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Expanded Food and Nutrition Education Program Generates Economic Value Through Body Mass Index Improvement: A Cost-Benefit Analysis

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Expanded Food and Nutrition Education Program Generates Economic Value Through Body Mass Index Improvement: A Cost-Benefit Analysis

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Abstract. Prior economic evaluations of the Expanded Food and Nutrition Education Program (EFNEP) perform cost-benefit analyses (CBA) reliant on self-reported behavioral data and unvalidated criteria for disease prevention. This study aims to conduct a CBA of Colorado and Washington EFNEP using an objective biomarker, Body Mass Index, to monetize program benefits. A longitudinal study of a convenience sample of EFNEP participants was conducted utilizing a single-group pretest-posttest design. Results indicate Colorado and Washington EFNEP generates $9.23 of benefits per $1.00 of costs and demonstrate the feasibility and value of using biomarkers in economic evaluations of nutrition education interventions delivered through Extension.

INTRODUCTION

The Expanded Food and Nutrition Education Program (EFNEP) is a community-based nutrition education program that promotes self-sufficiency, nutritional health, and well-being among low-income families and youth (USDA, 2021a). EFNEP is funded by the U.S. Department of Agriculture (USDA) and operates through the Cooperative Extension system at land-grant universities. Adult EFNEP provides an 8- to 12-lesson series focusing on diet quality, food resource management, food safety, food security, and physical activity. Lessons are taught in a small-group setting by peer educators, who are often indigenous to the community in which they teach. In 2020, EFNEP funding totaled $69 million, allowing the program to serve 59,853 adults and 204,525 youth (USDA, 2021b).

The creation of public value through social and economic change is fundamental to EFNEP's success. EFNEP policy defines *social change* as the ability to improve participants' food and physical activity behaviors, while *economic change* refers to EFNEP's ability to decrease chronic disease medical costs (USDA, 2021a). In 2002, a behavioral cost-benefit analysis (CBA) methodology was developed by Rajgopal et al. (2002) to evaluate the value generated by EFNEP through economic change. This methodology used standard EFNEP evaluation tools to identify changes in graduates' nutrition behaviors associated with chronic disease prevention. EFNEP benefits were estimated as the medical costs and lost earnings forgone due to chronic disease prevention or delay and compared to program costs. State-level applications of the behavioral CBA indicate that EFNEP generates $0.82 to $14.67 of benefits per $1.00 of costs (Block Joy et al., 2006; Burney & Haughton, 2002; Dollahite et al., 2008; Hradek et al., 2017; Rajgopal et al., 2002; Schuster et al., 2003). Benefit-cost ratio heterogeneity reflects differences in the estimates used in the CBA as well as the programs and time periods analyzed.

A key limitation of the behavioral CBA is its use of self-reported behaviors to estimate benefits. The accuracy of benefit estimates obtained from the methodology relies heavily on the unvalidated relationship between identified optimal nutrition behaviors (ONB) and chronic disease risk. The methodology further uses existing, Behavior Checklist, and 24-hour dietary-recall data to measure ONB. These self-reported tools are inherently subject to bias. Participants may inaccurately report food behaviors, given their inability to recall information (recall bias), their desire to respond in a manner viewed favorably by others (social desirability bias),

and/or a change in their internal standard of measurement for a construct pretest to posttest due to the nutrition education provided by EFNEP (response shift bias; Althubaiti, 2016; Rohs et al., 2001). The behavioral CBA methodology's use of self-reported ONB thus likely results in the under- or overestimation of benefits.

Biomarkers provide an alternative approach for benefit estimation. By definition, a *biomarker* is an objective, biological measure that can serve as an indicator for a disease or condition (Califf, 2018). Although more expensive and time-consuming to collect, biomarkers have two key advantages over behavioral data: (a) Biomarkers are not subject to self-report bias when collected by trained professionals, and (b) substantial scientific evidence shows a causal relationship between biomarkers and chronic disease risk (Freedman et al., 2010; Harris & Schorpp, 2018).

Integration of biomarkers into the CBA methodology would mitigate self-report bias and improve the validity of benefit monetization, resulting in improved estimates of the economic value created by EFNEP.

In a time of increased emphasis on program accountability, accurately demonstrating the economic value generated by nutrition education interventions to policymakers is of critical importance to Cooperative Extension and stakeholders. Incorporation of a chronic disease biomarker into the CBA methodology would serve as a means to obtain objective estimates of the economic value generated by nutrition education interventions. The aim of this study was to conduct a CBA of Colorado and Washington adult EFNEP by using an objective chronic disease biomarker, body mass index (BMI), to monetize program benefits.

METHODS

STUDY DESIGN, PARTICIPANTS, AND MEASURES

A longitudinal study of a convenience sample of Colorado and Washington adult EFNEP participants was conducted with a single-group pretest-posttest intervention design. Data were collected during four time periods: the first EFNEP lesson (pre), the final EFNEP lesson (post), 6- months-post EFNEP (6mo-post), and 1-year-post EFNEP (1yr-post). Incentives of $30, $30, $50, and $50 were provided to participants pre, post, 6mo-post and 1yr-post, respectively. Study approval was obtained from Colorado State University's and Washington State University's Institutional Review Boards.

Local supervisors identified EFNEP groups taught in English or Spanish and scheduled to begin during the 6-month study enrollment period in federal fiscal year 2017 (FFY2017). Twelve EFNEP groups in Colorado with 94 participants and 12 groups in Washington with 78 participants were deemed eligible. Educators then recruited participants from the identified groups during their first or second lesson. All EFNEP participants meeting the following criteria were invited to participate: ages 18 to 64 years, fluent in English and/or Spanish, not pregnant, and willing to allocate 45 to 60 minutes for data collection. Pregnant women were excluded, given the unsuitability of BMI as a biomarker during pregnancy. All together, 118 participants were enrolled: 65 in Colorado and 53 in Washington. Study participants received the EFNEP curriculum *Eating Smart • Being Active* over the course of 8 weeks (Baker & McGirr, 2017). Written informed consent was obtained from participants in their language of choice prior to data collection.

Participants' standing height and weight were measured pre, post, 6mo-post, and 1yr-post by trained research staff following procedures in the *National Health and Nutrition Examination Survey III Body Measurements (Anthropometry) Manual 1988* (CDC, 1988). Standardized equipment was used for measurement across all delivery sites. Three measures of height and weight were recorded each period to the nearest 0.1cm and 0.1kg, respectively, and averaged. Collected measures were then used to calculate BMI (kg/m^2).

COST-BENEFIT ANALYSIS

CBA is a policy assessment method that quantifies and compares the costs and benefits of an intervention in monetary terms. This study developed and applied a BMI CBA methodology to evaluate the economic value generated by Colorado and Washington adult EFNEP. To develop the BMI CBA methodology, we modified the general framework established in the behavioral EFNEP CBA methodology to estimate benefits by using BMI instead of ONB (Rajgopal et al., 2002). Specifically, the BMI CBA methodology estimated program benefits generated though the prevention of six chronic diseases and conditions for which BMI is a biomarker: colorectal cancer, heart disease, hypertension, stroke, type 2 diabetes, and obesity (Danaei et al., 2009; Wang et al., 2006). Note, BMI is not an established biomarker for four additional diseases and conditions considered in prior EFNEP CBA (foodborne illness, common infant diseases, low birthweight, and osteoporosis); these diseases and conditions were thus excluded from this analysis.

BMI was selected over other chronic disease biomarkers, given that EFNEP supports behavioral changes that form pathways to obesity prevention—that is, healthier food choices and greater physical activity. These behaviors align with the Community Nutrition Education Logic Model, which identifies healthy weight achievement and maintenance as a key indicator (USDA, 2014). BMI is further considered to be the best available anthropometric estimate of weight for public health purposes. It is easy to measure, inexpensive, noninvasive, and strongly correlated to direct measures of body fat (CDC, 2021).

The developed BMI CBA methodology was applied to adult EFNEP for two time periods: pre to 6mo-post-EFNEP and pre to 1yr-post-EFNEP. Note that the two periods were

not mutually exclusive; the pre to 1yr-post-EFNEP CBA considered the benefits accrued pre-EFNEP to 1yr-post-EFNEP, as opposed to 6mo-post-EFNEP to 1yr-post-EFNEP. The post-EFNEP time period was not considered, as it did not allow reasonable time for BMI reduction due to EFNEP-induced behavioral changes.

PROGRAM BENEFITS

Benefits were estimated as the sum of the direct and indirect benefits generated by adult EFNEP through chronic disease and condition prevention. Adult graduates with decreased chronic disease and condition risk were identified based on their BMI measurements pre-EFNEP, 6mo- post-EFNEP, and 1yr-post-EFNEP. For graduates with BMI improvement, direct benefits were estimated as the medical costs avoided through chronic disease and condition prevention.

Indirect benefits were estimated as the lost earnings forgone due to chronic disease and condition prevention.

As summarized in Figure 1, direct benefits [F] were estimated for each disease as [A] × [B] × [C] × [D] × [E] = [F]. [A] was the annual number of adult EFNEP graduates. Lifetime disease and condition incidence rates for low-income females [B] were obtained from the literature, with population estimates used when sex-specific estimates were unavailable. Note that all estimates used are summarized and cited in Table 1. [C] was the share of graduates with BMI improvement following EFNEP. [D] was the impact of the BMI reduction. For all diseases and conditions except obesity, [D] was measured as the mean BMI decrease multiplied by the relative risk reduction for each disease per kg/m^2 BMI decrease. The most recent estimates available in the literature indicated a relative risk reduction of 6%, 5%, 4%, 2.5%, and 18% per kg/m^2 BMI decrease for colorectal cancer, heart disease, stroke, hypertension, and type 2 diabetes, respectively (Bombelli et al., 2011; Canoy et al., 2013; Hartemink et al., 2006; Kroll et al., 2016; Reeves et al., 2007). For obesity, [D] was calculated as the mean BMI decrease multiplied by the percentage decrease in medical costs per kg/m^2 BMI decrease; a 1 kg/m^2 decrease was associated with a 4% reduction in obesity medical costs (Wang et al., 2006).

The present value (PV) of medical costs avoided was [E]. To calculate [E], treatment costs for each disease and condition were inflation-adjusted to 2020 dollars. Following Rajgopal et al. (2002), the PV of medical costs avoided was then calculated for life-threatening and non-life- threatening diseases and conditions. For life-threatening diseases (colorectal cancer, heart disease, stroke, and hypertension), [E] was calculated as the discounted value of lifetime medical costs incurred from the average age of disease onset to the average age of death following treatment. A standard discount rate of 5% was employed to account for the time value of money, or that a dollar is worth more today than it will be in the future (Rajgopal et al., 2002). Average age of onset (death) was assumed to be 69, 55, 69, and 47 years (74, 60, 78, and 67 years) for colorectal cancer, heart disease, stroke, and hypertension, respectively (CDC, 2020; Hradek et al., 2017; Kissela et al., 2012; Rajgopal et al., 2002; Siegel et al., 2020). For non-life-threatening diseases and conditions (type 2 diabetes and obesity), [E] was calculated as the discounted value of medical costs from the average age of onset to the average life expectancy. Average age of onset was assumed to be 46 and 40 years for type 2 diabetes and obesity, respectively, and average life expectancy was assumed to be 78 years (Koopman et al., 2005; Ogden et al., 2014; Rajgopal et al., 2002). Total direct benefits were then calculated by summing direct benefits for each disease.

Direct and Indirect Benefit Estimation Formulas

Direct Benefits: [F] = [A] x [B] x [C] x [D] x [E]
Indirect Benefits: [H] = [A] x [B] x [C] x [D] x [G]

[A]: Annual EFNEP graduates (#)
[B]: Incidence rate of chronic disease or condition (%)
[C]: Participants with body mass index improvement (%)
[D]: Impact of body mass index reduction on chronic disease risk (%)
[E]: Present value of medical costs (2020 $)
[F]: Direct benefit for disease or condition (2020 $)
[G]: Present value of lost earnings (2020 $)
[H]: Indirect benefit for disease or condition (2020 $)

Figure 1. Summary of formulas used to estimate direct and indirect benefits in a cost-benefit analysis of Colorado and Washington adult EFNEP using body mass index.

Table 1. Estimates Used to Calculate Direct and Indirect Benefits in a Cost-Benefit Analysis of Colorado and Washington Adult EFNEP, Using Body Mass Index

Disease or condition	[A] EFNEP graduates	[B] Incidence rate (%)[a]	[C] BMI decrease (%)		[D] Risk reduction impact (%)[b]		[E] PV of medical costs ($)[c,e]	[G] PV of lost earnings ($)[d,e]
			6mo	*1yr*	*6mo*	*1yr*		
Colorectal cancer	1,507	4.1%	47%	42%	4.9%	7.9%	$33,288	$0
Heart disease	1,507	31.7%	47%	42%	4.1%	6.2%	$11,804	$8,631
Stroke	1,507	21.1%	47%	42%	3.2%	4.9%	$39,219	$0
Hypertension	1,507	90.0%	47%	42%	2.0%	3.1%	$34,239	$4,598
Type 2 diabetes	1,507	39.6%	47%	42%	14.6%	21.1%	$109,357	$5,786
Obesity	1,507	39.7%	47%	42%	—	—	$55,846	$9,156
Direct benefit	—	—	—	—	3.2%	4.9%	—	—
Indirect benefit	—	—	—	—	3.0%	4.6%	—	—

[a] (Gregg et al., 2014; Hales et al., 2020; Lloyd-Jones et al., 1999; Seshadri et al., 2006; Siegel et al., 2020; Vasan et al., 2002).

[b] (Bombelli et al., 2011; Canoy et al., 2013; Hartemink et al., 2006; Kroll et al., 2016; Reeves et al., 2007; Van Nuys et al., 2014; Wang et al., 2006).

[c] (American Diabetes Association, 2018; Cawley & Meyerhoefer, 2012; Hradek et al., 2017; Park et al., 2017; Trogdon et al., 2007).

[d] (Fu et al., 2009; Guy et al., 2013; Song et al., 2015; Sullivan et al., 2008; Vuong et al., 2015).

[e] Medical costs and lost earnings were adjusted to 2020 dollars and calculated for the average participant age of 38 years.

Indirect benefits [H] were similarly estimated as [A] × [B] × [C] × [D] × [G] = [H], where [G] was the present value of lost earnings—that is, the value of productivity lost as a labor force or household worker due to each chronic disease. [A], [B], and [C] were measured as described above. Measurement of [D] differed only for obesity, where the impact of BMI reduction was measured as the mean participant BMI decrease multiplied by the percentage decrease in lost work days per kg/m^2 BMI decrease. A 1 kg/m^2 BMI decrease was associated with a 3.7% decrease in lost work days (Van Nuys et al., 2014). To calculate [G], estimates of the average number of workdays missed due to each disease and condition were conservatively multiplied by the weighted average state minimum wage ($12.72) and the average 8 hours worked per day. [G] was then calculated as the PV of lost earnings from the average age of onset to retirement (65 years), using a 5% discount rate. Total indirect benefits were calculated by summing indirect benefits for each disease.

COSTS

Costs were measured from the payer perspective—that is, federal, state, and local governments. *Direct costs* were defined as the monetary resources used for EFNEP administration. Indirect costs incurred by participants and society due to EFNEP were assumed to be low and excluded from this study. Direct costs considered included salaries and benefits; office space; utilities; equipment, supplies, and training; staff travel; and a standard 17% marginal excess burden (Ballard et al., 1985). Marginal excess burden accounts for the societal cost of taxation—that is, taxes induce economic distortions, such as changes in consumption and employment, that result in lost economic value to society. Direct costs for FFY2017 were obtained from EFNEP administrators. Estimates obtained included the cost of administering adult and youth EFNEP. To obtain costs for adult EFNEP, total costs were multiplied by the share of adult participants (as opposed to youth) in each state. Total costs were then calculated by summing Colorado and Washington costs and adjusting to 2020 dollars.

BENEFIT-COST RATIOS AND SENSITIVITY ANALYSIS

Benefit-cost ratios were calculated as total benefits (direct plus indirect benefits) divided by costs for the pre to 6mo-post-EFNEP and pre to 1yr-post-EFNEP time periods. A benefit-cost ratio of less than 1, 1, or greater than 1 indicated that EFNEP benefits were less than, equal to, or greater than program costs, respectively. Sensitivity analyses were conducted to

Table 2. Descriptive Characteristics of Study Sample and National Adult EFNEP Population in FFY2017

	National EFNEP Population (N = 108,216)	Pre to 6mo-Post Sample (n = 88)	Pre to 1yr-Post Sample (n = 62)
	n (%)	*n (%)*	*n (%)*
Gender			
Female	91,613 (85%)	82 (93%)	58 (93%)
Male	16,603 (15%)	4 (5%)	3 (5%)
Not provided	0 (0%)	2 (2%)	1 (2%)
Ethnicity			
White	59,334 (55%)	64 (73%)	42 (68%)
African American	24,402 (22%)	2 (2%)	2 (3%)
Other	10,541 (10%)	5 (6%)	5 (8%)
Not provided	13,939 (13%)	17 (19%)	13 (21%)
Hispanic or Non-Hispanic			
Hispanic	42,878 (40%)	71 (81%)	49 (79%)
Non-Hispanic	60,836 (56%)	15 (17%)	12 (19%)
Not provided	4,502 (4%)	2 (2%)	1 (2%)
Education Level			
Less than HS	22,088 (20%)	23 (26%)	16 (26%)
HS	32,689 (30%)	31 (35%)	21 (34%)
Some college	19,968 (19%)	13 (15%)	10 (16%)
Graduated college	6,481 (6%)	3 (4%)	2 (3%)
Graduate degree	1,584 (1%)	1 (1%)	1 (2%)
Not provided	25,406 (23%)	17 (19%)	12 (19%)

assess the robustness of resulting benefit-cost ratios. Variation in the discount rate (0%, 3%, 7%) and mean participant BMI decrease (upper and lower limit of 95% CI) were considered.

RESULTS

The final study sample consisted of 88 adult EFNEP participants pre to 6mo-post-EFNEP and 62 participants pre to 1yr-post-EFNEP. The study attrition rates of 25% and 47.5% 6mo-post and 1yr-post were comparable or better than the national EFNEP attrition rate of 32% (USDA, 2018). Detailed in Table 2, nearly all participants were female, and the majority were White or Hispanic and had a high school education or less. Pre to 6mo-post-EFNEP and pre to 1yr-post-EFNEP, 47% and 42% of participants experienced a BMI decrease averaging 0.81 kg/m^2 (95% CI 0.60–1.03) and 1.23 kg/m^2 (95% CI 0.94–1.51), respectively. Relative to the national EFNEP population, fewer sample participants were African American, and more were female, were Hispanic, and had less than a high school education.

Benefit and cost estimates are presented in Table 3. Total benefits were $6,218,683 pre to 6mo- post-EFNEP and $8,438,591 pre to 1yr-post-EFNEP. The cost of Colorado and Washington adult EFNEP was $913,841.86. Costs included salaries and benefits ($595,412); office space ($72,402); utilities ($6,661); equipment, supplies, and training ($83,115); staff travel ($23,472); and marginal excess burden ($132,780).

The pre to 6mo-post benefit-cost ratio for Colorado and Washington adult EFNEP indicates that the programs generated $6.80 in economic benefits for every $1.00 of program costs. Over the course of a year, the programs generated $9.23 in benefits for every $1.00 of program costs. Pre to 6mo-post-EFNEP, sensitivity analysis results indicate benefit-cost ratios of $20.52:$1:00, $10.25:$1:00, and $4.69:$1:00 for 0%, 3%, and 7% discount rates, respectively. Variation in the mean participant BMI decrease (95% CI lower limit of 0.60 kg/m^2 and 95% CI upper limit of 1.03 kg/m^2) yielded benefit-cost ratios of $5.04:$1:00 and $8.65:$1:00, respectively. Pre to 1yr- post-EFNEP, sensitivity analysis results indicated benefit-cost ratios of $27.85:$1:00, $13.91:$1:00, and $6.37:$1:00 for 0%, 3%, and 7% discount rates and $7.06:$1.00 and $11.34:$1.00 for the upper 95% CI limit (1.51 kg/m^2) and lower 95% CI limit (0.94 kg/m^2) for mean participant BMI decrease.

Table 3. Body Mass Index Cost-Benefit Analysis Results for Colorado and Washington Adult EFNEP in FFY2017

	Pre to 6mo-Post (n = 88)	Pre to 1yr-Post (n = 62)
Total Benefits	$6,218,683	$8,438,591
Direct Benefits	$5,767,066	$7,825,759
Indirect Benefits	$451,617	$612,832
Total Costs	$913,842	$913,842
Benefit-Cost Ratio	6.80	9.23

[a] All benefits and costs are adjusted to 2020 U.S. dollars ($).

CONCLUSION

CBA is a commonly employed tool for assessment of the economic value generated by an intervention. However, CBA hinges on the accuracy of the benefit and cost estimates used. Over- or underestimation of benefits in prior EFNEP CBA is likely, given their use of self-reported data and unvalidated behavioral criteria for chronic disease prevention. This study alternatively assessed the economic value generated by EFNEP by using an objective chronic disease biomarker, BMI, to estimate program benefits.

Results using BMI CBA provide objective evidence that Colorado and Washington adult EFNEP has generated considerable economic value through chronic disease prevention. More than 40% of graduates experienced sustained improvement in BMI 1yr-post-EFNEP. Corresponding medical costs and lost earnings forgone due to graduates' reduction of chronic disease risk far exceeded the costs of program administration. This result is consistent with prior EFNEP CBA that used self-reported behavioral data for benefit estimation (Hradek et al., 2017). Consistency of findings across alternative CBA methodologies strongly indicates that adult EFNEP is an effective use of taxpayer dollars for chronic disease prevention.

Considering magnitude, BMI CBA results indicate that Colorado and Washington adult EFNEP generates $9.23 of benefits per $1.00 of costs. Note that the BMI CBA only estimated benefits for 6 of the 10 diseases and conditions considered in prior behavioral EFNEP CBA. Despite this difference, the BMI CBA benefit-cost ratio estimate of $9.23:$1:00 is comparable to the highest estimates obtained in prior behavioral EFNEP CBA for Virginia ($10.64:$1.00) and California ($14.67:$1.00) EFNEP (Block et al., 2006; Rajgopal et al., 2002). This result may indicate that the BMI CBA captured additional benefits not accounted for in the behavioral CBA. Alternatively, differences may reflect variation in the EFNEP programs and time periods analyzed and/or the estimates used in the CBA. Study results merit further research on the potential value of using biomarkers to estimate the benefits of nutrition education interventions.

The present study is subject to limitations, including potential sample selection bias. Although study attrition rates are comparable or better than the national EFNEP attrition rate, it is possible that participant BMI improvement was correlated with study completion. Other unobserved factors may also have contributed to participant BMI improvement, including variation in income, weather, food access, employment, and psychological health. The potential for benefit overestimation should be recognized when analyzing study results. Cost overestimation is also possible, given that direct costs for adult EFNEP were estimated based on combined costs for adult and youth EFNEP.

IMPLICATIONS FOR EXTENSION

This study demonstrates the feasibility and potential value of using BMI as a biomarker to analyze the economic value generated by nutrition education programs, such as EFNEP. The developed BMI CBA methodology could be used by Cooperative Extension to obtain objective assessments of the economic value generated by its own respective nutrition education interventions through chronic disease prevention. Such evaluations are critical for effectively planning and selecting healthy-eating, active-living programs targeting low-income audiences. In an increasingly competitive funding environment, complementing behavioral assessment of nutrition education interventions with objective biomarker assessment may serve as a means for administrators to secure or increase programmatic funding.

REFERENCES

Althubaiti, A. (2016). Information bias in health research: Definition, pitfalls, and adjustment methods. *Journal of Multidisciplinary Healthcare*, *9*, 211–217. https://doi.org/10.2147/JMDH. S104807

American Diabetes Association. (2018). Economic costs of diabetes in the U.S. in 2017. *Diabetes Care*, *41*(5), 917–928. https://doi.org/10.2337/dci18-0007

Baker, S. S., & McGirr, K. (2017). *Eating Smart, Being Active.* Colorado State University. http://eatingsmartbeingactive.colostate.edu

Ballard, C. L., Shoven, J. B., & Whalley, J. (1985). General equilibrium computations of the marginal welfare costs of taxes in the United States. *American Economic Review, 75*(1), 128–138.

Block Joy, A., Pradhan, V., & Goldman, G. (2006). Cost-benefit analysis conducted for nutrition education in California. *California Agriculture, 60*(4), 185–191.

Bombelli, M., Facchetti, R., Sega, R., Carugo, S., Fodri, D., Brambilla, G., Giannattasio, C., Grassi, G., & Mancia,

G. (2011). Impact of body mass index and waist circumference on the long-term risk of diabetes mellitus, hypertension, and cardiac organ damage. *Hypertension, 58*(6), 1029–1035. https://doi.org/10.1161/HYPERTENSIONAHA.111.175125

Burney, J., & Haughton, B. (2002). EFNEP: A nutrition education program that demonstrates cost-benefit. *Journal of the American Dietetic Association*, *102*(1), 39–45. https://doi.org/10.1016/S0002-8223(02)90014-3

Califf, R. M. (2018). Biomarker definitions and their applications. *Experimental Biology and Medicine*, *243*(3), 213–221. https://doi.org/10.1177/1535370217750088

Canoy, D., Cairns, B. J., Balkwill, A., Wright, F. L., Green, J., Reeves, G., Beral, V., & the Million Women Study Collaborators. (2013). Body mass index and incident coronary heart disease in women: A population-based prospective study. *BMC Medicine, 11*(87), 1–9. https://doi.org/10.1186/1741-7015-11-87

Cawley, J., & Meyerhoefer, C. (2012). The medical care costs of obesity: An instrumental variables approach. *Journal of Health Economics, 31*(1), 219–230. https://doi.org/10.1016/j.jhealeco.2011.10.003

Centers for Disease Control and Prevention, Division of Nutrition, Physical Activity, and Obesity. (2021). *About Adult BMI*. www.cdc.gov/healthy weight/assessing/bmi/adult_bmi/index.html

Centers for Disease Control and Prevention, National Center for Health Statistics. (1988). *NHANES III: Body measurements (anthropometry)*. wwwn.cdc.gov/nchs/data/nhanes3/manuals/anthro.pdf

Centers for Disease Control and Prevention, National Center for Health Statistics. (2020). *NHANES 2017-2018 Questionnaire data: Blood pressure and cholesterol*. wwwn.cdc.gov/nchs/nhanes/search/datapage.aspx?-Component=Questionnaire&CycleBeginYear=2017

Danaei, G., Ding, E. L., Mozaffarian, D., Taylor, B., Rehm, J., Murray, C. J. L., & Ezzati, M. (2009). The preventable causes of death in the United States: Comparative risk assessment of dietary, lifestyle and metabolic risk factors. *PLOS Medicine, 8*(1), 10.1371. https://doi.org/10.1371/journal.pmed.1000058

Dollahite, J., Donald, K., & 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. https://doi.org/10.1016/j.jneb.2007.08.011

Freedman, L. S., Kipnis, V., Schatzkin, A., Tasevska, N., & Potischman, N. (2010). Can we use biomarkers in combination with self-reports to strengthen the analysis of nutritional epidemiologic studies? *Epidemiologic Perspectives and Innovations, 7*(1), 1–9. https://doi.org/10.1186/1742-5573-7-2

Fu, A. Z., Qiu, Y., Radican, L., & Wells, B. J. (2009). Health care and productivity costs associated with diabetic patients with macrovascular comorbid conditions. *Diabetes Care, 32*(12), 2187–2192. https://doi.org/10.2337/dc09-1128

Gregg, E. W., Zhuo, X., Cheng, Y. J., Albright, A. L., Narayan, K. M. V., & Thompson, T. J. (2014). Trends in lifetime risk and years of life lost due to diabetes in the USA, 1985–2011: A modelling study. *Lancet Diabetes and Endocrinology*, *2*(11), 867–874. https://doi.org/10.1016/ S2213-8587(14)70161-5

Guy, G. P., Jr., Ekwueme, D. U., Yabroff, K. R., Dowling, E. C., Li, C., Rodriguez, J. L., de Moor, J. S., & Virgo, K. S. (2013). Economic burden of cancer survivorship among adults in the United States. *Journal of Clinical Oncology*, *31*(30), 3749–3757. https://doi.org/10.1200/JCO.2013.49.1241

Hales, C. M., Carroll, M. D., Fryar, C. D., & Ogden, C. L. (2020). *Prevalence of obesity and severe obesity among adults: United States, 2017–2018*. NCHS Data Brief No. 360. www.cdc.gov/nchs/products/databriefs/db360.htm

Harris, K. M., & Schorpp, K. M. (2018). Integrating biomarkers in social stratification and health research. *Annual Review of Sociology*, *44*, 361–386. https://doi.org/10.1146/annurev-soc-060116- 053339

Hartemink, N., Boshuizen, H. C., Nagelkerke, N. J., Jacobs, M. A., & van Houwelingen, H. C. (2006). Combining risk estimates from observational studies with different exposure cutpoints: A meta-analysis on body mass index and diabetes type 2. *American Journal of Epidemiology*, *163*(11), 1042–1052. https://doi.org/10.1093/aje/kwj141

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).* Report 17-SR 112. Center for Agricultural and Rural Development (CARD) at Iowa State University, Ames, Iowa.

Kissela, B. M., Khoury, J. C., Alwell, K., Moomaw, C. J., Woo, D., Adeoye, O., Flaherty, M. L., Kharti, P., Ferioli, S., De Los Rios La Rosa, F., Broderick, J. P., & Kleindorfer, D. O. (2012). Age at stroke: Temporal trends in stroke incidence in a large, biracial population. *Neurology*, 79(17), 1781–1787. https://doi.org/10.1212/WNL.0b013e318270401d

Koopman, R. J., Mainous, A. G., Diaz, V. A., & Geesey, M. E. (2005). Changes in age at diagnosis of type 2 diabetes mellitus in the United States, 1988 to 2000. *Annals of Family Medicine*, *3*(1), 60–63. https://doi.org/10.1370/afm.214

Kroll, M. E., Green, J., Beral, V., Sudlow, C. L. M, Brown, A., Kirichek, O., Price, A., Yang, T. O., Reeves, G. K., & For the Million Women Study Collaborators. (2016). Adiposity and ischemic and hemorrhagic stroke: Prospective study in women and meta-analysis. *Neurology*, *87*(14), 1473–1481. https://doi.org/10.1212/WNL.0000000000003171

Lloyd-Jones, D. M., Larson, M. G., Beiser, A., & Levy, D. (1999). Lifetime risk of developing coronary heart disease. *Lancet*, *353*(9147), 89–92. https://doi.org/10.1016/S0140- 6736(98)10279-9

Ogden, C. L., Carroll, M. D., Kit, B. K., & Flegal, K. M. (2014). Prevalence of childhood and adult obesity in the United States, 2011–2012. *JAMA*, *311*(8), 806–814. https://doi:10.1001/jama.2014.732

Park, C., Fang, J., Hawkins, N. A., & Wang, G. (2017). Comorbidity status and annual total medical expenditures in US hypertensive adults. *American Journal of Preventive Medicine*, *53*(6), S172–S181. https://doi.org/10.1016/j.amepre.2017.07.014

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. https://doi.org/10.1016/S1499-4046(06)60225-X

Reeves, G. K., Pirie, K., Beral, V., Green, J., Spencer, E., & Bull, D. (2007). Cancer incidence and mortality in relation to body mass index in the Million Women Study: Cohort study. *BMJ*, *335*(7630), 1134. https://doi.org/10.1136/bmj.39367.495995.AE

Rohs, F. R., Langone, C. A., & Coleman, R. K. (2001). Response shift bias: A problem in evaluating nutrition training using self-report measures. *Journal of Nutrition Education*, *33*(3), 165–170. https://doi.org/10.1016/S1499-4046(06)60187-5

Schuster, E., Zimmerman, Z., 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. https://doi.org/10.1016/S1499-4046(06)60334-5

Seshadri, S., Beiser, A., Kelly-Hayes, M., Kase, C. S., Au, R., Kannel, W. B., & Wolf, P. A. (2006). The lifetime risk of stroke: Estimates from the Framingham Study. *Stroke*, *37*(2), 345–350. https://doi.org/10.1161/01.STR.0000199613.38911.b2

Siegel, R. L., Miller, K. D., Goding Sauer, A., Fedewa, S. A., Butterly, L. F., Anderson, J. C., Cercek, A., Smith, R. A., & Jemal, A. (2020). Colorectal cancer statistics, 2020. *CA: A Cancer Journal for Clinicians*, *70*(3), 145–164. https://doi.org/10.3322/caac.21601

Song, X., Quek, R. G., Gandra, S. R., Cappell, K. A., Fowler, R., & Cong, Z. (2015). Productivity loss and indirect costs associated with cardiovascular events and related clinical procedures. *BMC Health Services Research*, *15*(1), 1–14. https://doi.org/10.1186/s12913-015-0925-x

Sullivan, P. W., Ghushchyan, V., & Ben-Joseph, R. H. (2008). The effect of obesity and cardiometabolic risk factors on expenditures and productivity in the United States. *Obesity*, 16(9), 2155–2162. https://doi.org/10.1038/oby.2008.325

Trogdon, J. G., Finkelstein, E. A., Nwaise, I. A., Tangka, F. K., & Orenstein, D. (2007). The economic burden of chronic cardiovascular disease for major insurers. *Health Promotion Practice*, *8*(3), 234–242. https://doi.org/10.1177/1524839907303794

USDA, National Institute of Food and Agriculture. (2014). *Community Nutrition Education Logic Model Detail*. https://nifa.usda.gov/resource/community-nutrition-education-cne-logic-model

USDA, National Institute of Food and Agriculture. (2021a). *The Expanded Food and Nutrition Education Program Policies*. https://www.nifa.usda.gov/sites/default/files/resource/EFNEP-Policy-November-2021-Update.pdf

USDA, National Institute of Food and Agriculture. (2021b). *2020 Impacts: Expanded Food and Nutrition Education Program (EFNEP)*. https://nifa.usda.gov/sites/default/files/resource/2020%20EFNEP%20National%20Data%20Reports.pdf

USDA, Research, Education & Economics Information System. (2018). *2017 EFNEP Tier Data*. https://reeis.usda.gov/content/2017-efnep-tier-data

Van Nuys, K., Globe, D., Ng-Mak, D. Cheung, H., Sullivan, J., & Goldman, D. (2014). The association between employee obesity and employer costs: evidence from a panel of U.S. employers. *American Journal of Health Promotion*, *28*(5), 277–285. https://doi.org/10.4278/ajhp.120905-QUAN-428

Vasan, R. S., Beiser, A., Seshadri, S., Larson, M. G., Kannel, W. B., D'Agostino, R. B., & Levy, D. (2002). Residual lifetime risk for developing hypertension in middle-aged women and men: The Framingham Heart Study. *JAMA*, *287*(8), 1003–1010. https://doi.10.1001/jama.287.8.1003

Vuong, T., Wei, F., & Beverly, C. (2015). Absenteeism due to functional limitations caused by seven common chronic diseases in US workers. *Journal of Occupational and Environmental Medicine*, *57*(7), 779–784. https://doi.10.1097/JOM.0000000000000452

Wang, F., McDonald, T., Bender, J., Reffitt, B., Miller, A., & Edington, D. W. (2006). Association of healthcare costs with per unit body mass index increase. *Journal of Occupational and Environmental Medicine, 48*(7), 668–674.