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Danielle Raso
danielle.raso@yale.edu

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Cost Effectiveness of a Produce Prescription Intervention

Danielle Raso, Masters of Public Health, 2020.

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Department of Health Policy and Management, Yale School of Public Health

Primary Advisor: David Paltiel, MBA, PhD

Secondary Advisor: Mona Sharifi, MD, MPH

ABSTRACT

In this study, we examined the effectiveness, cost, and cost-effectiveness of a produce prescription program. The program analyzed in this study is run by Community Health and Social Services (CHASS) Center, a Federally Qualified Health Center (FQHC) in Detroit, Michigan. The prescription produce intervention begins with eligibility screening and referral by patients' physicians at clinical visits for eligibility. Eligible patients are then given "prescriptions" for free fruits and vegetables that they can exchange at participating farmers markets or farm stands. Farmers markets also host cooking demonstrations and distribute healthy recipes. Finally, coordinators and volunteers follow up with patients and provide nutrition education with a standardized nutrition curriculum. We observed an average effect size of .532 unit reduction in hemoglobin A1c and a cost effectiveness ratio is $1,901 per one unit change in HbA1c, with 95% confidence intervals of 1208.72; 3016.96.

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INTRODUCTION

Over the course of the last few decades, there have been a number of shifts in the average American diet that have fueled the obesity crisis, including increased sugar intake, decreased fruit, vegetable, and fiber intake, and an overall increase in calories consumed each day.[1] Studies have shown that even without reducing calories consumed, increasing fruit and vegetable consumption has independent benefits to patients' diets by increasing their fiber intake, reducing sodium and fat intake, and increasing the micronutrient content.[2] Increasing the consumption of fruits and vegetables can improve health by promoting healthy weight and reducing the risk of heart disease, stroke, some types of cancer, digestive problems, and spikes in blood sugar[3].

There are grave disparities in access to healthy foods based on income, race, geographic location, and immigration status, which in turn drive disparities in overall health and quality of life.[4] Prescription produce programs are a relatively new type of intervention which have the potential to reduce health disparities resulting from differential access to healthy food. They allow healthcare providers to act when they encounter patients with food insecurity or whose health is suffering because they find fruits and vegetables to be prohibitively expensive. In addition to providing free or discounted access to produce, many prescription produce programs also attempt to address other cultural and socio-contextual barriers to accessing healthy food by providing educational and skill-building programming such as cooking demonstrations,

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[1] Lewis K and Basu S. Epidemiology of obesity in the United States. Metabolic Syndrome 2015, 1-21.
[2] Fulton, S. L., Cardwell, C. R., Mckinley, M. C., & Woodside, J. V. (2011). The effect of increasing fruit and vegetable consumption on overall diet: a systematic review and meta-analysis. Proceedings of the Nutrition Society, 70(OCE3). doi: 10.1017/s0029665111001066
[3] Vegetables and Fruits. (2019, May 22). Retrieved from https://www.hsph.harvard.edu/nutritionsource/what-should-you-eat/vegetables-and-fruits/.
[4] Neff, R. A., Palmer, A. M., McKenzie, S. E., & Lawrence, R. S. (2009). Food Systems and Public Health Disparities. Journal of Hunger & Environmental Nutrition, 4(3–4), 282–314. https://doi.org/10.1080/19320240903337041

suggestions of meal plans for the whole family, and nutritional information at the point of purchase.

There have been few studies published that examine the effectiveness of produce prescription programs, but the existing literature points to significant dietary improvements and reductions in food insecurity from similar programs.[5][6][7][8][9] One study showed a clinically-significant decrease in BMI among participants in produce prescription program retrospectively compared to a nonintervention group.[10] Another observational pre-post study showed clinically-significant improvement in hemoglobin A1C (HbA1c) , which is associated decreased risk for type II diabetes.[11] Most studies have shown an increase in participant-reported consumption of fruits and vegetables.

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[5]Aiyer, J. N., Raber, M., Bello, R. S., Brewster, A., Caballero, E., Chennisi, C., … Sharma, S. V. (2019). A pilot food prescription program promotes produce intake and decreases food insecurity. Translational Behavioral Medicine, 9(5), 922–930. https://doi.org/10.1093/tbm/ibz112

[6] Chinchanachokchai, S., Jamelske, E. M., & Owens, D. (2017). Tracking the Use of Free Produce Coupons Given to Families and the Impact on Children's Consumption. WMJ: Official Publication of the State Medical Society of Wisconsin, 116(1), 40–43.

[7] Marcinkevage, J., Auvinen, A., & Nambuthiri, S. (2019). Washington State's Fruit and Vegetable Prescription Program: Improving Affordability of Healthy Foods for Low-Income Patients. Preventing Chronic Disease, 16. https://doi.org/10.5888/pcd16.180617

[8] Ridberg, R. A., Bell, J. F., Merritt, K. E., Harris, D. M., Young, H. M., & Tancredi, D. J. (2019a). A Pediatric Fruit and Vegetable Prescription Program Increases Food Security in Low-Income Households. Journal of Nutrition Education and Behavior, 51(2), 224-230.e1. https://doi.org/10.1016/j.jneb.2018.08.003

[9] Ridberg, R. A., Bell, J. F., Merritt, K. E., Harris, D. M., Young, H. M., & Tancredi, D. J. (2019b). Effect of a Fruit and Vegetable Prescription Program on Children's Fruit and Vegetable Consumption. Preventing Chronic Disease, 16. https://doi.org/10.5888/pcd16.180555

[10] Cavanagh, M., Jurkowski, J., Bozlak, C., Hastings, J., & Klein, A. (2017). Veggie rx: An outcome evaluation of a healthy food incentive programme. Public Health Nutrition, 20(14), 2636-2641. doi:http://dx.doi.org/10.1017/S1368980016002081

[11] Bryce, R., Guajardo, C., Ilarraza, D., Milgrom, N., Pike, D., Savoie, K., … Miller-Matero, L. R. (2017). Participation in a farmers' market fruit and vegetable prescription program at a federally qualified health center improves hemoglobin A1C in low income uncontrolled diabetics. Preventive Medicine Reports, 7, 176–179. https://doi.org/10.1016/j.pmedr.2017.06.006

In this study, we examined the effectiveness, cost, and cost-effectiveness of a produce prescription program. We hypothesized that the produce prescription program will result in statistically significant improvement in HbA1c among participants with diabetes and describe the cost and cost-effectiveness of the intervention. Our aim was to inform policy-makers and clinical decision makers interested in implementing programs to address food insecurity and to promote good nutrition and health.

METHODS

Intervention Details:

The programs analyzed in this study are sample programs that originated from a grant scheme that funded the administration and evaluation of several prescription produce programs in the Detroit metropolitan area, organized through the nonprofit Eastern Market. Our primary analysis focuses on the program by the Community Health and Social Services (CHASS) Center, a Federally Qualified Health Center (FQHC) in Detroit, Michigan. The prescription produce intervention begins with eligibility screening and referral by patients' physicians at clinical visits for eligibility. Eligible patients are then given "prescriptions" for free fruits and vegetables that they can exchange at participating farmers markets or farm stands. Farmers markets also host cooking demonstrations and distribute healthy recipes. Finally, coordinators and volunteers follow up with patients and provide nutrition education with a standardized nutrition curriculum.

Estimation of Effect:

To estimate the effect of the program, we looked at its effect on reduction in HbA1c, because it is a reliable and clear indicator of effects of increased vegetable consumption. In previous research on this set of programs, there has been more sufficient evidence showing a reduction of HbA1c than there has been for any effects on weight or blood pressure, likely because HbA1c is more reliably dependent on change in diet. CHASS and HFHS are vastly different care settings, and while their efforts for the prescription produce programs were coordinated and similar, the implementing environment was too different to equate their programs. As the costs of the two interventions as implemented in CHASS and HFHS are not equivalent, we considered the effects of their interventions separately.

Population

Participants from CHASS are low-income patients seen for primary care visits, and have been diagnosed with diabetes. As reported in prior studies, most participants were female, with an average age of 49, and have a household income of less than $24,999. In 2015-2016, 44% of patients were African American, 37% were Hispanic/Latino, and 19% were either Caucasian, Native American, or selected “other”.[12] The data analyzed for this study did not include demographic level data about participants.

Data

Yale’s Institutional Review Broad (IRB) approved this study as nonhuman research. For the pre intervention HbA1c, post intervention HbA1c, year of participation, and number of visits was shared with the evaluator, along with costing data. No identifying information was shared with the research team.

[12] Ibid. Bryce, R., “Participation in a farmers’ market…”

Statistical Analysis

We first checked the normality of the data using a Shapiro test on the variance. We performed a series of paired t-test on the pre and post intervention HbA1c. We looked at the effect estimates of the data in its entirety and for CHASS, examined potential data limited to participants who completed more than 1 visit, more than 2 visits, more than 3 visits, and more than 4 visits. There were 171 total participants analyzed from CHASS, though only 96 completed 4 or more visits, which is the number of visits the organization would consider the program completed at. Participants were offered between 6 and 8 total visits, depending on year. CHASS data comes from three different implementation years- 2015, 2017, and 2018. HFHS provided only one year of data, from 2019, and only provided data from participants who completed all 6 offered visits. We separately tested HFHS's effect size, also using a paired t-test.

Cost Modeling Methodology:

In conjunction with partners at HFHS, CHASS, and Eastern Market, we measured the costs of the program using a micro-costing approach, including costs from a health systems perspective and limited societal perspective. Due to the relative strength of CHASS's effect data, their program was primarily analyzed. Micro-costing involves detailed measurement and analysis of each unit of input to the program, which is the most specific approach outlined by the 2nd edition of Cost-Effectiveness in Health and Medicine [13]. The costs were grouped into the following categories: Screening and Connection to Treatment, Transportation Costs for Events, Capital and Material Costs of the Events, Nutrition and Cooking Education, and General Program Costs.

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[13] Nyman J. A. (2018). Cost Recommendations in the Second Edition of Cost-Effectiveness in Health and Medicine: A Review. MDM policy & practice, 3(1), 2381468318765162. https://doi.org/10.1177/2381468318765162

We did not include related to research and evaluation because evaluation is not a part of the intervention and does not contribute to the effect estimates observed. Program implementers gave a range for each unit for each time and cost wherever possible. While the time ranges contributed represented the time spent by those working on this program, the salaries used were not the employee's real salaries, but Bureau of Labor Statistics (BLS) quintiles given for the general category of their job title. To ensure that the correct BLS category was used, several levels of similar positions were presented to the implementing team, and the team confirmed the level most similar to the actual employees.

After compiling estimates of costs and effectiveness, we conducted probabilistic sensitivity analyses using 1000 Monte Carlo simulations for each unit cost to examine the uncertainty around our estimates cost and cost-effectiveness. We then conducted a one-way sensitivity analysis around the estimate of the program director's time costs given high levels of uncertainty in this estimate.

RESULTS

Estimation of Effect:

Among 171 participants in the CHASS produce prescription program, mean HbA1c at baseline was 9.556. A majority (56%) attended 4 or more of the total of XX program visits. In paired t-tests, we observed a mean reduction in HbA1c of 0.532 (95% CI: .313%, .751%;). The results of the t-tests stratified by levels of participation are displayed in table 1. Effect sizes range between .532 and .927 unit reduction in HbA1c points, and are statistically significant in all cases with the greatest mean reduction among participants who attended ≥5 visits. The mean HbA1c level for all participants at baseline was 9.55614, representing a clinically significant 5.6 percentage point reduction in HbA1c levels[14].

Table 1. Effect Estimates by Level of Participation

	N (%)	**Mean change in HbA1c unit change, 95% confidence interval**	**P-value**
All Participants	171 (100%)	.532 (.313, .751)	<.001
≥2 visits	140 (82%)	.576 (.342. .811)	<.001
≥3 visits	122 (71%)	.635 (. 372, .898)	<.001
≥4 visits	96 (56%)	.768 (.481, 1.054)	<.001
≥5 visits	37 (22%)	.927 (.614, 1.240)	<.001

For Henry Ford Health System (HFHS), we have data from the per protocol group only, with pre and post interventions 30 participants who completed all visits to the farmers markets. Though the sample size and for HFHS is lower, limiting our power to detect a significant difference, we

[14] Radin, M. S. (2014). Pitfalls in Hemoglobin A1c Measurement: When Results may be Misleading. Journal of General Internal Medicine, 29(2), 388–394. https://doi.org/10.1007/s11606-013-2595-x

observed an effect estimate that is nearly identical results of CHASS's intervention, with a mean reduction in HbA1c of 0.52% (95% CI: -.01%, 1.05%;).

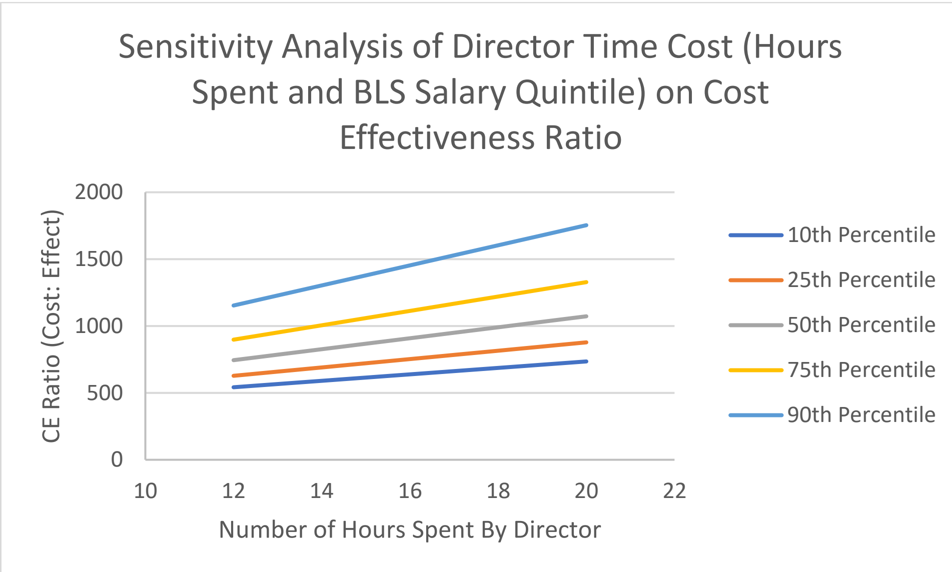
Costing:

After completing 1000 Monte Carlo Simulations, we estimate an average total cost of the CHASS produce prescription program of $59,152.66 per year, with 95% Confidence Intervals 37,413.01; 88,451.38.

Program Component	Average Cost	95% CI (Upper)	95% CI (Lower)
Total Costs Screening And Connection to Treatment	$3,645.56	$4,322.29	$3,030.80
Total Transportation Cost of Events	$555.74	$1,081.74	$222.42
Capital and Material Costs of Farmers Markets	$2,073.76	$2,425.37	$1,749.80
Total Nutrition and Cooking Education	$9,255.85	$15,539.69	$4,012.02
General Program Costs	$43,621.75	$72,582.62	$22,467.27
Total Average	$59,152.66	$88,451.38	$37,413.02

Putting together the cost and effect portions of this study, the cost effectiveness ratio is $1,901 per one unit change in HbA1c, with 95% confidence intervals of 1208.72; 3016.96.

The greatest amount of variation comes from the "General Program Costs" category because the estimation of director's time given by the organization was a wide estimation of 12-20 hours a week, and the quintiles for the salary of a medical and health services director is a highly variable category, according to the Bureau of Labor Statistics data. We performed a sensitivity analysis on the director time unit cost because it is not only the most variable cost, but it is also the largest cost of the categories, and the largest single unit cost in our analysis. The sensitivity analysis shows that varying the director's time and salary alone could change the cost effectiveness ratio from $1019.04 to $3295.11 per unit reduction in Hemoglobin A1C. The results of the sensitivity analysis shown in Figure 1 show the CE variation along 5 different curves which represent the BLS salary quintiles.



DISCUSSION

We examined the effectiveness and costs associated with a produce prescription program based in a primary care setting and observed an average effect size of .532 unit change in hemoglobin A1c and a cost effectiveness ratio is $1,901 per one unit change in HbA1c, with 95% confidence intervals of 1208.72; 3016.96. In our base case scenario, the time of the program's director comprised 74% of the total costs of the intervention with a high level of variability in our time and salary estimates. We found that varying the program director's time in sensitivity could vary the CE ratio between $1019.04 to $3295.11 per unit reduction in Hemoglobin A1C.

The results from our effect estimate stratified by number of visits to the farmers market indicate a greater effect size upon each incremental increase in visits, however this does not necessarily imply that offering a higher number of "doses" causes a greater effect size, as we do not have the ability to control for confounding factors that may cause participants to drop out of the program early.

Our results suggest that produce prescription programs may difficult to compare to other interventions aimed at reduction in HbA1c, but may have similar cost effectiveness as compared to other short term interventions to reduce HbA1c. This intervention's cost effectiveness ratio cannot fairly be compared to the standard of care, which is a lifestyle intervention combined with metformin because the incremental cost effectiveness ratio produced from this research reflects longitudinal observations[15]. However, a similarly short-term study of a common pharmacological interventions, liraglutide and exenatide, showed a similar effect size (between .5-1 (Hemoglobin A1C change) with a similar cost per unit change in HbA1c [16]. The cost-effectiveness ratio is higher than for one program that includes only nutrition and diabetes education and resulted in similar levels of HbA1c reduction[17].

The results of the micro-costing analysis and sensitivity analysis show general program costs should be the main focus of an organization trying to replicate this program at a low cost. Due to the low number of variables, having an employee with a lower salary coordinate the program could affect the cost of the program dramatically, as this one unit represents nearly ¾ of the total program costs. Having coordination represent such a large percentage of the total cost of

[15] Herman, W. H., Hoerger, T. J., Brandle, M., Hicks, K., Sorensen, S., Zhang, P., Hamman, R. F., Ackermann, R. T., Engelgau, M. M., Ratner, R. E., & Diabetes Prevention Program Research Group. (2005). The cost-effectiveness of lifestyle modification or metformin in preventing type 2 diabetes in adults with impaired glucose tolerance. Annals of Internal Medicine, 142(5), 323–332. https://doi.org/10.7326/0003-4819-142-5-200503010-00007
[16] DeKoven, M., Lee, W. C., Bouchard, J., Massoudi, M., & Langer, J. (2014). Real-World Cost-Effectiveness: Lower Cost of Treating Patients to Glycemic Goal with Liraglutide versus Exenatide. Advances in Therapy, 31(2), 202–216. https://doi.org/10.1007/s12325-014-0098-8
[17] Prezio, E. A., Pagán, J. A., Shuval, K., & Culica, D. (2014). The Community Diabetes Education (CoDE) Program. American Journal of Preventive Medicine, 47(6), 771–779. https://doi.org/10.1016/j.amepre.2014.08.016

the program may mean that having funding for more participants should result in economies of scale, meaning lower cost per participant and a lower cost-effectiveness ratio.

Limitations

The primarily limitation of the data used in this analysis is that while diabetes and other metabolic diseases this intervention addresses are chronic diseases, this intervention is very short, consisting of just 16-18 consecutive weeks. It is obviously challenging to institute lasting lifestyle change in this period of time, but it is also difficult to measure the results of an intervention's impact on chronic disease in such a short period of time. The most sophisticated cost-effectiveness research would calculate an incremental cost effectiveness ration (ICER) and would therefore depend on calculating a quality adjusted life year (QALY), which typically requires an understanding of effects on lifetime mortality and quality of life[18]. Being able to collect more longitudinal data from a prescription produce program would also give researchers the ability to calculate reductions in spending on metabolic disease related care that might result from improved glycemic control.

Another limitation is that we do not have RCT data, which is forthcoming from the intervention at CHASS, and this data could make evidence of a consistent effect stronger. RCT data would make us more able to detect the effect of this intervention as compared to standard care. With the current data because, we also did not have any demographic information on that participants so could not control for variables that may have confounding effects on why participants were or were not able to complete the intervention.

[18] Li, R., Zhang, P., Barker, L. E., Chowdhury, F. M., & Zhang, X. (2010). Cost-Effectiveness of Interventions to Prevent and Control Diabetes Mellitus: A Systematic Review. Diabetes Care, 33(8), 1872. https://doi.org/10.2337/dc10-0843

Finally, our costing data was limited by being reported retrospectively, well after the implementation of the intervention as measured. This is inherently less reliable than directly observed costs or time costs more minutely measured during the intervention, such as if we had records of staff daily time logs, because retrospectively reported data may be subject to recall bias. In particular, participant transportation data and participant time cost was difficult for staff to estimate and while these represent a very small portion of the total cost, it would have been better to have data from the participants themselves.

In summary, the intervention is both effective at improving glycemic control and, with a cost effectiveness ratio of $1,000.62 to achieve an average .532 unit change in HbA1c, is more cost effective than the "standard care" lifestyle intervention. Longer term interventions should be tested and more research should be done about both the long term effectiveness and cost-effectiveness of prescription produce interventions.