2021

Quantifying the Benefits of the Expanded Food and Nutrition Education Program (EFNEP) Using Biomarkers for Chronic Disease Risk

Richard Acquah-Sarpong
South Dakota State University

QUANTIFYING THE BENEFITS OF THE EXPANDED FOOD AND NUTRITION EDUCATION PROGRAM (EFNEP) USING BIOMARKERS FOR CHRONIC DISEASE RISK

By

RICHARD ACQUAH-SARPONG

A thesis submitted in partial fulfillment of the requirement for the degree

Master of Science

Major in Economics

South Dakota State University

2021

THESIS ACCEPTANCE PAGE

Richard Acquah-Sarpong

This thesis is approved as a creditable and independent investigation by a candidate for the master's degree and is acceptable for meeting the thesis requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Andrea Leschewski
Advisor Date

Eluned Jones
Department Head Date

Nicole Lounsbery, PhD
Director, Graduate School Date

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

QUANTIFYING THE BENEFITS OF THE EXPANDED FOOD AND NUTRITION EDUCATION PROGRAM (EFNEP) USING BIOMARKERS FOR CHRONIC DISEASE RISK.

RICHARD ACQUAH-SARPONG

2021

The Expanded Food and Nutrition Education Program (EFNEP) is among the major nutrition education programs funded by the United States Department of Agriculture (USDA) with the aim of reducing food insecurity among low-income families. The program reaches about 70,000 adults and youth of low-income families in the US, District of Columbia, and six U.S. territories.

Prior studies have used self-reported data, which possesses measurement errors, to estimate the benefits of the program. This can lead to underestimation or overestimation of results. To address this limitation, I use clinically measured objective biomarkers, such as body mass index (BMI), blood sugar level (HbA1C) and blood pressure to estimate the benefits of EFNEP and compare it to the program costs. Results show that EFNEP benefits outweigh program costs. However, the use of self-report data underestimates the benefits of the program.

CHAPTER 1

1.0 INTRODUCTION

1.1 Background

The Expanded Food and Nutrition Education Program (EFNEP) is one of the leading nutrition education programs aimed at reducing nutrition insecurity of low-income families and youth in the United States. Established in 1969 by the US government and managed by the USDA NIFA, EFNEP is among the earliest nutrition education programs and remains at the forefront of food and nutrition educational efforts (USDA, 2020). The program's main aim is to reduce nutrition insecurity among U.S low-income families and youth. EFNEP currently operates through the 76 Land-Grant Universities (LGUs) in every state, the District of Columbia, and six U.S. territories – American Samoa, Guam, Micronesia, Northern Marianas, Puerto Rico, and the Virgin Islands.

As a community-based nutrition education program, the goal of EFNEP is to address the health issues of the community as well as to improve the nutritional well-being of low-income households. EFNEP focuses on four main education areas: improving the quality of diet and physical activity of participants, proper food resource management, food safety and food security (USDA, 2020). These goals are accomplished through the participants' increased knowledge of the essentials of nutrition, as well as from increased skills in food selection, purchasing, preparation, production, storage, safety, and sanitation. The program also seeks to enhance the ability of participants to manage resources relating to food. The program receives about $70 million in federal funding each year and reaches approximately 650,000 adults and youth in both rural and urban areas (USDA, 2020). Researchers such as Lambur et al. (1998), Burney et al., (2002), and Koszewski et al.

(2011), conclude that EFNEP is an effective use of tax dollars i.e. the benefit of EFNEP in terms of avoiding or delaying specific chronic diseases, improvements in participants' food expenditures, and changes in nutritional behaviors exceed program costs.

1.2 Problem Statement

Over the years, several studies have evaluated the economic efficiency of EFNEP (Lambur et al., 1998; Burney et al., 2002; and Koszewski et al., 2011). Limitations of the existing literature, particularly in estimating the direct benefits of EFNEP, motivate this study. These limitations include the use of self-reported behavioral data, which are dietary recalls from participants of EFNEP, to determine those who have benefited from the program. Dietary recalls, which are collected through interviews before their first lesson and at the last lesson are used to determine those who benefit from the program by following the behaviors taught in the program. Benefits are measured as the number of people who have improved their nutrition and health behaviors after graduating from the program, and hence able to avoid or delay the onset of specific chronic diseases. There are obvious limitations to self-reporting in that some people may not remember past diets and physical activity correctly, or they may have difficulty quantifying them accurately (Hagen, 2012). The use of self-reported data and the dietary measurement error it poses can cause underestimation or overestimation of results (Rosenman et al., 2011). These limitations likely biased the results of prior EFNEP impact and cost-benefit analyses.

Considering the large amount of federal funding allocated to EFNEP (e.g. $69,400,680 for 2020) (NIFA,2020), a thorough cost-benefit analysis is needed to advance the literature by developing a cost-benefit analysis model that provides more accurate estimates of the net benefits and costs of the program. To address the challenges associated

with the use of self-reported behavioral data, I make use of objective, quantitative biological markers (biomarkers) reflective of nutritional intake and indicative of chronic disease risk (Combs et al., 2013). Biomarkers provide unbiased measurements and are therefore useful to validate self-report instruments (Hagen, 2012). Examples of biomarkers include body mass index (BMI), blood pressure (BP) and blood sugar level (HbA1C). This study will provide other nutrition education programs with a more accurate, easy-to-use procedure for conducting an economic analysis and give useful information to the administrators of EFNEP and similar nutrition education programs.

1.3 Objectives

The main objective of this study is to develop and apply a cost-benefit analysis methodology that provides more accurate estimates of the net benefit of EFNEP by using objective biomarker data. The specific objectives are to (1) quantify EFNEP benefits using biomarker data and (2) examine, using biomarkers, if EFNEP behaviors are maintained one-year-post graduation.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Cost-Benefit Analysis

Cost-benefit analysis (CBA), also referred to as benefit-costs analysis, is a systematic method to ascertain the value (benefits) of programs or projects against their costs where both are expressed in monetary terms. Results of CBA are usually expressed as discounted net benefits (program benefits minus program costs), as a rate of return, or as a ratio of benefits to costs, (Boardman et al. 2017). CBA provides a framework for measuring the efficiency of programs and projects. It can be thought of as a situation in which resources, such as land, labor, and capital, are employed in their highest-valued uses. (Boardman et al. 2017).

Such a quantitative comparison of program's benefits to its costs has been widely applied in the evaluation of health programs including EFNEP within the United States. Rajgopal, Ruby, Lambur, and Lewis (2002) define the benefits of a program as the outcomes or consequences that participants or non-participants derive from the program. The primary positive outcome that participants and others involved in the program derive directly is referred to as the direct benefit of the program. The secondary outcomes that program participants and non-participants or society derive indirectly are referred to as its indirect benefits.

Costs can also be categorized as direct or indirect costs. Budgeted resources are used directly in the administration of the program while some resources are not budgeted for but are necessary for operating or running the program. These are referred to as direct costs and indirect costs, respectively. Indirect costs can be the opportunity costs to the

individuals for direct involvement in the program. For example, indirect costs include the lost work hours due to participation in the program (Lambur, Cox, & Ellerbrock, 1998).

2.2 Economic Evaluation of EFNEP

Among the earliest economic evaluations of EFNEP is that of Virginia which evaluated the cost-benefit of Virginia EFNEP using the CBA methodology (Lambur et al. 1998). Direct benefits were measured as benefits from chronic diseases and conditions that are diet-related and that would have been delayed or avoided if participants adopted the behaviors that were taught and measured by EFNEP. The measurement of changes in behavior was captured from 24-hour dietary recalls reported by participants before and at the exit of the program. The Virginia methodology calculates direct benefits as the present value of the medical costs ($ dollars) saved per disease/condition multiplied by the number of EFNEP graduates who practiced food behaviors associated with avoiding or delaying the onset of the specific disease/condition (Lambur et al. 1998). Indirect benefits were measured as benefits that accrued to EFNEP participants due to increased work productivity. When a person becomes sick or dies, his or her earnings or productivity are threatened since he or she cannot work anymore. It is beneficial to avoid or delay the onset of a disease/condition because it has the potential of increasing an individual's productivity/earnings significantly. Also, the possibility of avoiding or delaying illness benefits society indirectly because it increases people's ability to work. Costs used in the Virginia methodology were direct administrative costs of the program (Radhika et al. 2002).

Lambur et al. (1998) and Radhika et al. (2002) categorized the disease/conditions into three types; Type A, B, and C. Type A is the life-threatening diseases/conditions which

are associated with nutritional behaviors that are expected to be affected positively by appropriate diet behaviors. These are heart disease, colorectal cancer, hypertension, and stroke. Type B disease/conditions are non-life-threatening diseases that are also associated with nutritional behaviors which are expected to be affected positively by appropriate diet behaviors. These are obesity, type 2 diabetes, osteoporosis, foodborne illness, and commonly occurring infant diseases. Type C disease/conditions are those whose cost of treatment is incurred only once such as low birth weight (LBW) in infants. The direct benefit of type C disease is based on the present value of avoiding the costs of treating an infant with low birthweight.

After calculating program benefits and costs, Lambur et al. (1998) used three analytical measures of benefits, namely benefit-cost ratio (BCR), internal rate of return (IRR), and net present value (NPV) to measure the efficiency of Virginia EFNEP. They used the 1996 Virginia adult EFNEP self-reported data from the EFNEP Evaluation Reporting System which included pre and post self-reported data on program participants' food-related behaviors. The authors concluded that Virginia EFNEP generates a significant return on investment with a $10.64/$1.00 benefit to cost ratio. Addressing the uncertainty of whether the results were due to assumptions in their analysis, such as the unavailability of estimates of incidence rates for some of the disease conditions for low-income households, they conducted several sensitivity analyses. The result of the sensitivity analysis was a benefit to cost ratios ranging between $2.66/$1.00 and 17.04/$1.00.

Other studies have looked at the economic evaluation of the EFNEP program in various states using a similar methodology as that of Virginia evaluation reviewed above

(Lambur et al. 1998; Radhika et al. 2002). These studies have been summarized in Table 1.

2.3 Behavioral Changes of EFNEP Participants

Burney et al., 2002 analyze whether the benefits of participating in EFNEP exceed its cost and if these positive behaviors are maintained over a long period. Using an experimental design in the cost-benefit analysis methodology, a sample size of 384 participants was randomly assigned to one of three different groups to determine improvements in participants' food expenditures. Group A are those who received nutrition education from EFNEP and collected cash receipts for their food purchases; Group B are those whose food expenditures were estimated from recall; and Group C, the control group, are those who had qualified for enrollment in the program but had to start their lessons after groups A and B had graduated from the program. Cash receipts to determine food expenditures were used to differentiate Group A from Groups B and C. Using the Analysis of Variance technique, comparing the combined experimental group (A and B) with the control group, data gathered from food and nutrition intake between entry and exit of the program showed positive average changes in food and nutrition intake. Statistically, changes in food and nutrition intake by the experimental group were significantly higher than those of the control group after participating in EFNEP. Also, there were significantly higher mean scores of food resources management practices for the experimental group than the control group. Pairwise comparisons between groups were made and the results showed that EFNEP participants had the most improvement in their food expenditures and that they retained their behavior changes from the program over a long period after

graduation. To compare the benefits, which is the amount of money saved on food expenditures to the costs, the net present value (NPV) ranged from $147 to $696.

Almost all the studies on the economic evaluation of EFNEP have demonstrated that the benefits of EFNEP exceed its cost (Amstutz and Dixon, 1969; Arnold and Sober, 2000; Greer and Poling, 2001). But another question of interest and importance is how long will such positive nutritional behaviors and benefits be sustained? To answer this question, Koszewski et al. (2011) determined if graduates from either SNAP-Ed or EFNEP in Nebraska showed changes in their behavior 6 months after completing the program. Data for the analysis was gathered from EFNEP's Behavior Checklist Survey and analyzed using chi-square analysis to determine the effectiveness of SNAP-Ed/EFNEP nutrition education six months after graduation. The authors found that 25% (n=1,100) of the graduates from the two programs improved and maintained their behaviors within the entry and exit of the program, as well as 6 months later. This result was emphasized by Wardlaw and Baker, (2012) who also conducted a long-term evaluation of EFNEP and SNAP-Ed using checklists and semi-structured interviews to identify the changes in behavior, food, and nutrition behaviors as well as other life changes attributed to their involvement in the program over time. The study sample were previous graduates who were enrolled within one to four years. The results of their study indicate that following EFNEP participation, graduates maintained positive food- and nutrition-related behaviors for approximately one to four years within the period which they were enrolled and they performed these behaviors more often than non-participants.

The research presented in this subsection indicates positive findings on the economic efficiency of EFNEP and other related health education programs. Nonetheless,

there are several limitations associated with the approaches used in these studies such as their use of self-reported data on dietary intake and behavior changes. This limitation creates the potential for self-report bias (Rosenman et. al, 2011). Participants may make more acceptable answers or recall rather than being truthful or may not be able to remember their food behaviors accurately.

2.4 Self-Report Data and Biomarkers

One challenge in nutrition and health care evaluation is the use of self-reported data and the measurement error it poses which can cause underestimation or overestimation of results. Few studies have evaluated self-reported dietary intake data against objective data. Park et al. (2018) estimated the prevalence of under- and overreporting of dietary intake by comparing self-reported dietary intakes which were gathered from the automated Self-Administered 24-hr recall (ASA24s), 4-d food records (4DFRs), and food-frequency questionnaires (FFQs) against recovery biomarkers. Over a study period of 12 months, 530 men and 545 women, aged 50–74 years were made to complete automated Self-Administered 24-h recall (ASA24s), 2 unweighted 4-d food records (4DFRs), 2 FFQs, two 24-h urine collections (biomarkers for protein, potassium, and sodium intakes), and 1 administration of doubly labeled water (a biomarker for energy intake). When absolute intakes of some nutrients were assessed by all self-reported instruments, they were found to be systematically lower than the absolute intakes of the same nutrients accessed from recovery biomarkers, though there was underreporting of energy which was greater compared to the other nutrients. Nutrients accessed were energy, protein, potassium, and sodium. Comparing estimates of dietary intake from self-reported data with the biomarkers, there was an underestimation of intake by 15–17% on ASA24s, 18–21% on 4DFRs, and

29–34% on FFQs. FFQs had the most underreporting compared to ASA24s and 4DFRs and among obese individuals. Mean protein and sodium densities on ASA24s, 4DFRs, and FFQs were similar to biomarker values, but potassium density on FFQs was 26–40% higher, which led to a significant increase in the prevalence of overreporting compared with absolute potassium intake.

Table 1: Economic Evaluations of the Expanded Food and Nutrition Education Program.

Citation	Objectives	Methodology	Results
Dollahite, Jamie, Donald Kenkel, and C. Scott Thompson. "An economic evaluation of the expanded food and nutrition education program." *Journal of nutrition education and behavior* 40, no. 3 (2008): 134-143.	Use economic methodology to evaluate New York State EFNEP	Design: Estimating potential health benefits using an epidemiological modeling approach. estimates of cost-effectiveness are from behavior change and QALY weights. Subjects: 5730 low-income participants. Setting: 35 counties of New York State	Benefit-to-cost ratio of $9.58:$1.00 (sensitivity $1.44-$41.92:$1:00); Narrow governmental benefit-to-cost ratio of $0.82:$1.00 (sensitivity $0.08-$4.33:$1:00).
Hradek, Christine, Helen H. Jensen, Nicole Schimerowski Miller, and Miyoung Oh. "Evaluation of the Cost and Effectiveness of Direct Nutrition Education to Low-Income Audiences in Iowa: EFNEP and SNAP-Ed graduates practicing Optimal Nutritional Behaviors (ONB)." (2017).	Evaluate the costs and benefits of EFNEP and SNAP-Ed programs as well as update a study conducted in Iowa from 1998 to 2000.	Design: Analyze outcomes and costs based on updated data collected from the Iowa EFNEP and FNP program (updated Virginia methodology) Subjects: 947 graduate participants. Setting: Iowa State.	Benefit-to-cost ratio of $2.48/$1.00 Less restrictive measures of benefits lead to benefit-to-cost ratios between $1.51/$1.00 - $2.48/$1.00

Joy, A., Vijay Pradhan, and George Goldman. "Cost-benefit analysis conducted for nutrition education in California." California Agriculture 60, no. 4 (2006): 185-191.	Justify and determine expenditures and ensure continued funding by documenting the cost-effectiveness of nutrition education programs	Design: Standard Virginia methodology. Subjects: Settings: California State	Benefit-cost ratio of 14.67/1.00. (Sensitivity 3.67 to 1.00, to 8.34 to 1.00)
Schuster, Ellen, Zelda L. Zimmerman, Molly Engle, Janice Smiley, Ellen Syversen, and Jill Murray. "Investing in Oregon's Expanded Food and Nutrition Education Program (EFNEP): documenting costs and benefits." *Journal of nutrition education and behavior* 35, no. 4 (2003): 200-206.	To estimate a cost-benefit ratio for Oregon's EFNEP by applying the standard CBA model from Virginia study.	Design: Standard Virginia methodology. Subjects/Settings: 368 adult graduates of Oregon State University's Extension Service EFNEP during the 1999-2000 program year.	Benefit-cost ratio of 3.63/1.00

Rosenman et al. (2011), further demonstrate how to identify self-reported data bias in response and its covariates by examining how participant demographics affect response bias before and after program participation. The stochastic frontier model (SFE) by Aigner et al. (1977) and Meeusen and van den Broeck (1977) was the approach of measuring response bias and its changes between two time periods. They conclude that the magnitude of bias and its changes across time are affected by gender and race/ethnicity which is lower at post-test than at the pre-test.

To address the problem of dietary measurement bias error, efforts have been made to use biological markers (biomarkers) of nutritional intake (Freedman et al., 2010). Examples of such biomarkers include weight, body mass index (BMI), blood pressure (BP) and blood sugar level (A1C). Information on physiological or biological responses to dietary behavior can provide information on interindividual differences in response to diet and nutrition revealed by such measurements and be useful to monitor responses to interventions (Hagen, 2012). Biomarkers provide almost unbiased measurements and are therefore useful to validate self-report instruments.

CHAPTER 3

3.0 DATA AND METHODOLOGY

3.1 Participants

EFNEP participants are primarily families with income below the poverty line (USDA, n.d.). Approximately 70% of EFNEP participants are indicated to be of minority status (USDA n.d.). The program focuses on minority and low-income groups given their disproportionate risk for chronic diseases and poor health (USDA n.d.). This study's population was composed of 1,507 graduates of EFNEP in both states in 2016-2017, of which 725 were in Washington and 782 were in Colorado. EFNEP graduates are participants who completed all their lessons as well as both the entry and exit interviews (Wessman et.al, 2001). The sample for the study is 129 EFNEP graduates of average age of 37 years, all of whom are females, with complete data for dietary recalls, biometric measures and food practice scores. EFNEP graduates are defined as program participants who completed all their lessons as well as both the entry and exit interviews (Wessman et.al, 2001). Participants were recruited during the first EFNEP class, during which they agreed to allow collection of their biometric measures.

For each individual, the biometric measures collected are, height, weight, body mass index (BMI), systolic blood pressure (SBP), diastolic blood pressure (DBP), blood sugar level (HbA1C), and pulse rate. These measures were collected with clinical diagnostic instruments and taken at four different time points: pre (at the first lesson), post (at the final lesson), and 6 and 12 months after the lesson series. At each time point, the average of multiple measures was taken for each biometric measure. The participants were

given cash incentives of $30 (pre), $30 (post), $50 (6 months post), and $50 (12 months post). (RNECE final report, 2019).

Table 2: Demographic and biometric data from pretest(n=129)

Variable	Mean (sd)
Age (Years)	37.4 (10.7)
Colorado State	
Washington State	
Height (cm)	159.0(7.5)
Weight (kg)	80.8(20.9)
BMI (kg/m^2)	31.9(7.6)
Systolic blood pressure (mmHg)	109.0(12.4)
Diastolic blood pressure (mmHg)	75.6(8.6)
Hemoglobin A1c	5.6(0.9)
Pulse Rate	77.5(24.5)
Number of complete observations	

Source: RNECE final report, 2019

Figure 1 summarizes the pre-EFNEP biometric indicators for the sample of 129 EFNEP participants. The majority of the sample participants were between the ages of 25 and 40 years. At the first lesson, most of the participants weighed between 60kg and 120kg and were between 155cm and 175cm tall. Some participants had weight above 120kg with two out of the five outliers having height above 175cm.

Body Mass Index (BMI) was centered between 20 kg/m^2 and 50 kg/m^2 with the Hemoglobin A1C Test (HbA1C) centering between 4mmol/L and 7mmol/L. Normal BMI range is between 18.5 to 24.9 kg/m^2. BMI range greater than 29.9 are considered obese (Center for Disease Control, 2020). Normal blood sugar levels (HbA1C) ranges below 5.7mmol/L. HbA1C levels greater than 6.5mmol/L are considered diabetic. Participants

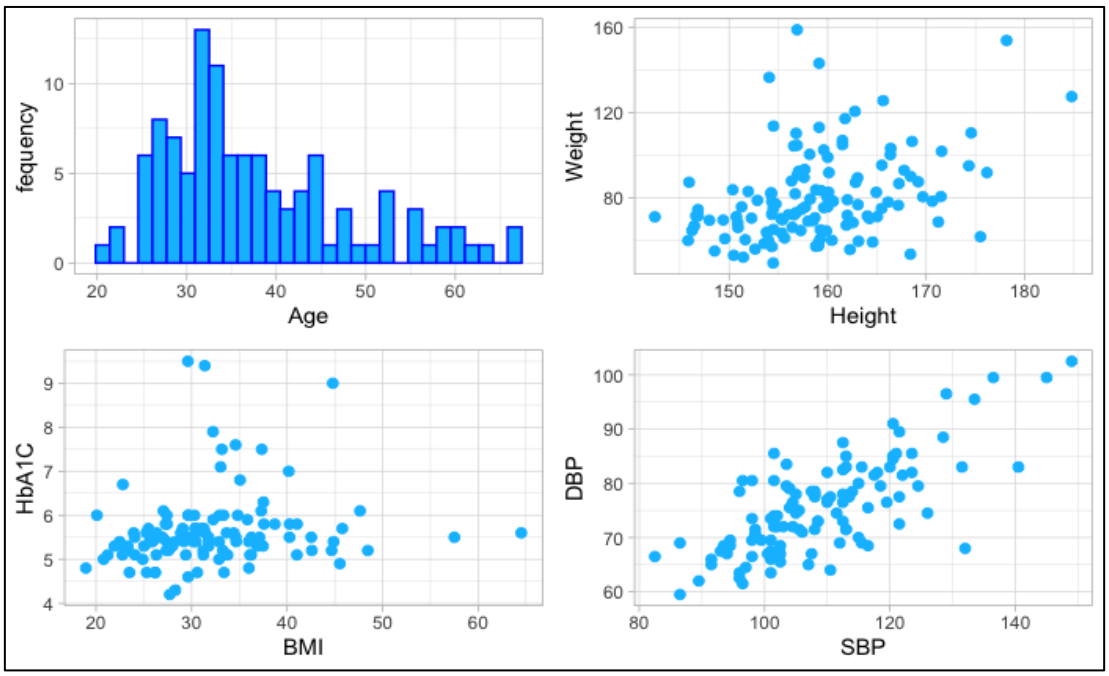

Figure 1: Pre-EFNEP demographic and biometric data distribution

with higher systolic blood pressure (SBP) also had high diastolic blood pressure (DBP). Most of the participants who had SBP between 80mmHg and 130mmHg also had DBP between 60mmHg and 90mmHg. Normal ranges of SBP and DBP are less than 120mm Hg and 80mm Hg respectively. There were few participants with DBP greater than 90mmHg.

The main cost-benefit analysis will be done with the entire data excluding participants with missing values.

3.2 Data

Both primary and secondary data play an important role in quantifying the economic benefits of EFNEP. To calculate the direct and indirect benefits of EFNEP, primary and secondary data were obtained from four sources. Biomarkers were collected in 2017 and 2018 as part of the long-term follow-up evaluation of EFNEP by the Regional Nutrition Education and Obesity prevention Centers of Excellence (RNECE). Identical models of the clinical equipment were used at each time point by trained professionals to collect the biometric measurements including scales, stadiometers, blood pressure monitors, and HbA1c test kits.

The goal of the evaluation was to determine if EFNEP impacted participants' biomarkers (BMI, BP, HbA1c) and if participants of EFNEP could be retained for one year (RNECE final report, 2019). Demographic characteristics, food and physical activity questionnaires and 24-hour dietary recalls are administered at entry and at exit to measure behavior change. This was collected through EFNEP's Web-Based Nutrition Education Evaluation and Reporting System (WebNEERS). Food Practice Checklist (FPC) questions were answered by the participants to measure specific food consumption and handling behaviors on a scale of 1-5.

In addition to biomarker and WebNEERS data, estimates from the literature (Hradek et. al., 2015) were used to calculate program direct and indirect benefits. These estimates include average age of onset and years of survival of the diseases, number of years diseases are delayed as a result of participation in EFNEP, per patient medical costs discounted to 2020 dollars, average age of retirement, average number of annual lost

workdays, incidence rate of the disease in the low-income population, incidence rate of the disease related to diet, incidence rate of disease related to biomarkers and minimum wage rate. Annual costs of lost workdays were obtained by multiplying the average number of annual lost workdays, eight hours of daily work hours and the 2020 federal minimum wage for covered nonexempt employees of $7.25 per hour (US Department of Labor, n.d.).

Table 3: Data used for calculating direct and indirect benefits

Disease Condition	Av. age of participants	Av. Age of onset	Av. Years of survival	No. of years onset delayed	average lifespan	Per patient cost adjusted to 2020 Dollars	Av. age of retirement	Av. number of annual lost workdays	Annual cost of lost workdays (2020 dollars)
				Type A Diseases					
Colorectal Cancer	37	50	5	5	78	$34,793	65	50	$2,900.00
Heart disease	37	55	5	5	78	$14,830	65	59	$3,422.00
Stroke	37	45	10	5	78	$22,984	65	65	$3,770.00
Hypertension	37	41	20	5	78	$805	65	40	$2,320.00
				Type B Diseases					
Osteoporosis	37	50			78	$10,669	65	7	$406.00
Type 2 Diabetes	37	54			78	$8,670	65	11	$638.00
Obesity	37	40			78	$2,046	65	3.72	$215.76
Foodborne Illness	37	24			78	$1,811	65	1.5	$87.00
Infant Diseases	37	0			78	$2,539	65		
				Type C Diseases					
Low Birthweight	37	0			78	$21,799	65		

Source: Hradek et. al., 2015

Data on direct costs (Table 4) are also utilized in this study. Direct costs associated with EFNEP were annual direct costs of adult EFNEP (2018 Dollars) obtained from collaborators on the pilot project. The direct costs consisted of the value of resources, including direct payments of real and in-kind dollars, used in program administration and implementation. They included salaries and benefits; facilities (office space, IT support and utilities); equipment, supplies and training; staff travel; and marginal excess burden (17%).

Table 4: Summary of Annual Direct Costs (2018 Dollars) - FTE % Approach

Category	**Cost**
Salaries and Benefits	$1,221,053.80
Office Space	$124,204.77
Utilities	$13,217.29
Equipment, Supplies and Training	$155,195.62
Staff Travel	$43709.56
Marginal Excess Burden (17%)	$264754.78
Total Direct Cost	**$1822,135.82**

Source: (Administrative costs assembled from EFNEP Washington and Colorado Extension)

3.3 The Cost-Benefit Analysis Methodology.

Cost-benefit analysis (CBA) is commonly used to inform society which project or program to choose from among a number of similar programs. An accurate CBA thus requires a precise and unbiased definition or identification of benefits and costs that are generated from the program (Torrance, G.W, 2006). To decide on the desirability of a project, all positive and negative aspects of the project should be expressed in terms of a common unit (Watkins and Valley, 2006). The most convenient and most used common unit is money. This means that all benefits and costs of a project should be measured in

terms of their equivalent money value of a particular time. The CBA methodology is applicable for this study as it analyzes a single program to determine whether its benefits outweigh its cost. The program has economic value if it contributes positively to human well-being (Frew, E., 2010). The ultimate role of CBA is to aid in allocating scarce resources.

Results of CBA are usually represented as (1) the discounted net benefit, which is the difference between program benefits and costs, (2) a ratio of benefits to costs, or (3) a rate of return (Net Present Value (NPV)/Internal Rate of Return (IRR)) (Boardman et al. 2017). Discounting is a way to compare benefits and costs that occur in different time periods by expressing their values in present terms since a dollar available five years from now is not as good as a dollar available now. That dollar can be invested and earn interest in the next 5 years. For example, if r is the interest rate, then investing $1 now will grow to be of $1(1 + r)^t$ in the next t years. Therefore, the amount of money needed to be deposited to today so that it will grow to be $1 in the next t years is $1(1 + r)^{-t}$. $1(1 + r)^{-t}$ is referred to as the present value of $1 which will be available in the future. $(1 + r)^t$ is called the discount factor. When applied properly, discounting can inform us about how much a future benefit or cost of a project or program is worth today (Neubauer et al., 2010). Thus, when the dollar value of the benefits or costs of a project is multiplied by the discounted value of $1 at that future time, the result referred to as the discounted present value (Watkins and Valley, 2006). CBA provides a framework for measuring the efficiency of programs and projects and it can be thought of as a method whereby resources are valued in their highest-valued uses. (Boardman et al. 2017). Such a quantitative comparison of a program's benefits to its costs has been widely applied in the evaluation

of health programs within the United States (Schuster et al, 2006, Hradek et al., 2017). The cost-benefit ratio is used to ascertain the value of a program by determining whether its benefits outweigh its costs within a specific period. The ratio gives the value of the discounted benefits obtained per the costs of the program and is defined as follows:

$$Cost - Benfit\ Ratio(BCR) = \frac{Present\ Value\ of\ Total\ Benefits}{Present\ Value\ of\ Total\ Costs}$$

$$= \frac{\sum_{t=1}^{n}\left(\frac{Total\ Bnefit_t}{(1+r)^t}\right)}{\sum_{t=1}^{n}\left(\frac{Total\ Cost_t}{(1+r)^t}\right)} \quad (1)$$

where r is the discount rate which captures the level of future uncertainty and n is the number of years in the future for discounting.

A potentially worthwhile project is one which has its discounted present value of the benefits exceeding the discounted present value of the costs. Equivalently, the ratio of the present value of the benefits to the present value of the costs (cost-benefit ratio) must be greater than one. A cost-benefit ratio of less than one means that discounted present value of the costs exceeds the discounted present value of the benefits. A benefit-cost ratio that is equal to 1 means that there is a break-even situation where the discounted present value of the benefits of the program equals its discounted present value of costs. When comparing alternative programs, the program with the highest benefit-cost ratio is preferred.

3.4 Monetizing Benefits of EFNEP

Estimated medical costs avoided or delayed for each disease/condition represented the direct benefits of EFNEP. The assumption is that participants practicing Optimal Nutritional Behaviors (ONB) and those with biomarker improvement will save these medical costs by avoiding or delaying the diseases. Benefits such as reduced food costs, food production and preservation, better use of nutritional food related resources and job readiness and performance would not be included in the benefit calculations because these data are not consistently or routinely collected across states in EFNEP and cannot be easily monetized (Rajgopal et al., 2002).

Medical costs used were 2017 present value medical costs of diseases obtained from existing literature (Hradek et al., 2017). The future benefits for each disease which were the costs avoided for some specific time periods were discounted to 2020 dollars at a discount rate of 5% which is the rate used for most cost benefit analyses (CBAs) in healthcare studies (Rajgopal et al., 2002). Indirect benefits that accrue to EFNEP participants are the lost earnings of wages from lost productivity. This indirect benefit calculation assumes that the individual loses personal wages from lost workdays when he or she becomes ill from any of these chronic diseases. The 2020 federal minimum wage for employees of $7.25 per hour were used in calculating the lost earnings from lost productivity. Chronic diseases and conditions are categorized into three types: Type A, Type B, and Type C.

The monetized benefit of avoiding or delaying a disease/condition is the sum of the present value of direct benefits (medical costs avoided or delayed) and the present value of indirect benefit (lost earnings of wages from lost productivity forgone), as follows.

$$\text{Estimated PV Benefits} = \text{PV of direct benefit} + \text{PV of indirect benefit}$$

$$= \sum_{t=1}^{n}\left(\frac{Direct\ Benefit_t}{(1+r)^t}\right) + \sum_{t=1}^{n}\left(\frac{Indirect\ Benefit_t}{(1+r)^t}\right) \qquad (2)$$

3.5 Type A Disease Benefits

Type A consists of life-threatening diseases, which are normally incurable, can considerably reduce a person's life expectancy and are associated with nutritional behaviors that are expected to be affected positively by appropriate diet behaviors. These are heart disease, colorectal cancer, hypertension, and stroke. The estimated present value of total benefit of type A disease consist of direct and indirect benefit of delaying the onset of the disease:

$$\text{Est PV benefits of delaying Type A disease} =$$

$$= \text{PV of Type A direct benefit} + \text{PV of Type A indirect benefit}$$

$$= \sum_{t=1}^{n}\left(\frac{Type\ A\ Direct\ Benefit_t}{(1+r)^t}\right) + \sum_{t=1}^{n}\left(\frac{Type\ A\ indirect\ Benefit_t}{(1+r)^t}\right) \qquad (3)$$

The direct benefits of type A diseases are the present value of medical costs avoided as a result of delaying the onset of the diseases as a result of participation in EFNEP. For example, if the average age of onset of a type A disease is at age 50, and EFNEP can delay the onset for 5 years to age 55, then the estimated present value medical cost avoided for the 5 years of delay (from age 50 to 54) becomes the benefit of delaying the disease. For type A diseases, the present value of medical costs is estimated for the average years of

survival. The direct benefit of type A diseases is calculated as the difference between the sum of the present value of treatment costs from average age of onset to average age of death and the sum of the present value of the treatment costs from the delayed age of onset to the delayed age of death. The present value of all benefits is discounted to 2020 dollars to determine how much future benefit is worth today.

$$PV\ of\ Type\ A\ direct\ Benefit =$$

$$= \sum_{t=1}^{n}\left(\frac{Medical\ cost_{\ from\ \ age\ of\ onset}}{(1+r)^t}\right) - \sum_{t=1}^{n}\left(\frac{Medical\ cost_{from\ delayed\ age\ of\ onset}}{(1+r)^t}\right) \quad (4)$$

$$PV\ of\ Medical\ costs_{from\ age\ of\ onset} =$$

$$= \sum_{t=1}^{n}\left(\frac{Annual\ cost\ of\ treatment\ \times number\ of\ years\ from\ onset\ to\ death}{(1+r)^t}\right) \quad (5)$$

$$PV\ of\ Medical\ costs_{from\ delayed\ age\ of\ onset} =$$

$$= \sum_{t=1}^{n}\left(\frac{\begin{array}{c}Annual\ cost\ of\ treatment\ \times \\ number\ of\ years\ from\ delayed\ onset\ to\ delayed\ death\end{array}}{(1+r)^t}\right) \quad (6)$$

Table 5: Type A disease Direct Benefit Illustration:

Present value of Stroke treatment cost if incurred at age of onset till death				**Present value of stroke treatment cost if delayed for 5 years**		
Age	**year**	**PV**		**Age**	**year**	**PV**
37-44	8	$0.00		37-49	13	$0.00
45	9	$14,815.42		50	14	$11,608.27
46	10	$14,109.93		51	15	$11,055.50
47	11	$13,438.03		52	16	$10,529.04
48	12	$12,798.12		53	17	$10,027.66
49	13	$12,188.69		54	18	$9,550.15
50	14	$11,608.27		55	19	$9,095.38
51	15	$11,055.50		56	20	$8,662.27

52	16	$10,529.04	57	21	$8,249.78
53	17	$10,027.66	58	22	$7,856.94
54	18	$9,550.15	59	23	$7,482.80
Total		**$120,120.81**	**Total**		**$94,117.80**

PV of Direct Benefit of delaying Stroke = $120,120.81 - $94,117.80 = $26,003.01

Type A disease indirect benefits are the loss of productivity avoided due to the delay of the onset of the diseases. The loss of productivity prevents the individual from earning wages. Therefore, the benefits from avoiding the loss of productivity are the wages that would have been forgone. The indirect benefit of type A diseases is the difference between the sum of the present values of lost wages from the average age of onset to average age of death and the sum of the present value of lost wages from the delayed age of onset to the delayed age of death – discounted to 2020 dollars.

$$PV\ of\ Type\ A\ Disease\ Indirect\ BEnefit =$$

$$= \sum_{t=1}^{n}\left(\frac{Lost\ wages_{from\ age\ of\ onset}}{(1+r)^t}\right) - \sum_{t=1}^{n}\left(\frac{Lost\ Wages_{from\ delayed\ age\ of\ onset}}{(1+r)^t}\right) \quad (7)$$

$$PV\ of\ Lost\ Wages_{average\ age\ of\ onset} =$$

$$= \sum_{t=1}^{n}\left(\frac{Annual\ lost\ of\ wages\ \times \\ number\ of\ years\ from\ onset\ to\ delayed\ death}{(1+r)^t}\right) \quad (8)$$

$$PV\ of\ Lost\ Wages_{from\ delayed\ age\ of\ onset} =$$

$$= \sum_{t=1}^{n}\left(\frac{Annual\ lost\ of\ wages\ \times \\ number\ of\ years\ from\ onset\ to\ delayed\ death}{(1+r)^t}\right) \quad (9)$$

Table 6: Type A Disease Indirect Benefit Illustration:

Present value of lost wages from stroke if incurred at average age of onset			**Present value of lost wages from stroke if delayed for 5 years**		
Age	**year**	**PV**	**Age**	**year**	**PV**
37-44	8	$0.00	37-49	13	$0.00
45	9	$2,430.18	50	14	$1,904.11
46	10	$2,314.45	51	15	$1,813.43
47	11	$2,204.24	52	16	$1,727.08
48	12	$2,099.28	53	17	$1,644.84
49	13	$1,999.31	54	18	$1,566.51
50	14	$1,904.11	55	19	$1,491.92
51	15	$1,813.43	56	20	$1,420.87
52	16	$1,727.08	57	21	$1,353.21
53	17	$1,644.84	58	22	$1,288.77
54	18	$1,566.51	59	23	$1,227.40
Total		**$19,703.43**	**Total**		**$15,438.15**

Indirect Benefit of Stroke Disease = $19,703.43 - $15,438.15 = $4,265.277

3.6 Type B Diseases Benefits

Type B disease and conditions are non-life-threatening diseases, which are diseases that can be treated and are also associated with nutritional behaviors that are affected positively by appropriate diet behaviors. These are obesity, type 2 diabetes, osteoporosis, foodborne illness, and commonly occurring infant diseases. The estimated present value of total benefit of type B disease consist of direct and indirect benefit of delaying the onset of the disease.

$$\text{Est PV benefits of delaying Type B disease} =$$

$$= \text{PV of Type B direct benefit} + \text{PV of Type B indirect benefit}$$

$$= \sum_{t=1}^{n} \left(\frac{Type\ B\ Direct\ Benefit_t}{(1+r)^t} \right) + \sum_{t=1}^{n} \left(\frac{Type\ B\ indirect\ Benefit_t}{(1+r)^t} \right) \quad (10)$$

The benefits of type B diseases are the estimated present value of medical costs avoided as a result of avoiding the onset of the disease through the rest of one's lifetime until the average life expectancy by participating in the program. For example, if the life expectancy is at age 78, and the average age of onset of the disease is at age 50, then the present value of medical costs one could have incurred from age 50 till average lifespan is the benefit of avoiding the disease.

For type B diseases, the present value of medical costs is estimated for the average lifespan of the individual from the onset of the disease. The direct benefit of type A diseases is calculated as the sum of the present value of treatment costs from average age of delayed age of onset through the rest of the lifetime (average age of death), discounted to 2020 dollars. The present value of all benefits is discounted to 2020 dollars.

$$PV\ of\ Type\ A\ direct\ Benefit =$$

$$= \sum_{t=1}^{n} \left(\frac{\begin{matrix} Annual\ cost\ of\ treatment\ \times \\ number\ of\ years\ from\ delayed\ onset\ to\ death. \end{matrix}}{(1+r)^t} \right) \quad (11)$$

Table 7: Type B Disease Direct Benefit Illustration

Present value of Type 2 Diabetes treatment costs if avoided for the rest of lifetime.		
Age	year	PV
37-53	18	$0.00
54	19	$3,431.21
55	20	$3,267.82
56	21	$3,112.20
57	22	$2,964.00
58	23	$2,822.86
59	24	$2,688.44
60	25	$2,560.42
61	26	$2,438.49
62	27	$2,322.38
63	28	$2,211.79
64	29	$2,106.46
65	30	$2,006.15
66	31	$1,910.62
67	32	$1,819.64
68	33	$1,732.99
69	34	$1,650.47
70	35	$1,571.87
71	36	$1,497.02
72	37	$1,425.74
73	38	$1,357.84
74	39	$1,293.19
75	40	$1,231.61
76	41	$1,172.96
77	42	$1,117.10
78	43	$1,063.91
Total PV		**$50,777.19**
Direct Benefit for Type 2 Diabetes = $50,777.19		

Type B disease indirect benefits are the loss of productivity avoided due to avoiding the diseases until the age of retirement. The loss of productivity prevents the individual from earning wages therefore the benefits from avoiding the loss of productivity are the wages that would have been forgone when one is sick as a result of the disease. The indirect benefit of type B disease is the sum of the present values of lost wages from average age of onset to average age of retirement, discounted to 2020 dollars.

$$PV\ of\ Type\ A\ Indirect\ Benefit =$$

$$= \sum_{t=1}^{n} \left(\frac{Annual\ Lost\ wages\ \times\ number\ of\ years\ from\ delayed\ onset\ to\ death.}{(1+r)^t} \right) \quad (12)$$

Table 8: Type B Disease Indirect Benefit Illustration

Present value of lost earnings for Type 2 Diabetes until retirement		
Age	**Year**	**PV**
37-53	18	$0.00
54	19	$252.48
55	20	$240.46
56	21	$229.01
57	22	$218.10
58	23	$207.71
59	24	$197.82
60	25	$188.40
61	26	$179.43
62	27	$170.89
63	28	$162.75
64	29	$155.00
65	30	$147.62
Total PV		**$2,349.67**
Indirect benefit for Type 2 Diabetes = $2,349.67		

3.7 Type C Disease Benefits.

Type C diseases and conditions are those whose cost of treatment is incurred once only when the child is born such as low birth weight (LBW) in infants. The direct benefit of Type C diseases and conditions is based on the present value of avoiding the one-time treatment costs of treating an infant with LBW.

3.8 Cost-Benefit Analysis (CBA) Models

Two different CBA are implemented in this study – the standard CBA model (Virginia methodology) which measures program benefits using self-reported dietary

recalls and the biomarker CBA model which uses biomarkers for benefit estimation. Previous CBA studies on EFNEP have employed the use of the standard model (Lambur et al. 1998, Radhika et al. 2002., and Hradek, et al., 2017) but the use of biomarkers is quite uncommon in the field of nutrition education. The use of the clinically measured and objective biometric data will help to eliminate bias and error such as under-reporting and over-reporting associated with the use of self-reported data. The difference in the methodologies is that while the total benefit estimation of the standard Virginia method uses graduates practicing ONB (calculated from the self-reported behavioral data) and the incidence rate of the disease related to diet, the biomarker method calculates the number of graduates with biomarker improvement and uses the risk of disease related to the biomarker in estimation of the benefits.

3.9 Standard CBA Model.

Following the literature, I first apply the Virginia methodology utilized in prior CBA of EFNEP (Lambur et al. 1999, Radhika et al. 2002, & Burney et al., 2002). The Virginia methodology uses self-reported behavioral data to determine the participants who are delaying or avoiding the diseases as well as uses the incidence rate of diseases related to diet to quantify the total benefits of the program. To avoid or delay the onset of the diseases, the participants must meet the selection criteria (recommended dietary behavior guidelines) in Table 6 (Wessman et al., 2001). The standard methodology estimates total benefit as the product of the total number of graduates in the program, the incidence rate of the disease in low-income population, incidence rate of the disease related to diet, the percent of graduates achieving optimal nutrition behavior and the present value of

estimated benefit of avoiding or delaying the disease. The benefits for each disease are calculated using the formula:

$$Benefit\ for\ disease = N\ \times\ I_l\ \times I_d\ \times\ grad_{ONB}\ \times PV(benefit) \quad (13)$$

Where N is the total number of EFNEP graduates, I_l is the incidence rate of disease in Low-income population, I_d is incidence rate of disease related to diet, $grad_{ONB}$ is the percentage of graduates achieving optimal nutrition behaviors (ONB) conditions for the specific disease, and PV(benefit) is the present value of the estimated benefit of avoiding or delaying the disease. The standard model calculates the total benefit of participating in EFNEP as the sum of benefits for each disease.

$$Total\ Benefit_{standard\ model} = \sum Benefit\ for\ each\ disease \quad (14)$$

3.10 Incidence Rate of the Disease/Condition

The incidence rates which measure the probability of occurrence of the diseases in a low-income US population within a specified period of time are provided in Table 5. These were obtained from a recent CBA of Iowa EFNEP (Hradek et.al, 2017). When possible, incidence rates specifically for the low-income US population are utilized. Where rates for the low-income population cannot be found, the incidence rates for the general population are used. The incidence rates of the diseases related to diet measure the portion of the occurrence of the disease/condition believed to be related to diet over a specific period. The rates act as a proxy for the percentage of EFNEP graduates who would normally get a disease or condition, but who might avoid or delay its onset by adopting recommended nutrition behaviors (Wessman et.al, 2001).

Table 9**:** Incidence Rates of Disease Related to Diet in the Low-Income Population**.**

Disease/condition	Incidence rate of the disease in the low-income population	Incidence rate of the disease related to diet
Colon Cancer	8.0%	80%
Heart Disease	25.8%	50%
Stroke	8.1%	49%
Hypertension	29.3%	45%
Osteoporosis	10.3%	15%
Diabetes	28.0%	45%
Obesity	38.0%	50%
Foodborne Illness	16.7%	100%
Infant Diseases	100.0%	22%
Low Birthweight (LBW)	8.0%	100%

Source: Hradek et.al (2017).

3.11 Selecting Graduates Practicing Optimal Nutritional Behaviors (ONB)

STATA statistical software was used to select participants among the 129 sample graduates who practiced optimal nutrition behaviors (ONB) at exit and those who had improvement in their biomarkers at exit, 6 months after graduation and 1 year after graduation. To be selected as practicing ONB, the participant must meet the selection criteria for ONB (see Table 5 in the Table 10). Graduates who were missing critical data related to the ONB were eliminated from the selection. The standard CBA model uses optimal nutritional behaviors (ONB) in Table 6 to determine whether a graduate avoids or delays the onset of a chronic disease or condition. The ONB criteria for a specific disease/condition were applied to entry and exit 24-hour food recall and the Food Practice Checklist (FPC) questions which measure food consumption behaviors and food handling

practices on a scale from 1 to 5. To be considered as a graduate practicing ONB, the graduate must satisfy the criteria at graduation, but not at entry. This is because satisfying the criteria at entry implies that the participant was already practicing ONB and that EFNEP did not impact his or her behavior (Lambur, et al., 2015).

Table 10 : Optimal Nutrition Behavior Criteria By Disease (Based on 2015-2020 DGA)

Disease	Normal Graduates (2000 kcal)	Pregnant or Nursing graduates (2600 kcal)	FPC(questions #)	FPC score
Colon Cancer	total fat ≤ 78gms, saturated fat ≤ 22gms fiber ≥ 25gms, fv ≥ 4.5cup-eq	total fat ≤ 101, saturated fat ≤ 29gms fiber ≥ 28gms, fv ≥ 5cup-eq	7&9	≥ 4
Heart Disease	total fat ≤ 78gms, saturated fat ≤ 22gms fiber >= 25gms, fv>= 4.5cup-eq	total fat ≤ 101, saturated fat ≤ 29gms fiber ≥ 28gms, fv ≥ 5cup-eq	8&9	≥ 4
Stroke/Hypertension	Fv ≥ 4.5 cup-eq, Ca ≥ 1000mg	Fv ≥ 5 cup-eq, Ca ≥ 1000mg	8&9	≥ 4
Osteoporosis	Ca ≥ 1,000 mg , Dairy ≥ 3 cup-eq	Ca ≥ 1,000 mg , Dairy ≥ 3 cup-eq	7	≥ 4
Diabetes	fiber ≥ 25gms, kcal ≤ 2300 kcal carbohydrate ≤ 325gms	fiber ≥ 28gms, kcal ≤ 2600 kcal for pregnant women kcal ≤ 2500 kcal for nursing women carbohydrate ≥ 423gms	7&9	≥ 4
Obesity	fiber ≥ 25gms, fv ≥ 4.5cup-eq total fat ≤ 78gms, saturated fat ≤ 22 gms kcal ≤ 2300 kcal	fiber ≥ 28gms, fv ≥ 5cup-eq total fat ≤ 101, saturated fat ≤ 29gms kcal ≤ 2600 kcal for pregnant women kcal ≤ 2500 kcal for nursing women	7&9	≥ 4

Foodborne Illness	-	-	5&6	≤ 2
Infant Diseases	yes for nursing	-	7	≥ 4
Low Birthweight		yes for pregnant kcal>=2200	9	≥ 4

The Optimal Nutrition Behavior (ONB) Criteria is based on 2015-2020 Dietary Guidelines.
FPC # Q5. This question is about meat and dairy foods. How often do you let these foods sit out for more than two hours?
Q6. How often do you thaw frozen foods at room temperature?
Q7. When deciding what to feed your family, how often do you think about healthy food choices?
Q8. How often have you prepared foods without adding salt?
Q9. How often do you use the "Nutrition Facts" on the food label to make food choices?

Source (Hradek et al., 2017)

Table 11 : Percent of Graduates Practicing Optimal Nutrition Behaviors

Disease	**Graduates practicing ONB**
	entry - exit
Colon Cancer	7.5%
Heart Disease	7.5%
Stroke	12.5%
Hypertension	12.5%
Osteoporosis	5%
Type 2 Diabetes	12.5%
Obesity	5%
Foodborne Illness	19.23%
Infant Diseases	27.5%
Low Birth Weight	-

3.12 Biomarker CBA Model

There are obvious limitations to self-reporting in that some people may not remember food intake and exercise levels correctly, or they may have difficulty quantifying them accurately (Combs et al., 2013). This problem may lead to underestimation or overestimation of the results when self-reported data are used in the analysis (Park et al., 2018). To solve the problem of using self-reported data in the standard model, biomarkers, which are objective and quantitative biological measurements that indicates the potential for developing a disease or medical condition in an individual are used. In this model, the assumption is that behaviors learnt from EFNEP impact chronic disease biomarkers i.e. BMI, blood pressure and HbA1C. A participant's improvement in the biomarkers provides a means to accurately measure the benefits of EFNEP. Biomarkers provide almost unbiased measurements and are therefore useful to validate self-report instruments (Hagen, 2012). The biomarker model also uses the PV of medical cost and lost earnings of avoiding the diseases (Type A, B and C) as the benefits. The difference between the two models is that while the standard CBA model uses graduates achieving ONB conditions for each disease and the incidence rate of disease related to diet, the biomarker model uses instead, the number of graduates improving their biomarkers and the risk of the disease related to the biomarker respectively. The benefit of each disease calculated using the biomarker model is:

$$Benefit\ for\ each\ disease = N \times I_l \times I_b \times grad_{imbrove\ bio} \times PV(benefit) \quad (15)$$

where N is the total number of EFNEP graduates, I_l is the incidence rate of disease in the low-income population, I_b is incidence rate of disease related to biomarker, $grad_{\text{improve bio}}$ is the percentage of graduates improving in their biomarkers for the specific disease, and

PV(benefit) is the present value of the estimated benefit of avoiding or delaying the disease. The biomarker model calculates the total benefit of participating in EFNEP as the sum of benefits for each disease.

$$Total\ Benefit_{biomarker\ model} = \sum Benefit\ for\ each\ disease \quad (16)$$

The risk of the disease related to the biomarkers is used as a measure of the portion of the occurrence of the disease/condition related to changes in the biomarker over a specific period. These rates give an indication of the likelihood of developing or having the disease/condition as a result of changes in biomarkers.

3.13 Identification of EFNEP Graduates with Biomarker Improvement

The goal of EFNEP is ultimately to improve the nutritional health of participants, therefore it follows that, by practicing these behaviors, biological characteristics such as weight, blood sugar, blood pressure, etc., which are indicators of good health and proper nutrition behaviors will be impacted. The criteria for determining graduates with biomarker improvement were based on general population rates of standard status categories of biomarkers provided by the Center for Disease Control (CDC) and the American Heart Association (provided in Table 12). The criteria for selecting graduates who have improvement in biomarkers are presented in Table 13. To be selected as having improvement in biomarkers at graduation, there must be quantitative change in values of biomarkers towards the normal category of each biomarker. For example, using the normal BMI range as a reference point, an overweight or obese graduate is selected to have improvement in BMI when BMI at graduation (exit) is less than the BMI at entry, and an underweight graduate is selected as having improvement in BMI when the BMI at graduation (exit) is greater than the BMI at entry. The same criteria were used to determine

graduates who had improvements in their biomarkers six months after graduation and one year after graduation. Graduates who were missing critical data related to biomarkers were eliminated from the sample. The risks of diseases associated with the biomarkers are presented in Table 10. Figure 2 provides the percentage of graduates who had improvements in their biomarkers at graduation (entry-exit), 6 months after graduation (entry-6months) and 1 year after graduation (entry-1year).

Table 12: Biomarker Status Categories.

Biomarker	Range (general population)	Category	Source
BMI	Less than 18.5	Underweight	Center for Disease Control (2020)
	18.5 to 24.9	Normal/Healthy weight range	
	25.0 to 29.9	Overweight	
SBP & DBP	Systolic: less than 120 mm Hg Diastolic: less than 80 mm Hg	Normal	Center for Disease Control (2020)
	Systolic: 120-129 mm Hg Diastolic: less than 80 mm Hg	Elevated	
	Systolic: 130 mm Hg or higher Diastolic: 80 mm Hg or higher	High Blood Pressure (hypertension)	
Pulse	78 - 157	Target heart rate zone (50-85%)	American Heart Association Guidelines for the prevention, detection, evaluation, and Management of high blood pressure in adults (2017)
Blood Sugar	Below 5.7%	Normal	Center for Disease Control (2020)
	5.7% to 6.4%	Prediabetes	
	6.5 or above %	Diabetes	

Table 13: Criteria for Selecting Graduates Who Had Biomarker Improvement

Biomarker	Direction of Improvement	Criteria for determining improvement in biomarkers at graduation
BMI	Underweight to Normal	entry BMI is less than 18.5 & exit BMI greater than entry BMI & exit BMI < 24.9
	Overweight and Obese to normal	entry BMI > 24.9 & exit BMI < entry BMI &

		exit BMI >18.5
SBP	Elevated and high BP to normal	entry SBP > 129 & exit SBP < entry SBP
DBP	High BP to Normal	entry DBP > 80 & exit DBP < entry DBP
Pulse	Changes towards the target heart rate zone	entry Pulse < 78 & exit Pulse > entry Pulse & exit Pulse < 132
HbA1C	Changes from prediabetic and diabetic towards normal	entry HbA1C > 5.7 & exit HbA1C < entry HbA1C

Table 14: Risk of Chronic Disease Associated with Changes in Biomarkers

Disease/condition	Biomarker used	Risk of disease associated to biomarker	Source
Type A Diseases			
Heart Disease	BMI	21%	WHO, 2009
Hypertension	Blood pressure	12%	Harvard SPH, 2020
Colorectal Cancer	BMI	30%	Harvard SPH, 2020
Stroke	Pulse	23%	WHO, 2009
Type B Diseases			
Type 2 diabetes	HbA1C	66%	Harvard SPH, 2020
Obesity	BMI	100%	Harvard SPH, 2020
Osteoporosis[1]		48%	Hradek et.al (2017).
Foodborne illness[1]		100%	Hradek et.al (2017).
Type C diseases			
Infant diseases[1]		22%	Hradek et.al (2017).

There was no direct relationship between biomarkers and osteoporosis, foodborne illness and infant diseases based on existing literature, therefore the risk of the disease associated to diet was used.

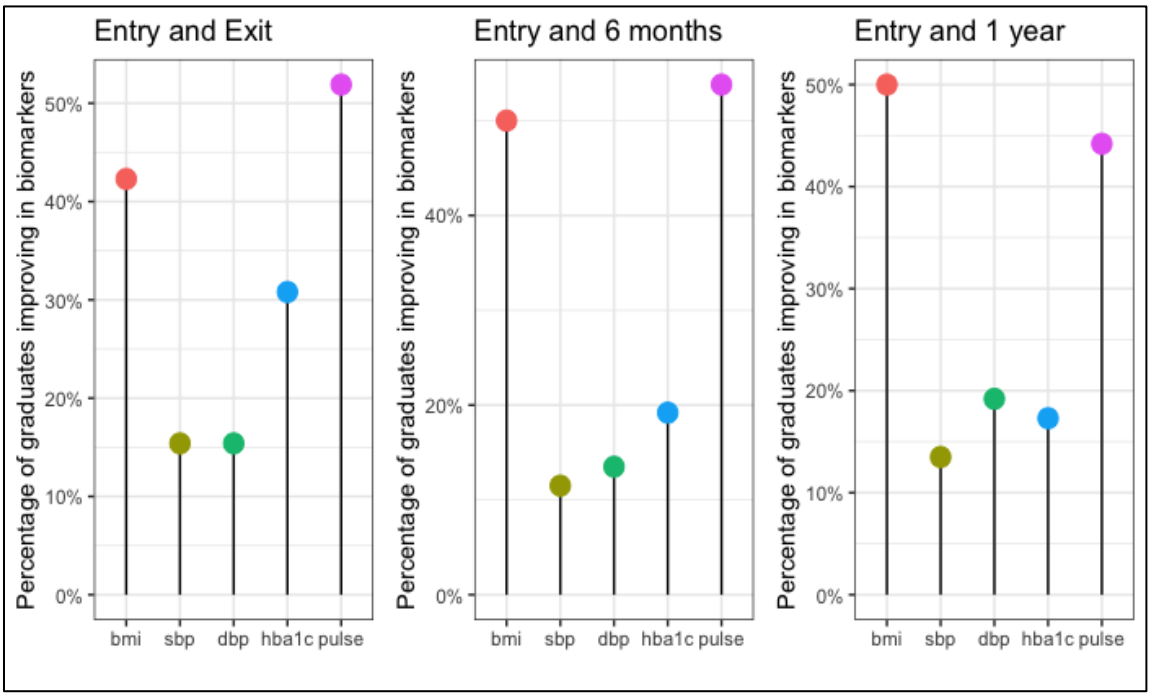

Figure 2: Percentage of graduates having improvement in biomarker

BMI and pulse rate had the highest percentage of graduates improving their biomarkers for all the three periods. There was an improvement in the percentage of graduates who had improved BMI, but there was not much change from 6 month to 1 year post-EFNEP . SBP had the lowest percent of graduate improving at all time periods (15.4%, 11.5%, 13.5%). DBP had the highest percentage of improvement at 1 year after graduation. The percentage of graduates improving in their blood sugar (HbA1C) was highest at exit (30.8%) and lowest after one year of graduation (17.3%). There were lower percent of graduates with improvement for pulse at 1 year after graduation (44.2%) compared to the higher percent of graduates with improvement of at graduation (51.9%) and at 6 months after graduation (53.8%).

CHAPTER 4

4.1 Results

The final sample size used in the analysis is 129 EFNEP graduates with complete data. Table 11 below provides the number and percentages of graduates who practiced ONB at exit of the program, as well as graduates who improved their biomarkers for the diseases at exit, 6 months post and one year post. For all the diseases except foodborne illness and infant diseases, the percentage of graduates with improved biomarkers exceeded the percentage with improved ONB across all three periods: graduation, six months after graduation and one year after graduation. No graduates were selected for practicing ONB or improving biomarkers for low-birth-weight disease. This is because there were no pregnant participants in the study sample. The highest percentage of graduates practicing ONB at exit is 27.5% for avoiding infant diseases and the lowest percentage of graduates practicing ONB at exit is 5% for avoiding obesity. The highest percentage of graduates improving their biomarkers are 51.92% for avoiding stroke at exit, 53.85% for avoiding stroke at 6 months after graduation and 50% for avoiding colon cancer, heart disease, and obesity after one year of graduation.

Table 15: Percentage of Graduates Improving in Their Biomarkers for Each Disease

Disease	Number & percentage of graduates avoiding disease			
	Graduates practicing ONB	Graduates improving in biomarkers		
	entry - exit	entry-exit	entry-6months	entry-1yr
Colon Cancer	7.5%	42.31%	50.0%	50.0%
Heart Disease	7.5%	42.31%	50.0%	50.0%
Stroke	12.5%	51.92%	53.85%	44.23%
Hypertension	12.5%	30.77%	25.00%	132.69%
Osteoporosis	5%	72.20%	72.20%	72.20%

Type 2 Diabetes	12.5%	30.77%	19.23%	17.31%
Obesity	5%	42.31%	50.0%	50.0%
Foodborne Illness	19.23%	19.23%	19.23%	19.23%
Infant Diseases	27.5%	9.62%	9.62%	9.62%
Low Birth Weight	-	-	-	-

A summary of the CBA results calculated using the cost-benefit ratio formula in equation (1) for both models is provided in Table 12. The PV of total benefit is derived by the summation of the total direct benefit and the total indirect benefit which is then compared to the total costs. The total cost of the program ($1,822,135.82) was obtained by adding the total administrative costs from the Washington and Colorado EFNEP programs.

The cost-benefit ratio is derived by dividing the total benefit by the total cost. From Table 12, the estimated PV of total direct benefits, which are the medical costs avoided or delayed, obtained by using the biomarkers at graduation ($15,695,056.81), six months after graduation ($15,610,152.67), and one year after graduation ($15,150,042.08) are higher than the estimated PV of total direct benefit ($4,383,751.24) obtained at graduation when dietary recalls (self-reported data) are used.

The PV of total indirect benefits (lost productivity/wages avoided or delayed) obtained using the biomarkers at graduation ($1,375,117.55), six months after graduation ($1,444,849.32), and one year after graduation ($1,420,879.22) is much higher than the estimates of PV of total indirect benefits obtained at graduation from using the self-reported data ($361,939.46). The estimated PVs of direct, indirect and total benefits calculated from the standard model, using self-reported data, are lower than the estimated PVs of direct, indirect and total benefits calculated using the biomarker model. The PV of total benefits from the standard model is $4,745,690.69 compared to the much higher PV of total benefit

of $17,070,174.36, $17,055,002.00, and $16,570,921.30 for all the three time periods using the biomarker model. Benefits were compared to the costs and incorporated into a benefit-cost ratio. From the standard model, EFNEP generates a benefit-cost ratio of $2.60: $1.00. The biomarker model yields benefit-cost ratios of $9.37: $1.00, $9.36: $1.00, and $9.09: $1.00 at exit, six months post and 1 year post respectively.

Table 16: Cost-Benefit Analysis Results

	Standard model	Biomarker model		
	entry - exit	**entry - exit**	**entry - 6 month**	**entry – 1 year**
Total direct benefits	$4,383,751.24	$15,695,056.81	$15,610,152.67	$15,150,042.08
Total indirect benefits	$361,939.46	$1,375,117.55	$1,444,849.32	$1,420,879.22
Total benefits	$4,745,690.69	$17,070,174.36	$17,055,002.00	$16,570,921.30
Total costs	$1,822,135.82	$1,822,135.82	$1,822,135.82	$1,822,135.82
Cost-benefit ratio	**$2.60: $1.00**	**$9.37: $1.00**	**$9.36: $1.00**	**$9.09: $1.00**

4.2 Sensitivity Analysis

Healthcare evaluations are prone to the uncertainties that beset the methodologies, assumptions and data which have implications on the interval of the estimates (Briggs and Gray, 1999). Sensitivity analysis is therefore important to evaluate the robustness of the assumptions in CBA. This is to determine how the uncertainties in the models and the data impact the estimated CBA results, and hence determine the range or confidence of the estimates (Sendi, Garfni and Birch, 2002).

The 5% discount rate, which describes the level of uncertainty in the time value of money, is commonly used in health- related studies (Attema et al., 2018). Since there is some uncertainty about using this value, a sensitivity analysis is done by varying the discount rate (0%, 3%, 7% and 10%). The incidence rates of the infant disease and foodborne illness related to diet were used in the biomarker models since there were no

studies found in the literature that provided an association of biomarkers to those diseases, so it is important to conduct a sensitivity analysis on these rates in the biomarker model. A sensitivity analysis is performed by reducing the incidence rates of infant disease and foodborne illness used in the biomarker model by 50%.

Table 17: One Way Sensitivity Analysis Table

	Standard Model	**Biomarker Model**			**BCR interval**
	Entry – Exit	Entry – Exit	Entry - 6months	Entry – 1year	
0% discount rate	$6.57	$24.54	$22.65	$21.99	($6.57 - $22.65)
3% discount rate	$3.60	$13.22	$12.83	$12.47	($3.60 - $13.22)
7% discount rate	$1.98	$6.94	$7.10	$6.89	($1.98 - $7.10)
10% discount rate	$1.42	$4.71	$4.95	$4.80	($1.42 - $4.95)
50% reduction of incidence rates of infant diseases and foodborne illness	$2.60	$8.89	$8.88	$8.61	($2.6 - $8.89)
Sensitivity interval	**($1.42 - $6.57)**	**($4.71 - $24.54)**	**($4.95 - $22.65)**	**($4.80 - $21.99)**	

The results indicate that the CBA outcome remained positive after altering the parameters. However, the benefit-cost ratio changed significantly for each analysis. The findings from the sensitivity analysis are consistent with that of the primary results of the cost-benefit analysis. The results were more sensitive to the varying the discount rate than to reducing the incidence rates for foodborne and infant diseases. Assuming no uncertainty in the model (0% discount rate) had the greatest impact on the benefit-cost ratios for both models. The cost-benefit ratio of the biomarker model lies within the sensitivity interval of $4.71 - $24.54: $1.00 for all the three time periods. The cost-benefit ratio of the standard model lies within the sensitivity interval of $1.42 - $6.57:$1.00. The sensitivity analysis

leads to the same conclusion that estimates from the biomarker model are higher than estimates from the standard model.

CHAPTER 5

5.1 Discussion and Recommendation

The cost-benefit ratios presented in Table 12 indicate that EFNEP generates significant return on investment. These results corroborate the positive returns found in prior EFNEP studies (Rajgopal et al., 2002; Lambur et al., 2009 and Hradek et al., 2017). The standard model, which uses self-reported dietary recall data from EFNEP participants, indicates a $2.67 return on every $1.00 invested (sensitivity: $1.42 - $6.57). The result from the standard model possesses measurement errors due to the use of self-reported dietary recalls. Therefore, to address the problems associated with the use of self-reported data, objective and clinically measured biomarkers of participants collected at graduation, 6 months after graduation and 1 year after graduation are used to estimate the benefits of EFNEP.

The results from using the biomarkers indicate an average return of $9.27 on every $1.00 invested (sensitivity: $4.71 - $24.54). The significant difference in the results from the two models emphasizes the bias, measurement errors, and underestimation associated with the use of self-report data (Rosenman et al., 2011). The use of biomarkers for chronic disease risk provides more accurate results that better reflect the true benefit of EFNEP. The results from both models indicate that taxpayer dollars are used effectively in addressing the issue of nutrition insecurity among low-income families. As individuals learn and implement proper nutritional behaviors and can avoid or delay the onset of these diseases by participating in the program, they are able to save these medical costs which may be used in purchasing food and other necessities for their families. The benefit-cost ratios from the biomarker model for all the three periods are approximately $9.00 for each

period which suggests that the nutritional behaviors derived from the EFNEP program are maintained for at least 1 year after participants graduate from the program.

Results from this study suggest that the program provides an effective use of taxpayer dollars in addressing nutrition insecurity. EFNEP participants experience sustained improvement in nutritional health through the adoption and maintenance of the behaviors taught in the program, and in wellbeing by avoiding or delaying specific disease/conditions. The results off this study can be used by EFNEP coordinators to demonstrate to policymakers the positive value of the program as well as leverage the information to increase the amount of funding available in support of this program obtained from a limited pool of state and federal dollars. Consequently, additional funding to be allocated to the program will allow to increase the impact of nutrition education disseminated to low-income families and youth in the 50 states, the U.S. territories, and the District of Columbia.

The results of this study show how using biomarkers could provide more accurate estimates of the true benefits of EFNEP. Nonetheless, this is a preliminary study with a small sample size. Therefore, additional studies will be needed using a large nationally representative dataset to ascertain and make firm generalizations of the results from this study. To effectively evaluate the benefits of EFNEP, we suggest that self-reported dietary recalls should be supplemented with biological markers (biomarkers) which are objective and reflective of nutritional intake to estimate the benefits of the program. Considering the additional cost of collecting these biomarkers from EFNEP participants, we recommend that the biometric data should be collected in some interval years based on decision by

EFNEP coordinators. For example, biometric data from EFNEP participants could be collected once every 5 years to determine whether EFNEP remain worthwhile.

5.2 Limitations of study

A key limitation of this study is the large share of participants with missing data on dietary recalls and biomarkers. About 50% of the total sample had to be dropped due to incomplete data. Because I compare graduates practicing ONB to those improving in biomarkers, I ensured that observations in the data had complete values for both dietary recalls, biomarkers, and food practice scores, but this led to a significant reduction in the sample size. Other data issues were the unavailability of more representative data on the incidence rates of disease related to biomarkers and the data on the costs of collecting biometric data from participants. Since EFNEP participants are low-income earners and are mostly women, rates of diseases related to biomarkers for low-income earners or women would have provided more accurate and representative results than using general population rates. Also, to determine the direct costs of collecting the biometric data from participants, it will require additional cash incentives for the volunteers, the cost of labor for collecting the data and the cost of medical supplies such as scale, stadiometer, blood pressure machine, blood sugar test kits, etc.

An important factor to consider, in assessing the impacts on graduates who benefited from the program at graduation, are the individuals' underlying medical conditions. This information could have been inferred from the data with the observations that were potential outliers. Nonetheless it will be difficult to determine if participants had underlying medical conditions, such as stroke, cancer, etc. Knowing this information could provide additional beneficial information in estimating the benefits.

The percentage of EFNEP graduates improving each biomarker were estimated as the as the percentage of EFNEP graduates who had quantitative improvement in biomarkers (e.g. an obese participant having a reduction in BMI at exit) regardless of the magnitude of improvement. Another approach is to consider participants who made qualitative improvement, or those who had categorical movement e.g., obese to normal weight. Both approaches have their own limitations. Regardless of the magnitude of the difference in biomarker values at entry and exit, moderate improvement is clinically significant as an improvement in health (Kirk et al., 2005 and Lemstra et al., 2016). Categorical changes of these biomarkers will require a longer duration outside that of the program to occur, therefore, this is expected to occur when these behaviors are maintained long-term.

The biometric data for blood sugar (HbA1C) were collected one time for each participant. Even though this is objective and more accurate than self-reported data, this could have potential measurement errors since the level of blood sugar can be highly influenced by other factors, such as the kind of food taken in a particular day, the day's activity, etc. A more accurate measure of blood sugar levels could have been the weighted average of multiple measures collected.

5.3 Future Research

Biomarkers, which are indicators of nutrient intake, status, or functional effects are needed to support evidence-based clinical guidance and effective health programs and policies related to food, nutrition, and health (McClure 2002). Studies by Pico et al. (2019), and McClure (2002) and others have established the impact of nutritional behavior on the biomarkers of individuals. Since diet behavior impacts biomarkers, it will be useful to develop a model or define a relationship that links changes in diet to improvement in

biomarkers. Such a model could be used to estimate or predict biometric changes of EFNEP participants given their dietary recalls so that, costs incurred in collecting biometric data from participants to evaluate EFNEP in the future could be avoided in the future. For more accurate results, this would need to be done using biometric and dietary recall data from a large, nationally representative sample of EFNEP participants.

Another important question to ask about the impact of EFNEP is how the behaviors learnt from the program impact the biomarkers of participants. Since it was assumed in the biomarker model that EFNEP impacts biomarkers, it is important to determine if the changes in the biomarkers at graduation, 6 months and 1 year after graduation were caused by EFNEP or if these changes occurred randomly. Statistical tests, such as paired sample tests and ANOVA, will be important in determining the statistical significance of the effect of the program on these biomarkers. The results from this study will provide another means of evaluating the programs impact and further guide EFNEP program coordinators programmatic decisions.

6.0 REFERENCES

1. Aigner, D., Lovell, C. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of econometrics*, *6*(1), 21-37.
2. Amstutz, M. K., & Dixon, D. L. (1986). Dietary changes resulting from the expanded food and nutrition education program. *Journal of Nutrition Education*, *18*(2), 55-60.
3. Arnold, C. G., & Sobal, J. (2000). Food practices and nutrition knowledge after graduation from the Expanded Food and Nutrition Education Program (EFNEP). *Journal of Nutrition Education*, *32*(3), 130-138.
4. Attema, A. E., Brouwer, W. B., & Claxton, K. (2018). Discounting in economic evaluations. *Pharmacoeconomics*, *36*(7), 745-758.
5. Auld, G., Baker, S., Conway, L., Dollahite, J., Lambea, M. C., & McGirr, K. (2015). Outcome effectiveness of the widely adopted EFNEP curriculum eating smart· being active. *Journal of nutrition education and behavior*, *47*(1), 19-27.
6. Battese, G. E., & Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical economics*, *20*(2), 325-332.
7. Boardman, A. E., Greenberg, D. H., Vining, A. R., & Weimer, D. L. (2017). *Cost-benefit analysis: concepts and practice*. Cambridge University Press.
8. Branca, F., Hanley, A. B., Pool-Zobel, B., & Verhagen, H. (2001). Biomarkers in disease and health. *British Journal of Nutrition*, *86*(S1), S55-S92.
9. Burney J, Houghton B. A nutrition education program that demonstrates cost-benefit. *J Am Diet Assoc*. 2002;102:39-45.
10. Cagney, D. N., Sul, J., Huang, R. Y., Ligon, K. L., Wen, P. Y., & Alexander, B. M. (2018). The FDA NIH Biomarkers, EndpointS, and other Tools (BEST) resource in neuro-oncology. *Neuro-oncology*, *20*(9), 1162-1172.
11. Cawley, J., & Meyerhoefer, C. (2012). The medical care costs of obesity: an instrumental variables approach. *Journal of health economics*, *31*(1), 219-230.Readiness, M. (2010). Military Leaders for Kids. Too Fat to Fight: Retired Military Leaders Want Junk Food Out of America's Schools.

12. Combs Jr, G. F., Trumbo, P. R., McKinley, M. C., Milner, J., Studenski, S., Kimura, T., ... & Raiten, D. J. (2013). Biomarkers in nutrition: new frontiers in research and application. *Annals of the New York Academy of Sciences*, *1278*(1), 1.
13. Cox, Ruby. "1996 Annual Report: Expanded Foods and Nutrition Education Program." *Narrative Summary of Accomplishments*. 1997.
14. Cox, Ruby. *Virginia EFNEP Policy and Procedure Manual.* Blacksburg, VA: Virginia Polytechnic Institute and State University, Department of Human Nutrition, Foods, and Exercise.
15. Danaei, G., Ding, E. L., Mozaffarian, D., Taylor, B., Rehm, J., Murray, C. J., & Ezzati, M. (2009). The preventable causes of death in the United States: comparative risk assessment of dietary, lifestyle, and metabolic risk factors. *PLoS med*, *6*(4), e1000058.
16. Dollahite, J., Kenkel, D., & Thompson, C. S. (2008). An economic evaluation of the expanded food and nutrition education program. *Journal of nutrition education and behavior*, *40*(3), 134-143.
17. Drummond, M. F., Sculpher, M. J., Claxton, K., Stoddart, G. L., & Torrance, G. W. (2015). *Methods for the economic evaluation of health care programmes*. Oxford university press.
18. Frew, E. (2010). *Applied methods of cost-benefit analysis in health care* (Vol. 4). Oxford University Press.
19. Greer, B., & Poling, R. (2001). Impact of participating in the Expanded Food and Nutrition Education Program on food insecurity. *Mississippi State: Mississippi State University, Southern Rural Development Center. Retrieved May*, *2*, 2002.
20. Hagen, T. J. (2012). Recent trends in biomarker research and development. *Biochem Anal Biochem*, *1*, e108.
21. Hradek, C., Jensen, H. H., Schimerowski Miller, N., & Oh, M. (2017). Evaluation of the Cost and Effectiveness of Direct Nutrition Education to Low-Income Audiences in Iowa: EFNEP and SNAP-Ed graduates practicing Optimal Nutritional Behaviors (ONB).
22. Joy, A., Pradhan, V., & Goldman, G. (2006). Cost-benefit analysis conducted for nutrition education in California. *California Agriculture*, *60*(4), 185-191.bat

23. Kearns, K., Dee, A., Fitzgerald, A. P., Doherty, E., & Perry, I. J. (2014). Chronic disease burden associated with overweight and obesity in Ireland: the effects of a small BMI reduction at population level. *BMC public health*, *14*(1), 1-10.
24. Kirk, S., Zeller, M., Claytor, R., Santangelo, M., Khoury, P. R., & Daniels, S. R. (2005). The relationship of health outcomes to improvement in BMI in children and adolescents. *Obesity research*, *13*(5), 876-882
25. Koszewski, W., Sehi, N., Behrends, D., & Tuttle, E. (2011). The impact of SNAP-ED and EFNEP on program graduates 6 months after graduation. *J Extension*, *49*(5), 5RIB6.
26. Ladd, H. F., & Goertz, M. E. (Eds.). (2014). *Handbook of research in education finance and policy*. Routledge.
27. Lambur, M. T., Rajgopal, R., Lewis, E. C., Cox, R. H., & Ellerbrock, M. J. (2009). Applying cost benefit analysis to nutrition education programs: focus on the Virginia Expanded Food and Nutrition Education Program.
28. Lambur, Michael, R. Cox, and M. Ellerbrock. "Applying Cost-Benefit Analysis to Nutrition Education Programs: Focus on the Expanded Foods and Nutrition Education Program." *Research Proposal*. August, 1996.
29. Lambur, Michael, R. Rajgopal, E. Lewis, R. Cox, and M. Ellerbrock. "Applying Cost-Benefit Analysis to Nutrition Education Programs: Focus on the Expanded Foods and Nutrition Education Program." (Work in Progress). 1998.
30. Lemstra, M. E., & Rogers, M. R. (2016). Improving health-related quality of life through an evidence-based obesity reduction program: the Healthy Weights Initiative. *Journal of multidisciplinary healthcare*, *9*, 103–109. https://doi.org/10.2147/JMDH.S100693
31. Lewis, E. C. (1998). *Cost benefit analysis of Virginia EFNEP: Calculating indirect benefits and sensitivity analysis* (Doctoral dissertation, Virginia Tech).
32. Livingstone, M. B. E., & Robson, P. J. (2000). Measurement of dietary intake in children. *Proceedings of the Nutrition Society*, *59*(2), 279-293.
33. Mayeux, R. (2004). Biomarkers: potential uses and limitations. *NeuroRx*, *1*(2), 182-188.

34. McClure, J. B. (2002). Are biomarkers useful treatment aids for promoting health behavior change?: An empirical review. *American journal of preventive medicine*, *22*(3), 200-207.
35. Montgomery DL, Splett PL. Economic benefit of breast-feeding infants enrolled in WIC. *J Am Diet Assoc.* 1997;97:379-385.
36. Nas, Tevfik. *Cost-Benefit Analysis: Theory and Application*. Thousand Oaks: SAGE Publications, Inc., 1996.
37. Nas, Tevfik. Cost-Benefit Analysis: Theory and Application. Thousand Oaks: SAGE Publications, Inc., 1996.
38. Neubauer, M. A., Hoverman, J. R., Kolodziej, M., Reisman, L., Gruschkus, S. K., Hoang, S., ... & Beveridge, R. A. (2010). Cost effectiveness of evidence-based treatment guidelines for the treatment of non–small-cell lung cancer in the community setting. Journal of oncology practice, 6(1), 12-18.
39. Panagopoulou, V., Deftereos, S., Kossyvakis, C., Raisakis, K., Giannopoulos, G., Bouras, G., ... & W Cleman, M. (2013). NTproBNP: an important biomarker in cardiac diseases. *Current topics in medicinal chemistry*, *13*(2), 82-94.
40. Park, Y., Dodd, K. W., Kipnis, V., Thompson, F. E., Potischman, N., Schoeller, D. A., ... & Subar, A. F. (2018). Comparison of self-reported dietary intakes from the Automated Self-Administered 24-h recall, 4-d food records, and food-frequency questionnaires against recovery biomarkers. *The American journal of clinical nutrition*, *107*(1), 80-93.
41. Picó, C., Serra, F., Rodríguez, A. M., Keijer, J., & Palou, A. (2019). Biomarkers of nutrition and health: New tools for new approaches. *Nutrients*, *11*(5), 1092.
42. Rajgopal, R., Cox, R. H., Lambur, M., & Lewis, E. C. (2002). Cost-benefit analysis indicates the positive economic benefits of the Expanded Food and Nutrition Education Program related to chronic disease prevention. *Journal of nutrition education and behavior*, *34*(1), 26-37.Frew, E. (2010). *Applied methods of cost-benefit analysis in health care* (Vol. 4). Oxford University Press.
43. Regional Nutrition Education and Obesity Prevention Centers of Excellence: West Region 2014-2018 *Final Report*, 8-9
44. Rosenman, R., Tennekoon, V., & Hill, L. G. (2011). Measuring bias in self-reported data. *International Journal of Behavioural and Healthcare Research*, *2*(4), 320-332.

45. Schuster, E., Zimmerman, Z. L., Engle, M., Smiley, J., Syversen, E., & Murray, J. (2003). Investing in Oregon's Expanded Food and Nutrition Education Program (EFNEP): documenting costs and benefits. *Journal of Nutrition Education and Behavior*, *35*(4), 200-206.
46. Torrance, G. W. (2006). Utility measurement in healthcare. *Pharmacoeconomics*, *24*(11), 1069-1078.
47. Wardlaw, M., & Baker, S. (2012). Long-term evaluation of EFNEP and SNAP-Ed. In *Forum Fam. Consum. Issues (FFCI)* (Vol. 17, No. 2).
48. Wessman, C., Betterley, C., & Jensen, H. H. (2001). *An Evaluation of the Costs and Benefits of Iowa's Expanded Food and Nutrition Education Program (EFNEP) Final Report* (No. 1038-2016-84798).
49. World Health Organization. (2009). *Global health risks: mortality and burden of disease attributable to selected major risks*. World Health Organization.