

- staff;
- printing and duplication;
- trainings;
- educational materials;
- food demonstrations;
- nutrition education supplies;
- physical activity supplies;
- communications;
- office supplies;

- conferences;
- mileage;
- indirect cost; and
- percentage of DPH overhead and operating costs.

These categories were aggregated within each of the 5 strategies, and then summed across the 5 strategies to calculate total investments in each SPA for FFY 2015. The total SNAP-Ed investments based on this method was $1.057 million for SPA 4 and $2.186 million for SPA 6. To determine the benefits associated with these annual investments, we used the results of our agent-based model (ABM) to estimate the annual reduction in obesity rates within each SPA for the 25-year period from 2016-2040, using 2015 as the base year for initial investment and measuring outcomes for the next 25 years. Applying these annual rates of reduction in obesity to the population estimates in each SPA produced an estimate of the number of prevented obesity cases as a result of the combined impact of the 5 SNAP-Ed strategies in each SPA.

The societal savings associated with reductions in obesity were estimated using data from Finkelstein et al. (2009) and Trogan et al. (2008) on the per capita direct medical savings and indirect cost savings, respectively, of obesity reduction. We inflated their estimate in 2008 dollars to 2015 dollars using the change in national personal health expenditures from the CMS web site. These calculations result in an estimated annual savings of $1,960 per person (in 2015 dollars) for each case of obesity prevented. Multiplying this estimated per person savings by the number of obesity cases prevented produced the total savings (or benefits) of the 5 SNAP-Ed strategies in each SPA for the years 2015-2040.

To keep the investment costs and savings calculations during the 2016-2040 period constant in 2015 dollars, we assumed that these expenses would increase at the same rate, and therefore, would remain in 2015 dollars if we didn't adjust them for inflation. However, present value (PV) calculations in most economic evaluations of health care apply a discount rate of 3% to future costs and benefits to reflect the fact that costs and benefits in the future have less value, all things being equal, relative to current costs and benefits (Gold et al. 1996; Neumann et al., 2017). Therefore, we discounted future costs and savings for the 2016-2040 into 2015 present values using a 3% annual discount factor.

The ROI calculations for the entire 2015-2040 time periods, and for 5-year intervals, are shown in Exhibit 24. After discounting, our present value (PV) estimates for SPA 4 indicate a total savings of $578.86 million resulting from total investments of $19.46 million, for a ROI of 29.75. For SPA 6, the comparable findings are a savings of $337.06 million produced by investments of $40.26 million, for an ROI of 8.37. Our findings indicate that obesity reductions that range up to 10.5% in SPA 4 and up to 8.5% in SPA 6 produce both substantially aggregate savings in both SPAs relative to program intervention costs, but also substantial ROIs, although the ROI in SPA 4 is almost 3.5 times greater than in SPA 6.

All data used in this analysis were de-identified, aggregated, and/or stored in a secure data enclave as appropriate and in accordance with University guidelines. This project was approved by the UCLA Institutional Review Board.

Exhibit 24. Return of Investment for SNAP-Ed Strategy Interventions in SPA 4 and SPA 6, 2015-2040

	2015-2020	2021-2025	2026-2030	2031-2035	2036-2040	Total 2015-2040
SPA 4						
Savings	$49.58	$123.37	$142.89	$324.46	$296.32	$936.62
Investments	$6.34	$5.28	$5.28	$5.28	$5.28	$27.48
ROI	7.82	23.35	27.04	61.41	56.08	34.09
PV Savings	$44.81	$96.30	$96.51	$191.10	$150.13	$578.86
PV Investments	$5.90	$4.17	$3.60	$3.11	$2.68	$19.46
PV ROI	7.60	23.07	26.80	61.52	56.03	29.75
SPA 6						
Savings	$27.26	$54.09	$128.88	$135.32	$204.21	$549.77
Investments	$13.12	$10.93	$10.93	$10.93	$10.93	$56.85
ROI	2.08	4.95	11.79	12.38	18.68	9.67
PV Savings	$24.22	$42.63	$87.21	$80.01	$102.99	$337.06
PV Investments	$12.20	$8.64	$7.45	$6.43	$5.54	$40.26
PV ROI	1.99	4.94	11.70	12.45	18.58	8.37

Note: Savings and investments are in millions of constant 2015 dollars.

Conclusions and Implications

The Supplemental Nutrition Assistance Program Education (SNAP-Ed) project in Los Angeles County has the overarching goal of reducing obesity and other diet-related chronic diseases among SNAP participants and SNAP-eligible populations. SNAP-Ed objectives included implementing policy, systems, and environmental change strategies alongside delivering nutrition education during the 2014-2016 grant cycle. Evaluating the long-term impacts of prevention programs involving the use of multiple strategy interventions presents several challenges, including but not limited to a lack of longitudinal data for capturing the complexity of SNAP-Ed; estimating the magnitude of change at various population levels; and identifying the relative contribution of each project component. Challenges such as these highlight the difficulty of measuring the impact of complex programming using conventional evaluation methods. Agent-based modeling (ABM) provides a complementary framework for evaluators to model a complex dynamic system in which individuals (agents) interact with each other and with the environment. It allows examination of the impact of several strategy interventions both individually (separately) and in combination. Additionally, ABM allows for the estimation of projected impacts by strategy interventions over the long-term.

As of 2015, SNAP-Ed had implemented 65 PSE interventions in SPAs 4 and 6, along with more than 700 nutrition education classes. The ABM results suggest that if these SNAP-Ed strategy interventions were to continue through 2040, they would lead to lower rates of obesity in 2040, relative to the control scenario in which these interventions were not implemented. Specifically, the estimated prevalence of obesity in 2040 in SPA 4 is 50% in the control scenario, as compared to 45% in the intervention scenario. In SPA 6, the estimated prevalence of obesity in 2040 is 58% in the control scenario, as compared to 54% in the intervention scenario. In ABM simulations involving nutrition education services operating alongside the four PSE strategies (farmers' markets, community gardens, healthy retail, and healthy food and beverage standards), direct nutrition education services were estimated to have the largest impact on weight change over time, followed by farmers' markets, and then community gardens. ABM results also suggest that the SNAP-Ed strategy interventions implemented in SPAs 4 and 6 would result in savings relative to the strategy intervention costs. The return-on-investment calculations estimate an ROI of 29.75 for SPA 4 and 8.37 for SPA 6.

The ABM results suggest that SNAP-Ed strategy interventions should be continued locally. The estimated reduction in the rate of increase in obesity prevalence assumes that the SNAP-Ed programming continues through 2040. In the absence of these interventions, the ABM results estimate that the prevalence of obesity would be higher in 2040 than if the interventions continued. The analyses also suggest that LACDPH could realize substantial return on investment in both SPA 4 and SPA 6, providing additional evidence supporting the effectiveness

of SNAP-Ed strategies in Los Angeles County. The result suggest that implementing PSE change strategies along with providing traditional nutrition education services has the potential for greater impact on weight change over time (than implementing these strategies individually). The estimated differences in obesity prevalence between the treatment and control scenarios assume that PSE strategy interventions are implemented in conjunction with traditional nutrition education services. It is worth noting that although fewer sites implemented farmers' markets and community gardens, these interventions had a larger impact on weight change over time than food and beverage standards or healthy retail programs, despite being implemented in slightly greater numbers.

There is a dearth of evidence about the long-term impact of more novel PSE change strategies such as healthy retail store makeovers and establishment of community gardens. Additional research is needed to further refine assumptions made about the long-term impacts of PSE strategies on obesity, particularly investigations that involve longitudinal data collection. Despite limited precedence for its use in nutrition program evaluation, ABM has proven to be a useful tool for modeling complex dynamic systems established by multi-faceted interventions. Estimating the impact of complex interventions like those implemented by SNAP-Ed, especially over the long term, is an important endeavor that can help inform planning of existing and future prevention programs in the region. It can provide critical information to assist decision-makers with challenging choices about resource allocation and/or investments in competing priorities (e.g., Program A versus Program B).

Appendix: Detailed Methodology

Population Health Indicators by SPA

Data Source

We used data from the 2013-14 California Health Interview Survey (CHIS) to examine population health indicators for adults living in Los Angeles County and each of the eight Service Planning Areas (SPAs). CHIS is a random digit-dial telephone survey of households designed to be representative of California's non-institutionalized population statewide. In addition, the Los Angeles County sample is designed to be representative of the county overall as well as of each of the eight SPAs. The number of adult respondents included in the Los Angeles County sample varies from year to year. Exhibit 25 displays the adult sample sizes for Los Angeles County overall and by SPA for each CHIS cycle. One randomly selected adult (aged 18 years or older) was interviewed in each household. In households with adolescents aged 12-17 years, one adolescent was randomly selected and interviewed directly after obtaining parental permission and assent from the adolescent. In households with children aged 0-11 years, one child was randomly selected and the adult most knowledgeable about that child was interviewed. Interviews were conducted in English, Spanish, Chinese (Mandarin and Cantonese), Vietnamese, and Korean.

Analyses

The selected indicators included obesity and obesity-related outcomes as well as health behaviors. Specifically, analyses described the prevalence of health conditions including obesity, diabetes, and hypertension as well as related health behaviors including physical activity, and consumption of fast food, and soda and other sugar sweetened beverages. We also report the percent of reporting they are SNAP recipients and the percent of the population that are SNAP-eligible. SNAP-eligible residents were identified based on income (below 185% FPL) and receipt of Medicaid.

Exhibit 25. CHIS Adult Sample Size by Service Planning Area (SPA), Adults age 18 and over, Los Angeles County, 2001-2014

	2001	2003	2005	2007	2009	2011-12	2013-14
Los Angeles County	**12,450**	**10,363**	**8,722**	**12,351**	**9,148**	**9,009**	**7,178**
SPA 1 – Antelope Valley	420	623	479	495	470	671	387
SPA 2 – San Fernando Valley	2,677	2,128	1,912	2,865	2,150	1,593	1,357
SPA 3 – San Gabriel Valley	2,602	1,917	1,690	2,431	1,514	1,587	1,503
SPA 4 – Metro LA	1,318	1,404	1,132	1,523	1,063	1,569	892
SPA 5 – West	1,061	800	513	801	829	620	523
SPA 6 – South	851	713	481	674	627	731	561
SPA 7 – East	1,335	1,078	1,063	1,409	1,102	930	863
SPA 8 – South Bay	2,186	1,700	1,452	2,153	1,393	1,308	1,092

Agent-Based Modeling

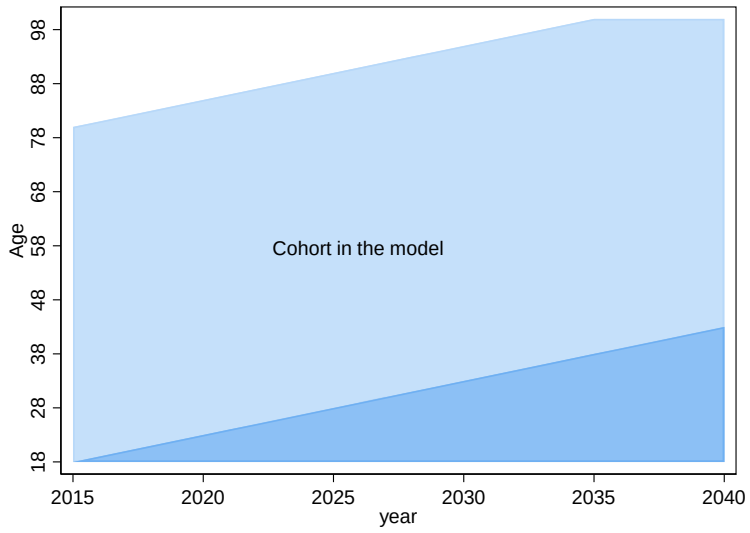
Data Source

A synthetic data set of adults (age>=18) was created for each of the two SPAs being modeled, SPA 4 and SPA 6. The data are at the individual (agent) level and are based on 2012 CHIS public data, which provides health behavior measures, body weight, height and BMI as well as demographic variables. We overlaid geographical information on the individuals to match with 2010 Census block level population data. The sampling weights were raked to match with 2015 SPA-specific distributions of key demographic variables, including race/ethnicity, age, gender, poverty level and population totals. In addition, two social network structures were created for modeling families and general social connections and interactions. The family network is generated based on the household size. The social network structure is generated as a random network overlaying on the participants with an average size of 5 members.

Analyses

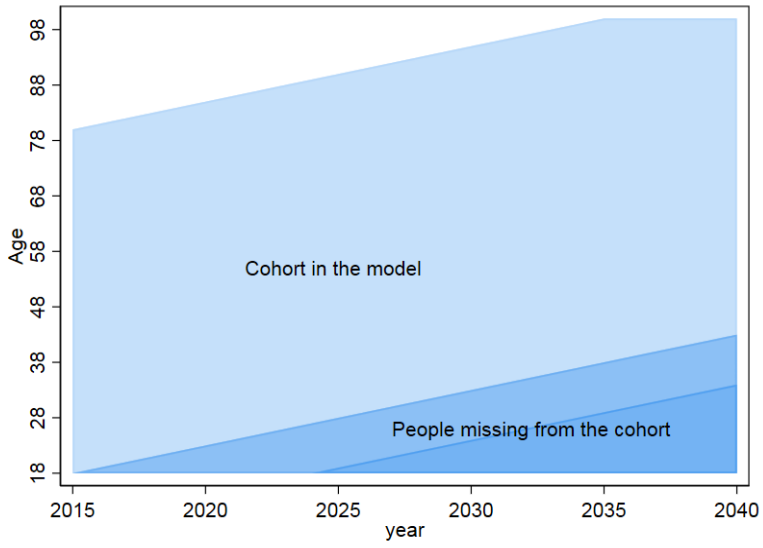
The ABM simulation is conducted as a cohort analysis. Adults, ages 18 and older, in 2015 were followed for 25 years from 2015 to 2040 (Exhibit 26). We evaluated a closed population that assumes persons did not change residency and were only removed from the simulated system upon death. The mortality rates in the simulation are from California 2010 age-specific death rates by gender provided by the California Department of Public Health: https://archive.cdph.ca.gov/data/statistics/Documents/VSC-2010-0503.pdf. These are assumed to be constant over the timeframe of the simulation. Population totals for the 2015 adult cohort are calculated at each simulation year and the final results are reweighted each year to reflect the initial population demographics and population change due to death over time.

Exhibit 26. Illustration of Population Cohort Included in Agent-Based Model



Analysis of the entire adult population is done by reanalyzing the data from the simulated results of the cohort (Exhibit 27). As our cohort analysis excludes the populations in each SPA that were under 18 years old in 2015 from participating in the model, one underlying assumption we made is that the excluded group is a random sample and behaved the same way as the same age group in the cohort. For example, at year 2016, the second year of the simulation, the youngest in the cohort would be 19 and those people who just turned 18 needs to be included in the analysis of the adult population. We assume that this group of 18 year olds in 2016 behaved similarly to those who were 18 in 2015.

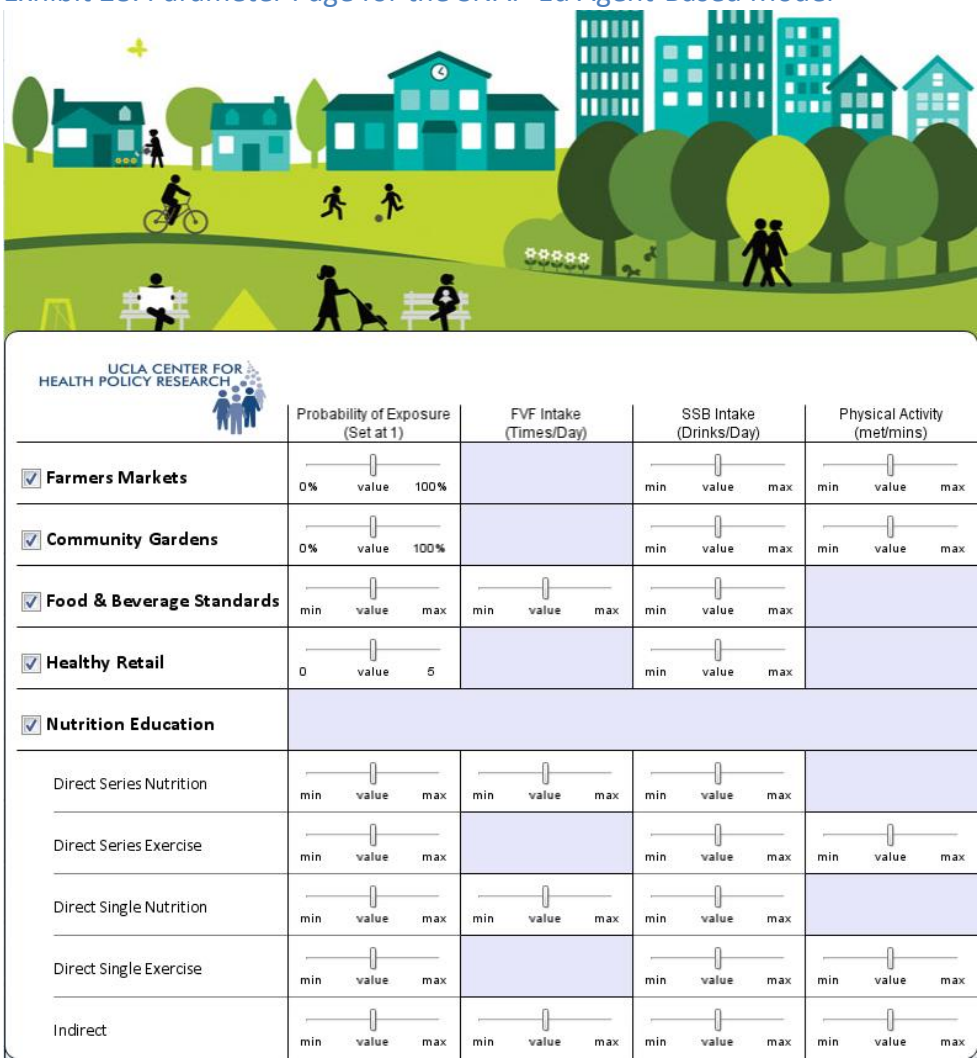
Exhibit 27. Illustration of Population Cohort in ABM and Population Included in Reanalysis of Entire Adult Population



Population growth is taken into consideration based on the Los Angeles County population projection provided by the Department of Finance of California. The annual sampling weight variables were generated to modify the sample so that it reflects the population for the year. Based on this reconstructed sample, annual population level obesity rates are calculated and reported in the results. This allows us to infer population-level effects based on the results of the cohort analysis conducted by the ABM.

Our model primarily uses a combination of discrete event and agent-based modeling to control when events occur while still allowing for enough variability to occur. Exhibit 28 displays the model parameter page, which determines which specific model effects could be manually set prior to running the simulation. For example, farmers markets have sufficient literature available to set the effect of visiting a farmer's market on the number of times per day a person consumes fresh fruits and vegetables (FV). However, research on the impact of farmers markets on sugar-sweetened beverage (SSB) consumption and physical activity was inadequate, and needed to be manually set using the sliding scales. When interventions are assumed to have no effect on a particular health behavior, as was the case for healthy retail interventions on physical activity, the effect is not introduced in the model and not enabled on the model parameter page. Exhibit 31, included at the end of this Appendix, describes the specific parameters used in the SNAP-Ed ABM described in this report.

Exhibit 28. Parameter Page for the SNAP-Ed Agent-Based Model



Persons - represented as agents - operate in a GIS environment defined by each SPA. On this level, many person variables are established and updated according to what is around them. At the agent level, which is unique for each person, the agents move through interventions, gain and lose exposure to interventions, have changes made to their health behaviors and changes made to their bodyweight based on their health behavior change. Agents also have model-defined family and social networks that influence how they interact with the interventions and how their health behaviors change due to their exposure to the interventions. Variables for agents are created twice in order to allow two states of the same agent - one set of variables is modifiable according to the effects of the intervention, and another is not. The second set serves as a control. These two states allow for the evaluation to use a true counterfactual, where the only difference between the intervention and control scenarios is the presence of the intervention.

Interventions are also operationalized in the model as agents and interact with the person agents to modify their participation and behavior. However, intervention agents behave differently than person agents, as their characteristics do not change over time and intervention agents do not interact with each other, meaning the interaction between interventions are not modeled explicitly. Each intervention is read into the model as a separate population of agents with their own unique parameters. Interventions with multiple sites are represented in the model as separate locations.

Exhibit 29.Intervention State-Based Models for the SNAP-Ed Agent-Based Model

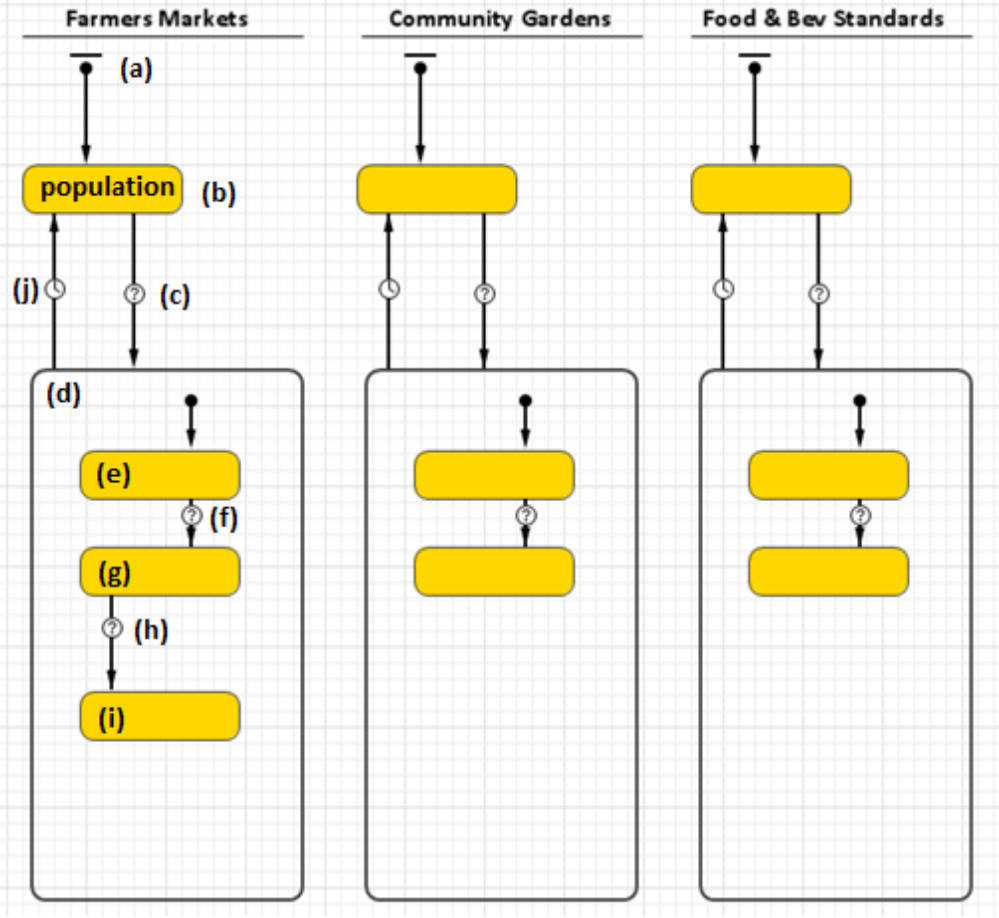


Exhibit 29 displays how states are used in model:

- (a) Entry transition;
- (b) Initial state;
- (c) Conditional transition;
- (d) Intervention population state;
- (e) Non-participation state;
- (f) Primary conditional transition;
- (g) Primary participation state;
    - (h) Secondary conditional transition;

    - (i) Secondary participation state; and
- (j) Unconditional transition back to initial state.

At the model startup, if the intervention is turned on in the parameter page, then each agent enters the intervention through the entry transition (a) and moves to the initial state(b). At the beginning of each model year, agents move from this holding state to the intervention population state (d) if they meet certain conditions (c) specific to each intervention. For the Farmers Market, only SNAP recipients are eligible to participate in the intervention so the conditional transition (c) evaluates whether this is true for each person agent before allowing the transition to occur. Once in the intervention population state (d), person agents automatically transition to the non-participating state (e), where agents are eligible to interact with the intervention but not yet exposed. Each person agents' probability of participating in the intervention is evaluated by the primary conditional transition (f) and if successful, is moved to the primary participation state (g). For most interventions, the primary participation state is the final state for the intervention and where person agents have a number of characteristics modified in order to reflect that they received the intervention effect. However, the Farmers Market intervention has a secondary conditional transition (h) before moving person agents into the secondary participation state (i) where the effect of the intervention is applied. This additional step is unique to the Farmers Market intervention, as only a certain percentage of visitors to farmers markets actually buy fresh fruits and vegetables.

Model Time: Steps and Cycles

Time is represented as steps in the model, which correspond to years. This approach is taken in order to have precise control over when parameters are updated and when calculations are performed. Events in AnyLogic have a particular hierarchy, which is modifiable in the software. Our events occur in a chronological order during the time step, where events are completed at the beginning of the step before performing activities that are set to occur during the step itself.

On the model start-up, static model parameters are initialized: person agents have their distances to the nearest intervention sites calculated for each type of intervention; and ideal health behaviors and bodyweight are calculated. After this first event, the model then performs 25 cycles of steps representing the years from 2015 to 2040.

At each cycle, events scheduled to occur before the model step take place first. Events here largely reset person parameters that were changed during the previous cycle in order to set up for the next cycle. Any changes made to agents' behavior and/or body weight are incorporated into the updated current parameters at the end of each step. For example, if I visited farmers markets in the previous year, parameters that represented the change in my FV consumption would have been modified by the intervention. This change is then applied to my current FV behavior, but the parameter that represents the change in my health behavior is reset to 0 for the beginning of the next step. Agents also have their age and sex-adjusted mortality rate applied before each model step in order to simulate death in the population. When agents die

in the model, their social and family links are broken and they are completely removed from the model.

Next, events scheduled to occur at the beginning of the step are performed. The probabilities of being exposed to each intervention are calculated for each agent according to their distance to the closest site, whether they were exposed to the intervention from the previous step and whether anyone in their family or social network are exposed during the current step.

Health Behavior Change

During the actual step, agents then have their probabilities of being exposed to the interventions applied and if they surpass the threshold for each intervention, they then experience the health behavior effects of the interventions. For instance, if an agent is successfully exposed to the farmers' market intervention, then their health behavior change for fresh fruit and vegetable consumption, physical activity and sugar-sweetened beverage consumption is set to the defined values for the farmers' market intervention. However, one check is performed before allowing agents to flow into this state; population caps are used to prevent interventions from exposing too many people. These caps are mostly derived from actual data on participation, however in a few cases caps are pulled from what data existed in the literature. Agents that meet both these criteria and are exposed to the intervention also transfer the health behavior change benefits to any family members not exposed by the same intervention - although physical activity effects are only allowed to apply to the agent directly exposed to the intervention.

Weight Change

Before the end of the step, intervention changes are summed for the 3 health behaviors. Once summed, total health behavior change values for each health behavior are adjusted using the previously mentioned ideal health behavior values. These values are set to align with public health guidelines and work by slowing down health behavior change the closer the agents' current health behavior values are to the ideal health behavior level. In other words, agents whose behavior values are farther from the ideal (i.e., values from public health guidelines) are allowed to experience greater behavior change than those whose values are closer to the ideal. Afterwards, the new idealized health behavior change is used to calculate a corresponding change in bodyweight for each health behavior. Once these bodyweight changes are summed to create a total change in bodyweight, ideal bodyweight values for each agent are also used to slow the agent's bodyweight change the closer they are to their ideal bodyweight. This prevents unrealistic changes to body weight that could result in agents in the model becoming underweight over the timeframe of the simulation. Ideal bodyweight values are established for each agent according to their bodyweight at BMI of 25. This idealized bodyweight change is then applied to the agent's current weight, in effect completing the impact of the interventions on weight loss/gain. In addition, annual bodyweight change estimates from a prediction model using pooled CHIS 2003-2014 data are applied to the agent's current weight. This is intended to model secular trends in body weight change in Los Angeles County over time. This event is the

only bodyweight function that applied to both the intervention and control populations and ensures that the only difference in bodyweight change between the two groups is a result of the interventions.

Health Behavior Decay

In the event that an agent is exposed to an intervention in previous steps but not in the current step, their health behavior decays towards their initial baseline health behavior. For example, if an intervention increases the annualized average number of MET minutes of physical activity an agent has each week by 10 but then the agent is not exposed to the same intervention the next cycle (year), their health behavior decreases by half of 10. This decay occurs indefinitely, making sure that health behavior change reduces back to baseline levels if agents are not re-exposed to interventions, but never goes below. Agents that are never exposed to any interventions, either directly or indirectly, only inherit the change in bodyweight that also occurs to their control counterpart.

After the agent steps are complete, the main events finish up at the end of the step by printing out all the variables for any remaining person agents. This ensures that the output data used to analyze the intervention effects captures all the changes for that year before any resets occur.

Logistic growth curves to model behavior change

We assume that weight and health behaviors do not increase or decrease indefinitely. Based on this assumption, changes in weight and health behavior are modeled using logistic growth curves. The following formula provides an example of the logistic growth curve used for modeling body weight.

$$Body\ Weight = a_0 + \frac{a_1}{1 + e^{-a_2 time}}$$

Changes in the amount of physical activity, fresh fruit and vegetable consumption and sugar-sweetened beverage consumption, as well as changes in body weight, are modeled as logistic growth curves. Exhibit 30 illustrates these logistic growth curves. Note that these curves model a period of increase (or decrease) which eventually levels off. As a result, these growth curves prevent weight or health behaviors from increasing or decreasing indefinitely, which could lead to unrealistic changes over the 25-year time frame of the ABM.

Exhibit 30. Illustration of Logistic Growth Curves Used to Model Behavior Change

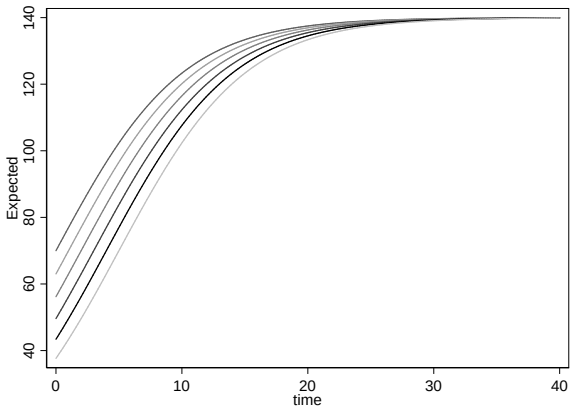


Exhibit 31. Effect Sizes Used for Each Parameter in the SNAP-Ed Agent-Based Model

Relationship	Effect Size	Source(s)
Farmer's Market		
• Probability of exposure/participation	Function of distance and past history visiting market, limited by market capacity	
• Probability of increasing fruit and vegetable (FV) consumption	78%	Young et al. 2011
• Fruit and vegetable consumption	+1.9 servings/day	Racine et al. 2010
• Sugar sweetened beverage (SSB) consumption	-0.1 servings/day	Gustafson et al. 2013
• Physical activity	+10 MET-mins per week based on average weekly MET-mins from visiting the Farmer's Market 8.5 times per year, accumulating 60 MET-mins each time (20 minutes of walking on flat surface at 3.0 METs)	MET estimate from 2011 compendium of physical activities and discussion with subject matter experts.
Community Gardens		
• Probability of exposure/participation	Function of distance and past history, limited by garden capacity	
• Fruit and vegetable consumption	+1.1 servings/day	Alaimo et al. 2008
• Sugar sweetened beverage consumption	-0.1 servings/day	Discussion with subject matter experts.
• Physical activity	8 MET-mins based on 20 participants typically accumulating a total of 160 MET-mins per week using 4.25 METs (average of 3.5 METs for light to moderate and 5.0 METs for moderate to vigorous gardening, from 2011 compendium of physical activities).	Draper & Freedman, 2010 review and discussion with subject matter experts.

Exhibit 31 continued: Effect Sizes Used for Each Parameter in the SNAP-Ed Agent-Based Model

Relationship	Effect Size	Source(s)
Healthy Retail		
• Probability of exposure/participation	Function of distance and past history, set to equal numbers on local use (~34% shop 1-2 times /month)	Gittelsohn et al 2009
• Fruit and vegetable consumption	0.351 servings of vegetables/day) within 100m of store	Bodor et al. 2007
• Sugar sweetened beverage consumption	-0.2	Discussion with subject matter experts.
• Physical activity	No change	Assumption that healthy retail interventions will not significantly modify levels of physical activity.
Healthy Food and Beverage Standards		
• Probability of exposure/participation	Function of distance and past history, limited by membership	
• Fruit and vegetable consumption	0.5 servings/day	Discussion with subject matter experts.
• Sugar sweetened beverage consumption	-0.1	Discussion with subject matter experts.
• Physical activity	No change	Assumption that healthy retail interventions will not significantly modify levels of physical activity.

Exhibit 31 continued: Effect Sizes Used for Each Parameter in the SNAP-Ed Agent-Based Model

Relationship	Effect Size	Source(s)
Nutrition Education – Nutrition Series		
• Probability of exposure/participation	Function of distance and attendance history, limited by attendance capacity	
• Fruit and vegetable consumption	+1.4 cups FV per day	Ha & Caine-Bish, 2009 and discussion with subject matter experts.
• Sugar sweetened beverage consumption	-0.5 servings/day	Discussion with subject matter experts.
• Physical activity	No change	Assumption that nutrition classes will not significantly modify levels of physical activity.
Nutrition Education – Exercise Series		
• Probability of exposure/participation	Function of distance and attendance history, limited by attendance capacity	
• Fruit and vegetable consumption	No change	Assumption that exercise classes will not significantly modify intake of FV
• Sugar sweetened beverage consumption	+0.25	Discussion with subject matter experts.
• Physical activity	20 MET-mins/week	Discussion with subject matter experts.

Exhibit 31 continued: Effect Sizes Used for Each Parameter in the SNAP-Ed Agent-Based Model

Relationship	Effect Size	Source(s)
Nutrition Education - Nutrition Single		
• Probability of exposure/participation	Function of distance and attendance history, limited by attendance capacity	
• Fruit and vegetable consumption	1.0 serving/day	Discussion with subject matter experts.
• Sugar sweetened beverage consumption	-0.35	Discussion with subject matter experts.
• Physical activity	No change	Assumption that nutrition classes will not significantly modify levels of physical activity.
Nutrition Education – Exercise Single		
• Probability of exposure/participation	Function of distance and attendance history, limited by attendance capacity	
• Fruit and vegetable consumption	No change	Assumption that exercise classes will not significantly modify intake of FV
• Sugar sweetened beverage consumption	+0.15	Discussion with subject matter experts
• Physical activity	12 MET-mins/week	Extrapolation of average annual MET-mins/week from participation in a single exercise class and discussion with subject matter experts.

Exhibit 31 continued: Effect Sizes Used for Each Parameter in the SNAP-Ed Agent-Based Model

Relationship	Effect Size	Source(s)
Nutrition Education - Indirect		
• Probability of exposure/participation	Function of distance and attendance history, limited by attendance capacity	
• Fruit and vegetable consumption	0.25	Discussion with subject matter experts
• Sugar sweetened beverage consumption	-0.1	Discussion with subject matter experts
• Physical activity	4 MET-mins/week	Discussion with subject matter experts
Behavior to Weight		
• Fruit and vegetable consumption to weight	Weight loss of 50g for an increase in one serving of FV	Schwingshackl et al 2015
• Sugar sweetened beverage consumption to weight	+/-1 SSB per day = +/- 0.42kg	Te Morenga et al 2013; fixed effects model results.
• Physical activity to weight	+60 MET-mins per week = -0.5 kg	Summary of three RCTs: McTiernan et al 2007, Irwin et al 2003, Franz et al 2007; also consistent with report from the Physical Activity Guidelines Advisory Committee. Original effect of 1.4 kg per 60 MET-mins was reduced to 0.5 kg per 60 MET-mins due to dramatic weight loss in model.

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