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SOY AND VEGETABLE GARDENING WITH SKILLS TRAINING AND SOY CONSUMPTION ARE COST EFFECTIVE METHODS TO IMPROVE THE BLOOD LIPID PROFILES OF WOMEN IN QWA-QWA, SOUTH AFRICA

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ABSTRACT

A cost effectiveness (CE) analysis was performed on a nutrition intervention program that included soy consumption, soy and vegetable gardening, and skills training designed to improve blood lipid levels in women. This intervention involved ninety women of ages 19-75 years living in Qwa-Qwa, South Africa. The actual nutrition intervention lasted 18 months. Outcomes measured were low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol, and serum triglycerides levels. All costs for the resources used in the program were considered and categorized into four main groups: labor, materials, transport, and miscellaneous. Following the recommendation for evaluating nutrition projects, a common base year of 2012 and discount rate of 5% were selected. The CE was calculated based on the total cost of the intervention program for all 90 women served and the number of women who achieved normal levels for a specified serum lipid during the 18 months of intervention. The CE ratios were expressed as the per subject cost of achieving the normal level of a specified serum lipid for example, HDL cholesterol. The average cost (in 2012 dollars) was approximately $869 per person. The CE ratio for serum HDL cholesterol was the lowest compared to the CE ratios of other indicators of serum lipids. Material costs accounted for the majority of the costs (71%) followed by labor (22%). Training materials, gardening tools, soy preparation equipment, and seeds, which are critical for increasing the scale of the program, together contributed to a relatively low percentage of the total cost of materials (37%). In addition, it was noted that the per person cost is likely to decrease if the scale of the intervention is increased. Soy and vegetable gardening with skill training and soy consumption may be a feasible population-wide approach to prevent the development of cardiovascular diseases among women in Qwa-Qwa, South Africa.

Key words: Cardiovascular diseases, cost effectiveness, high-density lipoprotein, lipid profile, nutrition intervention, Qwa-Qwa, South Africa, soybean, vegetable gardening, women

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INTRODUCTION

Cardiovascular diseases (CVDs) such as coronary heart disease, hypertension, stroke, congenital heart disease, and heart failure are the leading causes of death around the world and were responsible for approximately 17.5 million deaths in 2012 [1]. More than three-quarters of these deaths occurred in low and middle-income regions, such as Africa [1]. Furthermore, CVDs' prevalence continues to increase at an alarming rate in Africa and currently is regarded as a public health threat throughout the region [2], and this growing trend has been observed even among children in this region [3]. Interestingly, most of the funds for research in Africa are dedicated to addressing determinants of maternal and child mortality or ill health, such as undernutrition, and infectious diseases such as malaria and HIV/AIDS, rather than CVDs [4]. Cardiovascular diseases alone contribute to approximately 18% of all deaths resulting from non-communicable diseases [5], and South African women between 35 to 59 years are approximately one and a half times more likely to die from CVD compared to those in the United States [5, 6]. This phenomenon is exacerbated because nearly 40% of women in South Africa are obese, a risk factor for CVDs [5]. Furthermore, hyperlipidemia (that is abnormal or elevated total serum lipid levels) is a well-documented risk factor for CVDs [7].

In many low-resource settings in Africa, there is limited access to optimum healthcare and physicians or health workers in general. In addition, the detection and management of CVDs may be unreliable and less readily available. Lipid-lowering drugs, such as statins, also may have severe side effects [8]. Studies have shown that behavior or lifestyle and dietary interventions can improve lipid profiles [9]. Soy consumption, and soy and vegetable gardening with skills training, as well as general nutrition education, have been shown to improve lipid profiles among women in low-income settings and have the potential to prevent, as well as manage CVDs [10].

Although the positive effects of nutrition interventions are acknowledged widely, resources are finite. In South Africa, for example, priority is given to programs that promote employment opportunities and improvements in income security, increased access to high quality and reliable public services, and education, all of which are key government policy agenda [11]. Therefore, any investment in nutrition programs must have the potential to reap important economic benefits, and provide reasonable return on investment, as other important programs compete for the same resources. In the light of budget limitations, it is necessary that governments and organizations maximize the effects of nutrition intervention programs for every dollar or resource invested, especially in developing countries [12]. Economic evaluation of nutrition programs is commonly conducted in developed countries and have been observed to provide substantial cost savings; specifically, health protection and health promotion interventions have resulted in higher median return on investment [13].

In 2008, a situation analysis was conducted in the peri-urban community of Qwa-Qwa, a poverty-stricken area in the Free State of South Africa. The study reported food insecurity, poor dietary intakes, and malnutrition (both under and over nutrition) in this community and all of which are linked to CVDs [14]. Therefore, a community-based pilot nutrition education program was implemented over a period of five years in this

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resource-deprived community by the research team. Topics included food groups, important nutrients and their functions in the body, the South African food-based dietary guidelines, balanced meal planning, health benefits of soy and vegetables, and hygiene during food preparation [15]. The program also included the implementation of a household soy and vegetable gardening program. As part of the program, 20 soy-based recipes (soy milk, yoghurt, steamed bread with *okara [soy bean pulp or the by-product during processing of soy beans into soy milk or tofu]*) were developed and the women were trained to prepare these and how to include it in the daily diet [16, 17, 18]. The effects of soy consumption over a period of 18 months on various nutrition and health outcomes were reported, often with positive outcomes [10, 19].

Measuring the costs and outcomes of this community-based nutrition intervention is important, because determining that it is efficient with respect to dollar cost per person needed to improve serum lipid profiles would justify expanding the scale of this program.

Thus, the main objective of this paper was to carry out a CE analysis of a community-based nutrition intervention that included soy consumption, soy and vegetable gardening and skills training, as well as general nutrition education, to improve blood lipid levels. Cost effectiveness is a common method of economic assessment for healthcare and nutrition interventions [12]. It is the intention of this study to develop awareness among researchers and stakeholders of the importance of economic evaluations of nutrition intervention, as the information generated could influence policy decisions and ultimately ensure the survival of nutrition programs. Cost effectiveness analysis of nutrition programs is an accountability process and it is hoped that such economic evaluations eventually will become a common practice among nutrition researchers in South Africa.

METHODS

In this paper, a CE analysis was conducted on soy and vegetable gardening with skills training, and general nutrition education, as well as the effects of the consumption of 40g whole soybean daily for 18 months on blood lipid levels of 90 women living in Qwa-Qwa, Free State province, South Africa.

A single system experimental design was used for the study, which compares the pre- and post-performance of an intervention in the absence of a control group. The study design was chosen because of ethical constraints (by not excluding some of the households from the benefits of using soy), logistical feasibility, and funding limitations. Single system designs are used widely in the study of the effect of interventions in behavioral sciences including social work, psychology, and education [20]. Although the use of this research design precluded a comparison of the estimated average cost per person of health improvements with other interventions or control groups, the information generated can be useful for future interventions designed to affect the same nutritional and health outcomes. This is because literature review revealed that there is a paucity of studies in this area.

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The nutrition intervention was implemented from 2010 to 2012 and included women aged 19-75 years living in the peri-urban Thabo Mufatsanyane district [14]. The district has a population of approximately 800,000 and is characterized by severe poverty, with 73% of its population living below South Africa's poverty line [21]. Moreover, in 2005, 31.9% and 28.8% of the population in the district were estimated to be at risk of hunger and food insecurity, respectively [21, 22]. Protocols for the intervention were approved by the Medical Ethics Committee for research on human beings of the University of Witwatersrand (M080931) and subjects gave informed consent before participation. The intervention involved soy awareness and education [23], home vegetable and soy gardening, and development of nutritious, affordable, and culturally acceptable whole bean soy recipes tested and adjusted for acceptability and published as a recipe book [16]. In addition, whole bean soy food preparation (soy recipes, soy milk and yoghurt) [16] and measuring skills training were conducted by a dietitian, public health nutritionist, and consumer scientist who visited the community at least three days in two alternate weeks a month during the intervention [15, 18]. The research team designed the nutrition education syllabus and the dietician and public health nutritionist assumed responsibility for the education. Lipid profiles were evaluated at pre- and post-intervention [10]. Precise details about program implementation and evaluation are presented elsewhere [14, 15, 16, 17, 18, 19].

Steps in economic analysis

The following steps were used for the analysis [24]:

1. Identifying the outcome or effect of interest in the nutrition intervention program
2. Identifying the period for the course of intervention program
3. Calculating the cost of all resources used to deliver the intervention program
4. Discounting all direct costs to present value
5. Calculating CE ratios

Selection of the type of economic analysis

There are two main types of economic analyses used to assess nutrition programs' effectiveness where resources are scarce: CE and cost-benefit analysis. CE analysis calculates the dollar cost of every unit of outcome (that is the program effect desired). Thus, CE indicates the cost of improving health using a particular intervention. Cost-benefit analysis goes one-step further and provides an estimate of the dollar value of the nutrition program outcomes, making it possible to compare the monetary value of both the costs and benefits of a program [25]. However, it is difficult, data intensive, and even controversial, to monetize all of the benefits or put a value on the outcome of a nutrition intervention program [26, 27], in this case, the monetary value of an improvement in women's lipid profiles. Therefore, a CE analysis was the most appropriate method to evaluate this intervention program. Accordingly, CE analysis answered the question, "What is the cost per woman to achieve a normal level of a specified serum lipid?"

Identification of outcome or effects of nutrition intervention

In most cases, CE analyses are conducted using one outcome measure; however, given the objective of the study, multiple outcome measures related to dyslipidemia were considered [28]: serum cholesterol; LDL cholesterol; HDL cholesterol, and serum triglycerides levels.

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The course of intervention

As explained earlier, the project intervention period was 18 months; however, when considering the additional time needed for program design and evaluation, it required a total of 5 years. Recruitment, training for soy gardening, nutrition education, and baseline data collection took place in the first year. Year two involved nutrition education that promoted soy and vegetable consumption, soy planting, vegetable gardening, monitoring, and recipe development training. In year three, soy and vegetable gardening, new recruitment, and further training were carried out. Year four involved recipe and skills training for the new group, as well as follow-up measurements. Finally, year five included training in the production of homemade soy milk and yoghurt and follow-up measurements. The actual intervention occurred in years three and four.

Cost analysis of resources

Our economic analysis was conducted from the perspective of a provider (in this case, an academic institution) interested in promoting health. Hence, all costs for the resources used in the nutrition intervention program were considered. Resources consumed were categorized in four main groups: labor; materials; transport; and miscellaneous. Labor included the cost to hire nurses, principal investigators, researchers, field workers, and support staff. These personnel costs were determined by calculating the salaries and cost for time spent in delivering the nutrition education, home gardening, and follow-up visits after baseline assessments, time for planning and documenting interventions, staff planning, and meetings. Costs for dietary and laboratory analyses were included in labor costs.

Cost of materials covered laboratory and training materials, gardening tools, weighing scales, cameras, and laptops. Materials and supplies used were recorded and the cost for purchases or duplicates of educational material was included in calculations. Durable items, such as laptops and cameras were used almost exclusively for the project, so all their costs were assigned to the project. It also was assumed that the salvage value of those items is zero, given the rapid changes in technology. Transport covered largely that for car rental to transport the fieldworkers and researchers to the study site (250 km from the university) for measurements and monitoring**,** and miscellaneous costs included accommodation and other contingencies. Costs for space, maintenance, and administrative services were included in miscellaneous costs. As explained earlier, we estimated the direct cost of resources in the several years preceding the intervention and the 18-month intervention period.

Discounting and inflation

When conducting CE during different years, it is important to adjust the costs to a common base year. The year 2012 was selected and all current cost values were shown in **2012 dollars** (i.e., to take into account inflation the observed costs in each year were divided by a price index with 2012 considered the base year). Another important factor is identifying a suitable discount rate. In this paper, a discount rate of 5% was used following the recommendation for evaluating nutrition projects [24]. The selection of base year and discount rate allowed the conversion of money into present value and

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comparison of costs spread unevenly over time. In so doing, adjustments were made for differences in the timing of costs.

Below is a presentation of the total cost of the intervention according to different resource categories and years after discounting (Table 2). The main equations used for the cost calculations are as follows:

Total cost of program = cost of labor + cost of materials + cost of transportation + cost of miscellaneous equation (i)

Cost per person = total cost of intervention program/number of women served equation (ii)

= $78,219/90
=$869.1
≈$869 per participant

Total number of participants = 90

CE ratios

The CE was calculated based on the total cost of the intervention program (for all 90 women served) and the number of women who achieved normal levels for a specified serum lipid during the 18 months of intervention. The CE ratios were expressed as the per subject cost of achieving the normal level of a specified serum lipid (example, HDL cholesterol). This is expressed mathematically as CE ratio = total cost of intervention program/number of women with normal levels of a specified serum lipid (that is effectiveness) [24, 26]. While the use of multiple outcomes and the corresponding multiple cost/benefit ratios can lead to conflicting implications, the use of subjective and arbitrary weights for the calculation of a single outcome measure also is problematic [29]; thus, multiple CE ratios were calculated and presented. This approach also has the additional advantages of being transparent and providing information that can be useful to programs that differ in their main outcomes of interest.

RESULTS AND DISCUSSION

The estimated total cost of the intervention was $78,219 and the average cost (in 2012 dollars) for a woman participating in the program was $869 (Table 3). The CE ratio for serum HDL cholesterol was the lowest ($899) compared to serum cholesterol ($4,117), LDL cholesterol ($3,911), serum triglycerides ($1,534) and HDL: LDL ratio ($2,697) (Table 3). Most of the total cost (71.4%) for the intervention program was the purchase of materials, while pay for personnel, such as field workers and consultants, contributed a relatively small percentage (21.7%: Table 4). Transport and miscellaneous costs accounted for a very small share of the total costs (only 6.94% combined).

Because materials accounted for most of the program costs, a breakdown of this aggregate cost category is presented; materials were grouped into eight main sub-categories (Table 5). Reagents and blood collection supplies accounted for the highest percentage of total material costs (34%). This was followed by “Others,” which included implementation and data collection equipment, such as laptops, cameras, and cooler

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bags, as well as running costs, such as refreshments that comprised approximately 26% of the total cost of materials.

The primary objective of this study was to conduct a CE analysis of a nutrition intervention program that consisted of soybean consumption, soy and vegetable gardening and skills training, as well as general nutrition education designed to improve women's blood lipid levels. The population's health overall is critical for the economic growth of any country [30]. Compared to other countries in the region with upper middle-income level status, South Africa is plagued by poor health outcomes despite its relatively high level of economic development. In 2012, 43.4% of all deaths in this country were related to non-communicable diseases [31]. Furthermore, the accumulated loss to South Africa's gross domestic product (GDP) between 2006 and 2015 from non-communicable diseases alone, such as diabetes, coronary heart disease, and stroke was US$1.88 billion [30].

Although there is a lack of similar programs for comparison in this region, it is plausible to say that the overall cost of the program (that is $78,219) for ninety women, or cost per woman (that is, $869), was relatively low since it covered both the 18-month intervention and the training activities implemented during the years preceding program implementation, as well as post-intervention evaluation activities. Moreover, project activities, including the consumption of 40g of soy protein, soy and vegetable gardening with skills training, and general nutrition education during the intervention period resulted in a significant improvement in mean serum HDL- and LDL-cholesterol, and total serum triglyceride levels in women diagnosed with hypercholesterolemia. Similarly, improved LDL-cholesterol levels also were observed in normocholesterolemic women [10]. The nutrition intervention led to improved serum HDL-levels in approximately 97% of the women [10], supporting previous reports, that soybean consumption can prevent dyslipidemia in normocholesterolemic, as well as treat dyslipidemia in hypercholesterolemic women. These results were confirmed further by the marked improvement in the HDL: LDL ratio on the part of 88.9% of the hypercholesterolemic women and 67.9% of the normocholesterolemic group post-intervention. A normal HDL: LDL ratio was observed in 18.9% and 32.2% of the total group before and after the intervention, respectively, suggesting a reduced risk of CVD events after the intervention. This was achieved at a CE ratio of $2,697 (Cost effectiveness ratio is the cost per woman who achieved the normal level of a specified serum lipid, Table 3). The highest CE ratio, $4,117, was associated with lowering serum cholesterol, followed by LDL cholesterol, $3,911, and $1,534 for triglycerides. The lowest CE ratio, $899, was associated with increasing HDL cholesterol. As indicated earlier, because of the paucity of data, these ratios could not be compared to ratios in other studies, either in South Africa or globally.

Statins typically are prescribed to treat high serum cholesterol levels. However, it has been reported that health promotion strategies, such as healthy eating, may be more cost-effective than such cholesterol-lowering drugs [32, 33]. Although the CE between soybean consumption and statins or any other lipid lowering drug was not determined, based on our findings, soybean consumption could be an alternative for the primary prevention of CVDs in this community. In addition, Dollahite *et al.* [12] also reported that community-based nutrition programs that focus on disease prevention are less costly

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than are treatments after the disease has been diagnosed, both in quality of life gained and actual money expended. Furthermore, dietary, behavior, or lifestyle improvements also can result in significant savings in healthcare costs [34].

In a related publication, it was observed that a nutrition intervention had positive effects on nutrient adequacy, dietary diversity, and food security among women in Qwa Qwa [10, 19]. The findings of this study, as well as previous related research, have shown that soybean gardening, as well as processing soybeans at the household level, was feasible, affordable, and sustainable during the study period. Furthermore, high compliance was observed among study participants with respect to soybean consumption. In support of this, Pestana *et al*. [35] recommended a broad-based population strategy to prevent and treat CVDs cost-effectively. However, the South African National Department of Health realized much later that the prevention of non-communicable diseases is significantly more effective and cost-effective than is treatment. In response, the health department developed and implemented the Strategic Plan for the Prevention and Control of Non-Communicable Diseases 2013-2017 to address this public health issue.

The percentage cost of labor for nutrition intervention programs varies widely [36, 37], and there are virtually no data for programs in Africa. Hilleren and Market's [36] study in the United States, for example, reported that labor represented between 41–65% of total school breakfast costs for one academic school year; thus, the 21.7% labor cost in this pilot program is relatively low. It is also important to point out that the cost per person for the implementation of this program likely will decrease if the program is implemented on a wider scale, in that it has been designed already (infrastructure is already in place) and a large part of the initial costs would not be required. In addition, this project included a strong research component that might not be necessary if implemented on a larger scale.

Over the duration of the intervention, reagents and blood collection supplies accounted for the highest percentage of the total cost of materials (approximately 34% or $18,988). Approximately 26% of this cost was attributable to the purchase of laptops, cameras, cooler bags, refreshments, etc. The percentage cost for training materials was 15.81% and 8.70% for soy preparation equipment. The percentage cost for seeds was only 3.17%. To expand this program would require more investment in training materials, gardening tools, soy preparation equipment, and seeds. Interestingly, these accounted for a low percentage of the total cost of materials, lending further support to the economic feasibility of expanding this program.

Most economic evaluations related to malnutrition have focused on micronutrient deficiencies in low-and middle-income countries [34]. This is the first CE evaluation that has assessed a nutrition intervention program, including soy and vegetable gardening and skills training, and general nutrition education intended to reduce blood lipid risk factors for CVD in South Africa. Thus, it contributes to the paucity of economic evaluations of nutrition interventions in the South African literature. However, this study also included limitations. First, there is a dearth of CE studies; thus, it is difficult to compare our results to others. Another limitation of this study is that it is difficult to disentangle program implementation and research costs in CE calculations. Specifically, the intervention was relatively complex and included multiple components (education, soy and vegetable

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gardening, processing, and consumption); therefore, it is impossible to parse out each component's relative effect on lipid profile. Furthermore, participating in a gardening program may have increased the physical activity levels of the women and this may have contributed to the reduction in cardiovascular risk. Physical activity was not measured as an outcome. Third, the study design had no control group. Fourth, this was a pilot study conducted in one community in South Africa, and therefore, the results should not be generalized to other communities or the population. Finally, only CE ratios related to blood lipid levels were addressed, which is a short-term outcome. Future work is needed to conduct CE analyses of this type of program with respect to longer-term outcomes, such as Quality-Adjusted Life Years.

CONCLUSION

This intervention determined that the CE ratio to improve HDL cholesterol was the lowest compared to other indicators of blood lipids, that is, total serum cholesterol, LDL-cholesterol, and serum triglycerides.

Implementing a program such as this can have an effect on serum cholesterol levels in both hypercholesterolemic and normocholesterolemic persons, and potentially lead to a reduction in cardiovascular risk. Furthermore, this strategy may be more cost-effective than treating high serum cholesterol levels with statins. This was one of the first community-based nutrition studies that used a variety of intervention strategies targeted at cardiovascular risk, and also was subjected to a CE evaluation. This is only the first stage in a long process, and longitudinal research is needed to evaluate the sustainability of programs, as well as the long-term cost-effectiveness of the intervention. The next step will be to determine the fundamental elements and cost efficiencies that would be needed to expand the intervention. This is necessary because assessing the health and economic effects of nutrition interventions is important in developing nutrition recommendations and informing regulatory processes [34], as well as assisting policy makers to ensure more efficient allocation of limited resources to reduce the burden of nutrition-related lifestyle diseases [33]. Furthermore, more priority should be given to assess the CE of nutrition interventions that prevent non-communicable diseases at the community and population level to prevent the increasing prevalence of non-communicable diseases and their related healthcare costs. Lastly, it is also important to emphasize the fact that the economic analysis of nutrition interventions need to be planned in advance, ideally during the phase of nutrition program planning, so that, for example, data collection efforts also include collection of data about resources used and their corresponding costs.

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Conflicts of interest: We declare no conflict of interest

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Table 1: Cost of intervention in nominal US dollars for different resource categories and years: N=90

	$ Nominal				
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Labor	829	1,588	6,767	4,675	1,754
Materials	2,711	10,711	24,667	4,777	7,915
Transport	592	NA	66	694	NA
Miscellaneous	646	NA	1,249	1,665	NA
Total	4,778	12,299	32,749	11,811	9,669

NA-no cost incurred
1 South African Rand= 0.064 US Dollar

Table 2: Cost of intervention after discounting in real US dollars for different resource categories and years: N=90

	$Real					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	
	$X (1+i)^4$	$X (1+i)^3$	$X (1+i)^2$	$X (1+i)	$X	Total
Labor	1,008	1,838	7,461	4,909	1,754	16,970
Materials	3,295	12,399	27,195	5,016	7,915	55,820
Transport	719	NA	73	728	NA	1,520
Miscellaneous	785	NA	1,377	1,748	NA	3,910
					Grand Total	**78,219**

Discount rate=5% [24]; $X is the amount in nominal US dollars; NA-no cost incurred

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Table 3: Cost, outcomes and cost-effectiveness ratios for the consumption of soy foods in improving blood lipid profiles of women: N=90

Measure	Cost/Outcome
Total cost of program (for all 90 women served)	$78,219
Cost per person	$869
Effectiveness: Number of women with serum cholesterol <5.2mmol/L	19
Effectiveness: Number of women with LDL cholesterol <3.3 mmol/L	20
Effectiveness: Number of women with HDL cholesterol >1.68 mmol/L	87
Effectiveness: Number of women with serum triglycerides <1.7 mmol/L	51
Effectiveness: Number of women with HDL: LDL ratio >0.4	29
Measure	**Cost effectiveness ratio**
Cost effectiveness ratio, serum cholesterol	$4,117
Cost effectiveness ratio, LDL cholesterol	$3,911
Cost effectiveness ratio, HDL cholesterol	$899
Cost effectiveness ratio, serum triglycerides	$1,534
Cost effectiveness ratio, HDL: LDL ratio	$2,697

*$ is in 2012 US dollars.
Total cost includes cost of labor, cost of materials, cost for transportation, and miscellaneous items or activities
Cost per person is the ratio of total cost of intervention per number of women served
Cost effectiveness ratio is the cost per woman who achieved the normal level of a specified serum lipid

Table 4: Percentage cost of program for different resource categories: N=90

Resource	Total cost in $	% of total cost
Labor	16,970	21.69
Materials	55,820	71.36
Transport	1,520	1.94
Miscellaneous	3,910	5.00
Grand total	78,219	

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Table 5: Total costs and percentage breakdown of material resource for the period of intervention program: N=90

Type of material resource	Amount in $ real	% of total cost
Reagents and blood collection supplies	18,988	34.02
Other materials	14,333	25.68
Training materials	8,824	15.81
Gardening tools	5,224	9.36
Soy preparation equipment	4,859	8.70
Seeds	1,768	3.17
Recipe development	1,702	3.05
Fieldworkers training workshop	123	0.22
	55,820	

"Other materials" include printer cartridges, laptops, cameras, cooler bags, refreshments.

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REFERENCES

1. **WHO.** Cardiovascular diseases (CVDs). World Health Organization Press, Geneva, 2016.

2. **Cappuccio FP and MA Miller** Cardiovascular disease and hypertension in sub-Saharan Africa: burden, risk and interventions. *Intern Emerg Med.* 2016;**11(3)**:299-305.

3. **Mocumbi AOH and MB Ferreira** Neglected cardiovascular diseases in Africa. *J Am Coll. Cardiol.* 2010; **55 (7):** 680-687.

4. **Mocumbi AO** Lack of focus on cardiovascular disease in sub-Saharan Africa. *Cardiovasc Diagn Ther*. 2012; **2(1):** 74-7.

5. **WHO.** World Health Organization - Noncommunicable Diseases (NCD) Country Profiles, 2014. WHO, Geneva, 2014.

6. **World Heart Federation**. Factsheet: Cardiovascular diseases in South Africa. World Heart Federation, Geneva, 2016.

7. **Nelson RH** Hyperlipidemia as a risk factor for cardiovascular disease. *Prim Care.* 2013; **40(1)**: 195-211.

8. **Moosmann B and C Behl** Selenoprotein synthesis and side-effects of statins. *The Lancet*, 2004; **363(9412)**: 892-4.

9. **Enkhmaa B, Surampudi P, Anuurad E and L Berglund** Lifestyle changes: Effect of diet,exercise, functional food, and obesity treatment, on lipids and lipoproteins. **In**: De Groot LJ, Chrousos G, Dungan K (editors) Endotext, South Dartmouth, MA, 2015.

10. **Oldewage-Theron W and A Egal** The effect of consumption of soy foods on the blood lipid profile of women: a pilot study from Qwa-Qwa. *J Nutr Sci Vitaminol.* 2013; **59(5):** 431-36.

11. **National Planning Commission.** National Development Plan 2030: Our future–make it work. National Planning Commission, Pretoria, 2012.

12. **Dollahite J, Kenkel D and CS Thompson** An economic evaluation of the expanded food and nutrition education program. *JNEB*. 2008; **40(3)**: 134-43.

13. **Masters R, Anwar E, Collins B, Cookson R and S Capewell** Return on investment of public health interventions: a systematic review. *J Epidemiol Community Health.* 2017; **71**: 827-834.

14. **Oldewage-Theron WH, Duvenage SS and AA Egal** Situation analysis as indicator of food security in low-income rural communities. *JCS*. 2012; **40**:38-58.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 18 No. 3 December 2018 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

15. **Oldewage-Theron W and AA Egal** Impact of a soy nutrition education program on knowledge in a low-income community in Qwa-Qwa, South Africa. *Int J Consum Stud.* 2012; **36(4)**: 480-85.

16. **Duvenage SS, Oldewage-Theron WH and AA Egal** Conceptualising of quantities by low-income consumers to guide recipe format. *IJHE*. 2013; **6(1)**: 21-33.

17. **Duvenage SS, Oldewage-Theron WH, Egal AA and GN Medoua** Home-prepared soymilk: Potential to alleviate protein-energy malnutrition in low-income rural communities in South Africa? *Health SA Gesondheid*. 2013; **18(1)**: 1-7.

18. **Duvenage SS, Oldewage-Theron WH and AA Egal** Acceptance of home-prepared soy dishes in low-income rural Qwa-Qwa communities. *IJHE*. 2012; **5(2)**: 151-66.

19. **Oldewage-Theron W and A Egal** The effect of a combination of nutrition education, soy and vegetable gardening, and food preparation skill training interventions on dietary intake and diversity in women: a case study from Qwa-Qwa. *South Afr J Clin Nutr.* 2015; **28(3)**: 113-20.

20. **Smith JD** Single-case experimental designs: A systematic review of published research and current standards. *Psychol methods*, 2012; **17(4)**: 510.

21. **Punt C, Pauw K and M van Schoor** PROVIDE project: A profile of the Free State province: demographics, poverty, inequality and unemployment. PROVIDE project, Elsenburg, 2005.

22. **Shisana O, Labadarios D, Rehle T, Simbayi L, Zuma K, Dhansay A, Reddy P, Parker W, Hoosain E, Naidoo P, Hongoro C, Mchiza Z, Steyn NP, Dwane N, Makoae M, Maluleke T, Ramlagan S, Zungu N, Evans MG, Jacobs L, Faber M and** South African National Health and Nutrition Examination Survey **(SANHANES-1) Team.** South African National Health and Nutrition Examination Survey. HSRC Press, Cape Town, 2013.

23. **Oldewage-Theron WH and AA Egal** Nutrition knowledge and nutritional status of primary school children in QwaQwa. *S Afr J Clin Nutr.* 2010; **23(3)**:149-154.

24. **Splett PL** The practitioner's guide to cost-effectiveness analysis of nutrition interventions. MCHING, Arlington, 1996.

25. **Davis GC and EL Serrano** Food and Nutrition Economics: Fundamentals for Health Sciences. Oxford University Press, Oxford, 2016.

26. **Tan-Torres Edejer T, Baltussen R, Adam T, Hutubessy R, Acharya A, Evans DB and CJL Murray** Making choices in health: WHO guide to cost-effectiveness analysis. World Health Organization, Geneva, 2003.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 18 No. 3 December 2018 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

27. **Ackerman F and L Heinzerling** Priceless. On Knowing the Price of Everything and the Value of Nothing. The New Press, New York City, NY, 2002.

28. **Sindelar JL, Jofre-Bonet M, French MT and AT McLellan** Cost-effectiveness analysis of addiction treatment: paradoxes of multiple outcomes. *Drug Alcohol Depend.* 2004; **73(1)**: 41-50.

29. **Bjørner J and H Keiding** Cost-effectiveness with multiple outcomes. *Health Econ.* 2004; **13(12)**: 1181-90.

30. **Hofman K** Non-communicable diseases in South Africa: A challenge to economic development. *SAMJ.* 2014; **104(10)**: 01-01.

31. **Pillay-van Wyk V, Msemburi W, Laubscher R, Dorrington RE, Groenewald P, Glass T, Nojilana B, Joubert JD, Matzopoulos R, Prinsloo M and N Nannan** Mortality trends and differentials in South Africa from 1997 to 2012: second National Burden of Disease Study. *Lancet.* 2016; **4(9)**: 642-53.

32. **Brunner E, Cohen D and L Toon** Cost effectiveness of cardiovascular disease prevention strategies: a perspective on EU food based dietary guidelines. *Public Health Nutr.* 2001; **4(2b)**: 711-5.

33. **Dalziel K and L Segal** Time to give nutrition interventions a higher profile: cost-effectiveness of 10 nutrition interventions. *Health Promot Int.* 2007; **22(4)**: 271-83.

34. **Gyles CL, Lenoir-Wijnkoop I, Carlberg JG, Senanayake V, Gutierrez-Ibarluzea I, Poley MJ, Dubois D and PJ Jones** Health economics and nutrition: a review of published evidence. *Nutr. Rev.* 2012; **70(12)**: 693-708.

35. **Pestana JAX, Steyn K, Leiman A and GM Hartzenberg** The direct and indirect costs of cardiovascular disease in South Africa in 1991. *S Afr Med J.* 1996; **86(6)**: 679-684.

36. **Hilleren H and MG Market** School Breakfast Program Cost/Benefit Analysis. UW-Extension, Family Living Program, 2007.

37. **Bartlett S, Glanz F and C Logan** School Lunch and Breakfast Cost Study-II, Final Report. Alexandria, VA: US Department of Agriculture. Food and Nutrition Service, Office of Research, Nutrition and Analysis, 2008.

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