Can locally available foods provide a healthy diet at affordable costs? Case of Armenia

Ghazaryan, Armen

Colorado State University

28 August 2018

Can Locally Available Foods Provide a Healthy Diet at Affordable Costs? Case of Armenia

Abstract: Nutrition-related health problems, such as obesity, stunting, anemia, and high blood pressure are common in Armenia. A large portion of the population lives below the national poverty line, and consumes less than the necessary energy intake per day. Linear programming is used in this study of diet optimization to create a healthy diet for children and adults of different ages at the minimum cost. The model is based on culturally appropriate food products. The study finds that, while average Armenians can afford a healthy diet, their current dietary choices do not meet the requirements of Dietary Reference Intakes (DRIs). Moreover, people earning minimum salary need to spend more than half of their monthly income on food to afford a healthy diet. Based on the study's findings, several policy recommendations are made.

Keywords: diet optimization, linear programming, healthy eating, diet affordability, Armenia

Published version: https://doi.org/10.1080/21665095.2018.1505531

Introduction

Nutrition-related problems are among some of the main health concerns in Armenia. Various studies have suggested that obesity, overweight, and stunting are common among both children and adults (Galea et al. 2013, NSS, MOH, and ICF 2017, 2012). Other diet-related health problems that are commonly reported in Armenia are high blood pressure, high blood cholesterol, high blood glucose, anemia, and vitamin A deficiency (NSS, MOH, and ICF 2017, IFPRI 2015). Different factors can lead to these health issues, such as the unaffordability of healthier diets, food preferences, low awareness of nutritional requirements, culturally accepted diets, and the lack of knowledge regarding food that is healthy and food that is not. The poverty headcount ratio at 3.2 USD a day is 13.5%, while it is 29.8% based on the national poverty line (World Bank 2015). At the same time, 60.8% of the population has a daily calorie intake of less than 2100 kcal (NSS 2017).

Thus, in this study, I will answer the following research question: Is meeting the Dietary Reference Intakes (DRIs) affordable in Armenia? The objective of this study is to analyze whether it is affordable to meet the DRIs for children and adults of different ages via food products that are commonly consumed in Armenia. I will use a diet-optimizing linear programming model with the objective of minimizing the cost of the food basket while still meeting the DRIs.

Background

Armenia is a landlocked country situated in the South Caucasus region. The country gained its independence from the Soviet Union in 1991. As was the case for other post-Soviet countries, Armenia experienced a major economic disruption after becoming independent. This resulted in

lower living standards, increased poverty rates, and poorer health status (AUA 2002). In 2015, the total population of Armenia was 3,017,712 (World Bank 2016a). In the same year, the GDP per capita adjusted for purchasing power parity (PPP) was 8,393.5 in current international $ (World Bank 2016b). On average, an Armenian household consists of 3.6 people, with 19% of household members being under the age of 15, and 17% being above 60 years of age (NSS, MOH, and ICF 2012). In 2015, the unemployment rate in the country was 18.5%, and 106,371 families were receiving family and social benefits (World Bank 2016c). In 2016, the average monthly nominal salary varied by region from 115,549 AMD in Aragatsotn region to 200,693 AMD in Syunik (NSS 2016b). Region-based monthly nominal salaries can be found in Table 1.

According to a 2012 report, 19% of children under the age of five in Armenia experienced stunted growth, while 15% was overweight - both conditions are caused by chronic malnutrition (NSS, MOH, and ICF 2012). The chronic malnutrition rate for children is significantly higher in urban areas outside of Yerevan, which can be attributed to three main reasons:

1. Nutrient-rich food may not be affordable for the urban poor;

2. such food may be unavailable due to their inability to engage in subsistence farming; and

3. people may have developed poor eating habits (WFP 2018).

All three countries in the South Caucasus region - Armenia, Azerbaijan, and Georgia - experience similar food security issues, including issues related to the availability of and access to sufficient amounts of food, nutrition, and a stable food supply (ISET 2016). Of the three

countries, Armenia has had a law pertaining to food security since 2002; Georgia's Ministry of Agriculture is working on developing such a law in collaboration with other international organizations while, in Azerbaijan, the only legal document on food security is the regulation requiring the compilation of the Food Balance Sheet (ISET 2016).

Estimates from 2008 indicated that 55.5% and 24% of the population in the age group of 20 years and above were overweight and obese, respectively (Galea et al. 2013). NSS, MOH, and ICF (2017) reported that the percentage of overweight or obese women had increased from 42% in 2000 to 45% in 2015-2016. The report also suggested that 13% of women aged 15-49 had anemia, which can be caused by a low intake of iron (NSS, MOH, and ICF 2017). In 2014, the prevalence of obesity in the adult population (18 years and older) was similar across the three South Caucasus countries - Armenia (19.1%), Azerbaijan (21.32%), and Georgia (20.85%) (FAO 2014). The three-year average dietary energy supply adequacy for 2014-2016 was also similar in the regions, with 121% for Armenia, 131% for Azerbaijan, and 118% for Georgia (FAO 2016). This indicator expresses the Dietary Energy Supply as a percentage of the Average Dietary Energy Requirement. If analyzed in conjunction with the prevalence of undernourishment, this indicator helps to understand whether the main source of undernourishment is an insufficient supply of food or the poor distribution of the food supply. While there are no data on the prevalence of undernourishment in Azerbaijan after 2010 when the value was 2.6%, the three-year average (2014-2016) value of the prevalence of undernourishment was 4.4% in Armenia and 7% in Georgia (FAO 2016).

Data for 2008 on diet-related metabolic risk factors indicated that 48% of the population in Armenia had high blood pressure, 41% had high blood cholesterol, and 12% had high blood glucose (IFPRI 2015). The same report showed that 11% of children aged 6-59 months had a

vitamin A deficiency (IFPRI 2015). The percentage of the population for whom bread and potatoes constituted 70% of the food ration in the urban and rural areas was 12.2% and 17.5%, respectively (NSS 2015).

In addition to the health problems associated with dietary choices in Armenia mentioned above, unhealthy eating can also lead to the increased risk of strokes, cancer, dental caries, asthma, and neurocognitive disorders, as well as to congenital anomalies (HHS 2015, Shepherd et al. 2006). Overall, fruits, vegetables, whole grains, legumes, seafood, and nuts are considered healthy foods; lower intakes of meat and poultry can also form part of healthy eating patterns (HHS 2015).

Multiple studies from different countries have shown that healthier diets actually cost more than do less healthy diets (Darmon and Drewnowski 2008, Andrieu, Darmon, and Drewnowski 2006, Rydén and Hagfors 2011). However, others have suggested that a well-planned food basket may be healthier and cheaper than are foods obtained from convenient sources (McDermott and Stephens 2010). There is a comprehensive review of the literature on price differences between healthier and less healthy food products (Rao et al. 2013). The existing literature suggests strategies for limiting access to low-cost food containing high quantities of added sugar, added fat, and a high refined grain content, as well as for limiting the advertising of soft drinks (Fried and Nestle 2002) or discouraging snack consumption through taxation (Jacobson and Brownell 2000).

Previous studies have used diet optimization via linear programming to meet nutritionally optimal dietary needs (Ferguson et al. 2004, Okubo et al. 2015), to develop food plans (Maillot et al. 2010), and to adjust these to attain different goals, such as cancer prevention (Masset et al.

2009). When implementing diet optimization, it is necessary to not only meet the DRIs, but also to include local and culture-specific food products to achieve practical dietary guidelines that promote healthy food choices (Okubo et al. 2015). To the best of my knowledge, there have not been other studies analyzing the affordability of meeting DRIs via culture-specific food products in Armenia or in the region.

Data and Method

One way to meet the objectives of this study was to use the Cost of the Diet (CoD) software developed by Save the Children. CoD has been used to determine cost-effective food fortification strategies, to identify nutrient deficiencies in commonly consumed food products within a country context, and to model healthy diet choices at the lowest cost (Biehl et al. 2016, Baldi et al. 2013, Frega et al. 2012). Perry et al. (2017) conducted a detailed study that described the software, the databases on which it relies, its applications, and its limitations. However, instead of using CoD, I built a linear programming model in Excel using Solver for the following three reasons:

(1) The diets recommended by CoD are based on 16 individual requirements - energy, protein, fat, and 13 vitamins and minerals (Perry et al. 2017). The model used in this study extends the number of these requirements to 28. The choice of the 28 requirements (Appendix A) was based on the recommended dietary allowances and adequate intakes of elements, vitamins, and macronutrients, as well as on the tolerable upper intake levels of vitamins and elements as reported by the National Institutes of Health (Ross et al. 2011).

(2) The CoD diet recommendations are adjusted for energy, protein, fat, vitamin, and mineral requirements for 237 individuals according to the following categories (Perry et al. 2017):

a. Children of either sex aged between 1–5, 6–8, 9–11, and 12–23 months;
b. children of either sex aged between 2 and 18 years in 1-year intervals;
c. men aged 18–29, 30–59 or 60+ years with a body weight of between 50 and 90 kg in 5 kg divisions, with three levels of physical activity - light, moderate, or vigorous;
d. women aged 18–29, 30–59 or 60+ years with a body weight of between 45 and 85 kg in 5 kg divisions, with three levels of physical activity - light, moderate, or vigorous; and
e. additional energy and nutrients specified during each of the three stages of pregnancy or lactation.

While this allows for individual-specific diet recommendations, it is less generalizable for policy recommendations. Given Armenia's population characteristics and family composition, the model used in this study is based on the DRI requirements for the following 11 population groups (Ross et al. 2011):

a. Children of either sex aged between 1-3 years;
b. children of either sex aged between 4-8 years;
c. females/males aged between 9-13 years;
d. females/males aged between 14-18 years;
e. females/males aged between 19-50 years;
f. females/males aged between 51-70 years; and

g. general: a 2100 kcal/day threshold, which is used to differentiate a poor energy intake from an adequate intake (Papavero et al. 2016, NSS 2016b).

(3) CoD requires survey data, while the model used in this paper allows for meeting the objective of the study by using data that are publicly available.

The problem can be represented algebraically as follows:

$$\text{minimize}\, C = \sum_{i=1}^{50} p_i x_i$$

$$\text{subject to} \begin{matrix} l_{kt} \le \sum_{i=1}^{50} n_k x_i \le u_{kt} \\ 0 \le x_i \le U_{x_i} \end{matrix}, \text{ where}$$

C is the total cost of the food basket,

p_i is the price of the i^{th} product,

x_i is the portion of the i^{th} product,

l_{kt} is the recommended dietary allowance (DRI) of the k^{th} component of calories, vitamins, elements and macronutrients for the t^{th} age group,

u_{kt} is the tolerable upper intake levels of the k^{th} component of vitamins, elements, and nutrients for the t^{th} age group,

$n_K x_i$ is the value of the k^{th} component of calories, vitamins, elements, and nutrients provided by the portion size of the i^{th} product,

U_{xi} is the chosen upper limit imposed on the quantity of the i^{th} product, and

$i \in (1;50)$ indicates that, for the purposes of this study, 50 food products have been selected.

In other words, this optimization problem states that the model should select a basket of products that meets the recommended dietary allowance of calories, vitamins, elements, and macronutrients, and which does not exceed the tolerable upper intake levels, at the cheapest cost. It also sets a combined restriction on the portions of fruits and vegetable recommended by the model at 800 g, of which at least 160 g should be fruits. This restriction is based on a recent meta-analysis, which found that consuming up to 800 g of fruits and vegetables a day is associated with a reduced risk of heart disease, stroke, cardiovascular disease, and cancer, as well as with a reduction in premature deaths (Aune et al. 2017). In addition, HHS (2015) recommended consuming at least two cups of fruits per day, which is equivalent to approximately 160 g. The portion limits for onion and garlic are 50 g/day and 5 g/day, respectively, based on the World Health Organization's recommendations (WHO 1999). The added sugar consumption limit is set at 36 g/day for men, and 25 g/day for women, based on the American Heart Association's recommendations (Johnson et al. 2009). The upper limit for yogurt is set at 200 g/day, given that it has been studied in clinical trials in amounts of up to 200 g/day (Arrigoni et al. 1994, Shermak et al. 1995, Rosado et al. 2005, Zemel et al. 2005, Tavani et al. 2002).

In total, 50 products have been selected and placed into six categories: grains and co-products, protein products, dairy, vegetables, fruits, and others. Other studies with similar objectives from different countries have used 18-78 products (Darmon, Ferguson, and Briend 2002b, Mamat et al. 2011, Ferguson et al. 2006, Biehl et al. 2016). The full list of products, their respective prices, and the price sources used in the model are presented in Table 2. The choice of products is based on food items having at least three grams of per capita consumption a day, as reported in the National Food Balances (NSS 2016a). However, since only 33 out of 41 products

reported in the National Food Balances meet this requirement, 17 additional culturally appropriate products were included. These 17 additional products are either processed products that are not included in the National Food Balances, which play an important role in the Armenian cuisine, such as lavash, wheat bread, and Lori cheese, or products that may not be consumed separately in large quantities but which are essential ingredients in some of the commonly consumed meals, such as grape leaves. The larger number of products included also allows the model to 'recommend' food baskets that have more product diversity.

[Table 2 here]

Product prices were collected primarily from three sources: www.globalprice.info (2017), www.numbeo.com (2017), and SAS (2017), which is one of the upper-class supermarkets in the capital of Armenia, Yerevan. Price information for (middle-class) supermarkets or stores is not publicly available, and the National Statistical Service stopped providing average consumer prices after 2010. In this study, 30 out of 50 product prices were taken from SAS (2017). In a 2015 local newspaper article, the prices of 26 commonly consumed food products were compared across four major supermarkets, namely Yerevan City, which primarily targets lower to upper middle-income consumers, Parma, Nor Zovq, and SAS www.yerevan.today (2015). However, only 13 out of 30 products that are based on the SAS prices in this study were available in the news article and, for those products, the SAS prices were 20% higher on average than were the Yerevan City Supermarket prices.

The amounts for the recommended daily intake of calories were taken from the 2015-2020 Dietary Guidelines for Americans (HHS 2015) due to the lack of similar recommendations specifically for Armenians. Given that the Dietary Guidelines for Americans are based on a

combination of methods that examine the scientific evidence for the relationship between diet and health, they can also be applied to the Armenian population. Overall, there is a limited evidence base, little data collection, and limited monitoring of food security and nutrition in Armenia (WFP 2018). The nutritional contents of the edible portions of these 50 products are based on National Nutrient Database for Standard Reference (SR28 2016).

Results

The food baskets recommended by the model differ across the population groups. A full list of recommendations can be found in Appendix B. Food products that were not selected by the model are excluded from Appendix B. On average, the food baskets consist of 13 products. Other studies have reported a similar number of food products recommended by their models (Darmon, Ferguson, and Briend 2002a, Frega et al. 2012). The 'general' group and the group of females aged 9-13, have the least diverse food baskets, consisting of ten products. Males in all age groups and the 4-8-year olds have the most diverse food baskets, consisting of 14 products. Certain products are strongly 'preferred' by the model, which means that these products are recommended for almost all the population groups. Those food products are lentils, wheat bread, lavash, whole milk, plain yogurt, sunflower oil, granulated sugar, apricots, grapes, cabbage, carrot, spinach, and potato. Most protein products are recommended in negligible amounts, or are not recommended at all by the model. This is in line with the literature, which generally recommends higher intakes of fruits, vegetables, whole grains, and lower intakes of meat and poultry (Shepherd et al. 2006).

After running the model for all 11 population groups, the results (Table 3) suggested that it would cost 2.48 USD per day to meet the DRIs for males aged 14-18, making this the most

expensive group. The next most expensive group is females aged 14-18, for whom the recommended food basket would cost 2.09 USD per day. The 'general' group, which is based on the general recommendations for the DRI and does not consider sex or age, would need to pay 2.00 USD per day to meet the nutritional requirements. According to the model's results, the nutritional requirements of children aged 1-8 years can be met by spending only 0.76-1.05 USD per day. In general, the food baskets recommended by the model are more expensive for males than they are for females in the same age ranges.

[Table 3 here]

According to the National Statistical Service of Armenia (2017), per capita consumer expenditure is 47161 AMD per month (93.2 USD) in urban areas, and 35786 AMD per month (73.8 USD) in rural areas. Per capita monthly expenditure on food is 18943 AMD (39 USD) (NSS 2017). Taking the cost of the recommended food basket for the 'general' group, and multiplying it by 30 (assuming a 30-day month), results in 60 USD per month to meet the requirements for a healthy diet. Thus, a single person who earns a monthly minimum wage of 55000 AMD (113.4 USD) would need to spend more than half (53%) of his or her monthly income on food products to have a healthy diet. A single person from Syunik or Aragatsotn earning an average monthly wage would need to spend about 14.5 or 25% of the monthly income, respectively, to have a healthy diet. A family consisting of a couple of opposite sexes aged 18-50, with one female and one male child both aged 14-18, and both parents earning a minimum monthly wage, would need to spend about 110% of the monthly income to afford a healthy diet for the entire family. However, assuming both parents earn an average monthly wage, the percentage of the monthly income spent on food would need to be about 53% in

Aragatsotn, or 30% in Syunik. Different family scenarios can be considered for policy recommendations.

The National Food Balances database (NSS 2016a) provides per capita consumption (g/day) data for 33 of the 50 products included in the model (Appendix C). If, on average, the daily food basket consists of these 33 products in the given amounts, that diet does not meet the general recommendations of the DRI. It only meets the DRI for protein, vitamins A, B6, B12, C, riboflavin, and for calcium, phosphorus, selenium, potassium, and sodium. However, the consumption of added sugar is about 65% higher than the amount recommended by the American Heart Association. This diet costs about 2.39 USD, which is more than the cost of any of the model's recommended diets that meet the DRI requirements, except for the diet recommended for males aged 14-18.

Given that the consumption levels reported in the National Food Balances do not meet most of the DRI requirements, one of the model specifications was to keep them at least at their current levels and to add either more products to the basket or to increase the consumption levels to meet all the DRIs. With this additional constraint, the model's recommended minimum-cost food basket becomes 22 USD per day for the 'general' group, and fails to meet the combined restriction on the portions of fruits and vegetables of less than 800 g. Without the latter restriction, the model's recommended food basket costs 5.65 USD per day for the 'general' group, and the model recommends increasing the consumption of trout from 17 to 21.8 g per day, of pears from 12 to 66.5 g per day, of strawberries from 8.8 to 22.5 g per day, of cabbage from 30 to 36 g per day, and of tomatoes from 190 to 1042 g per day (which is an unrealistic recommendation). At the same time, this specification recommends reducing the consumption of

chicken breast from 33.2 to 10.32 g per day, of milk—from 738.3 to 618 ml per day, and of garlic from 7.6 to 5 g per day.

In general, to meet the DRI requirements, the model recommends increasing the consumption of the following products:

- lentils from the current 1.5 g per day to 28-226 g per day, depending on the age/sex category;
- apricots from 66.4 g per day to 108-327 g per day, depending on the age/sex category;
- grapes from 12.2 g per day to 51-160 g per day, depending on the age/sex category;
- cabbage from 29.6 g per day to 55-164 g per day, depending on the age/sex category; and
- potatoes from 190 g per day to 295-588 g per day, depending on the age/sex category.

A sensitivity analysis (SA) suggests that, in order for the model to recommend the consumption of protein products (such as lentils, black beans, chicken breast, pork, and white fish) to the 'general' group, the prices should decrease by at least 24%. For the same group, the prices of fruits need to decrease by at least 18% to include more fruits in the recommended food basket. The price of vegetables should be decreased by at least 13%, depending on the product, for the model to recommend vegetables to the 'general' group. All the sensitivity analyses can be obtained upon request.

Conclusion and Discussion

Given that many people in Armenia have diet-related health problems in addition to having low incomes, the study's objective was to minimize the cost of a daily basket of healthy food based on the nutritional needs of children and adults in different age groups. In general, the model does not recommend the consumption of meat and poultry products due to their prices and nutritional values, whereas fruits and vegetables, as well as whole milk, yogurt, lentils, and wheat bread are part of the model's recommended food baskets.

Based on the study's results, I conclude that, while average Armenians can afford a healthy diet, their current diet does not meet the DRI recommendations. This can be attributed to the fact that most Armenians, regardless of their social status, lack knowledge about nutrition (WFP 2018), which leads to diet-related health issues. Thus, one of the policy implications is that the government should increase the awareness of healthy dietary choices among the population. One of the contributions of this study is that it will allow policy makers to compare the current consumption patterns with those recommended by the model, and to take necessary steps to address age, social status, and sex-specific diet-related health issues.

Another finding is that the minimum-wage earners can only have healthy diets if they spend more than half of their income, and sometimes more than their entire monthly income, on food products. Therefore, I recommend studying the option of implementing programs that would allow the low-income households to afford healthy food choices, such as the Supplemental Nutrition Assistance Program (SNAP) in the United States, which could lead to reduced healthcare costs due to a potential reduction in diet-related health issues in the population. It is also recommended that the population be informed about the recommended

daily limits for added sugar consumption given that, on average, Armenians consume almost 65% more added sugar than is recommended by the American Heart Association.

The study has a few limitations. One of the limitations is that only 50 food products are included in the model, which limits the number of choices the model can suggest. Second, not all food prices are representative of Armenia's average prices, given that most of them were obtained from one of the upper-class supermarkets in Armenia, which generally offers products at higher prices. Next, while vitamin D, iodine, chromium, molybdenum, and biotin DRIs can be obtained easily, their values per serving size for the 50 products included in this model are either not determined or are not reported. Therefore, these five nutritional elements are not included in the model.

Future extensions of this study could include a bigger variety of food products and could use prices that are closer to the national average, if these can be found. Otherwise, a survey of prices could be done as part of a study. For policy purposes, it would be useful to estimate the costs and benefits of promoting healthy eating, as well as of implementing programs such as SNAP.

References

Andrieu, Elise, Nicole Darmon, and Adam Drewnowski. 2006. "Low-cost diets: more energy, fewer nutrients." *European journal of clinical nutrition* 60 (3):434.

Arrigoni, Eviano, Philippe Marteau, Francoise Briet, Philippe Pochart, JC Rambaud, and B Messing. 1994. "Tolerance and absorption of lactose from milk and yogurt during short-bowel syndrome in humans." *The American journal of clinical nutrition* 60 (6):926-929.

AUA. 2002. NEEDS ASSESSMENT: Primary health problems and health education needs of vulnerable populations. Yerevan: The Center for Health Services Research and Development,

American University of Armenia.

Aune, Dagfinn, Edward Giovannucci, Paolo Boffetta, Lars T Fadnes, NaNa Keum, Teresa Norat, Darren C Greenwood, Elio Riboli, Lars J Vatten, and Serena Tonstad. 2017. "Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality–a systematic review and dose-response meta-analysis of prospective studies." *International Journal of Epidemiology*:dyw319.

Baldi, Giulia, Elviyanti Martini, Maria Catharina, Siti Muslimatun, Umi Fahmida, Abas Basuni Jahari, Hardinsyah, Romeo Frega, Perrine Geniez, and Nils Grede. 2013. "Cost of the Diet (CoD) tool: first results from Indonesia and applications for policy discussion on food and nutrition security." *Food and nutrition bulletin* 34 (2_suppl1):S35-S42.

Biehl, Erin, Rolf DW Klemm, Swetha Manohar, Patrick Webb, Devendra Gauchan, and Keith P West Jr. 2016. "What does it cost to improve household diets in Nepal? Using the cost of the diet method to model lowest cost dietary changes." *Food and nutrition bulletin* 37 (3):247-260.

Darmon, Nicole, and Adam Drewnowski. 2008. "Does social class predict diet quality?" *The American journal of clinical nutrition* 87 (5):1107-1117.

Darmon, Nicole, Elaine Ferguson, and André Briend. 2002a. "Linear and nonlinear programming to optimize the nutrient density of a population's diet: an example based on diets of preschool children in rural Malawi." *The American Journal of Clinical Nutrition* 75 (2):245-253. doi: 10.1093/ajcn/75.2.245.

Darmon, Nicole, Elaine L. Ferguson, and André Briend. 2002b. "A Cost Constraint Alone Has Adverse Effects on Food Selection and Nutrient Density: An Analysis of Human Diets by Linear Programming." *The Journal of Nutrition* 132 (12):3764-3771. doi: 10.1093/jn/132.12.3764.

FAO. 2014. Prevalence of obesity in the adult population (18 years and older). In *Suite of Food Security Indicators*, edited by Food and Agriculture Organization of the United Nations.

FAO. 2016. Prevalence of undernourishment (%) (3-year average). In *Suite of Food Security Indicators*, edited by Food and Agriculture Organization of the United Nations.

Ferguson, Elaine L, Nicole Darmon, Andre Briend, and Inguruwatte M Premachandra. 2004. "Food-based dietary guidelines can be developed and tested using linear programming analysis." *The Journal of nutrition* 134 (4):951-957.

Ferguson, Elaine L., Nicole Darmon, Umi Fahmida, Suci Fitriyanti, Timothy B. Harper, and Inguruwatte M. Premachandra. 2006. "Design of Optimal Food-Based Complementary Feeding Recommendations and Identification of Key "Problem Nutrients" Using Goal Programming." *The Journal of Nutrition* 136 (9):2399-2404. doi: 10.1093/jn/136.9.2399.

Frega, Romeo, Jose Guerra Lanfranco, Sam De Greve, Sara Bernardini, Perrine Geniez, Nils Grede, Martin Bloem, and Saskia de Pee. 2012. "What linear programming contributes: World Food Programme experience with the "Cost of the Diet" tool." *Food and nutrition bulletin* 33 (3_suppl2):S228-S234.

Fried, Ellen J, and Marion Nestle. 2002. "The growing political movement against soft drinks in schools." *Jama* 288 (17):2181-2181.

Galea, G, C Bollars, J Breda, T Kiaer, M Kouzeh, L McGale, and T Wijnhoven. 2013. Country profiles on nutrition, physical activity and obesity in the 53 WHO European Region Member States. Methodology and summary. Copenhague: WHO Regional Office for Europe.

HHS. 2015. 2015–2020 dietary guidelines for Americans. edited by US Department of Health and Human Services. Washington (DC): USDA.

IFPRI. 2015. 2015 Nutrition country profile: Armenia. In *Global Nutrition Report*: INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE.

ISET. 2016. Sssessing the Food Security Data Relevance and Collection Mechanisms in the South Caucasus. Agricultural Policy Center at the International School of Economics at Tbilisi State University.

Jacobson, Michael F, and Kelly D Brownell. 2000. "Small taxes on soft drinks and snack foods to promote health." *American journal of public health* 90 (6):854.

Johnson, Rachel K, Lawrence J Appel, Michael Brands, Barbara V Howard, Michael Lefevre, Robert H Lustig, Frank Sacks, Lyn M Steffen, and Judith Wylie-Rosett. 2009. "Dietary sugars intake and cardiovascular health." *Circulation* 120 (11):1011-1020.

Maillot, Matthieu, Florent Vieux, Marie Josèphe Amiot, and Nicole Darmon. 2010. "Individual diet modeling translates nutrient recommendations into realistic and individual-specific food choices." *The American journal of clinical nutrition* 91 (2):421-430.
Mamat, Mustafa, Yeni Rokhayati, NN Mohamad, and Ismail Mohd. 2011. "Optimizing human diet problem with fuzzy price using fuzzy linear programming approach." *Pakistan Journal of Nutrition* 10 (6):594-598.
Masset, Gabriel, Pablo Monsivais, Matthieu Maillot, Nicole Darmon, and Adam Drewnowski. 2009. "Diet optimization methods can help translate dietary guidelines into a cancer prevention food plan." *The Journal of nutrition* 139 (8):1541-1548.
McDermott, Andrew J, and Mark B Stephens. 2010. "Cost of eating: whole foods versus convenience foods in a low-income model." *Family medicine* 42 (4):280.
National Statistical Service of Armenia, Ministry of Health of Armenia, and ICF. 2017. 2015-16 ADHS Key Findings. Rockville, Maryland, USA: NSS, MOH, and ICF.
NSS. 2015. Percent of population whose food ration includes 70% of bread and potatoes by indicators and years. National Statistical Service of the Republic of Armenia.
NSS. 2016a. RA National Food Balances by food commodity, indicators and years. National Statistical Service of the Republic of Armenia.
NSS. 2016b. Regional Statistics: Main Statistical Indicators 2012-2016. National Statistical Service of the Republic of Armenia.
NSS. 2017. Per capita consumer expenditures of the household on food by indicators and years. National Statistical Service of the Republic of Armenia.
NSS, MOH, and ICF. 2012. Armenia 2010 Demographic and Health Survey: Key Findings. Yerevan, Armenia and Calverton, Maryland, USA: National Statistical Service, Ministry of Health and ICF International.
NSS, MOH, and ICF. 2017. 2015-16 ADHS Key Findings. Rockville, Maryland, USA: National Statistical Service of Armenia, Ministry of Health of Armenia, and ICF.
Okubo, Hitomi, Satoshi Sasaki, Kentaro Murakami, Tetsuji Yokoyama, Naoko Hirota, Akiko Notsu, Mitsuru Fukui, and Chigusa Date. 2015. "Designing optimal food intake patterns to achieve nutritional goals for Japanese adults through the use of linear programming optimization models." *Nutrition journal* 14 (1):57.
Papavero, Cinzia, Eugenie Reidy, Elmira Bakhshinyan, and Janne Utkilen. 2016. Armenia Comprehensive Food Security, Vulnerability and Nutrition Analysis (CFSVNA). World Food Programme.
Perry, Abigail, Alex Rees, Amy Deptford, Andrew Hall, Claudia Damu, Elaine Ferguson, James Seddon, Jennie Hilton, Paul Parham, and Rachel Childs. 2017. "Cost of the Diet: a method and software to calculate the lowest cost of meeting recommended intakes of energy and nutrients from local foods." *BMC Nutrition* 3 (1):26.
Rao, Mayuree, Ashkan Afshin, Gitanjali Singh, and Dariush Mozaffarian. 2013. "Do healthier foods and diet patterns cost more than less healthy options? A systematic review and meta-analysis." *BMJ open* 3 (12):e004277.
Rosado, Jorge L, Margarita Díaz, Karla Gonzalez, Ian Griffin, Steven A Abrams, and Roxana Preciado. 2005. "The addition of milk or yogurt to a plant-based diet increases zinc bioavailability but does not affect iron bioavailability in women." *The journal of nutrition* 135 (3):465-468.
Ross, A Catharine, JoAnn E Manson, Steven A Abrams, John F Aloia, Patsy M Brannon, Steven K Clinton, Ramon A Durazo-Arvizu, J Christopher Gallagher, Richard L Gallo, and Glenville Jones. 2011. "The 2011 report on dietary reference intakes for calcium and vitamin D from the Institute of Medicine: what clinicians need to know." *The Journal of Clinical Endocrinology & Metabolism* 96 (1):53-58.
Rydén, Petra J, and Linda Hagfors. 2011. "Diet cost, diet quality and socio-economic position: how are they related and what contributes to differences in diet costs?" *Public health nutrition* 14 (9):1680-1692.
SAS. 2017. www.sas.am.
Shepherd, J., A. Harden, R. Rees, G. Brunton, J. Garcia, S. Oliver, and A. Oakley. 2006. "Young people and healthy eating: a systematic review of research on barriers and facilitators." *Health Education Research* 21 (2).
Shermak, Michele A, Jose M Saavedra, Teri L Jackson, SS Huang, Theodore M Bayless, and Jay A Perman. 1995. "Effect of yogurt on symptoms and kinetics of hydrogen production in lactose-malabsorbing children." *The American journal of clinical nutrition* 62 (5):1003-1006.
SR28, USDA. 2016. "National Nutrient Database for Standard Reference, Release 28." *US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory.* http://www. *ars. usda. gov/ba/bhnrc/ndl. Accessed* 26.
Tavani, A, S Gallus, E Negri, and C La Vecchia. 2002. "Milk, dairy products, and coronary heart disease." *Journal of Epidemiology & Community Health* 56 (6):471-472.
WFP. 2018. Armenia Transitional Interim Country Strategic Plan. World Food Programme.
WHO. 1999. *WHO monographs on selected medicinal plants*. Vol. 2: World Health Organization.
World Bank. 2015. Poverty headcount ratio at national poverty line (% of population).
World Bank. 2016a. Data. In *Population, total*.
World Bank. 2016b. GDP per capita, PPP (current international $).
World Bank. 2016c. Statistical Indicators.

www.globalprice.info. 2017. "The costs of groceries in Armenia in Yerevan." http://www.globalprice.info/en/?p=armenia/grocery-items-prices-yerevan.
www.numbeo.com. 2017. "Cost of Living in Armenia." https://www.numbeo.com/cost-of-living/country_result.jsp?country=Armenia.
www.yerevan.today. 2015. "Snndamterqi gnery` Yerevani Supermarketnerum (Food product prices at Yerevan supermarkets)." *Yerevan.Today*. http://yerevan.today/all/infographica/5522/snndamterqi-gnery-erevani-supermarketnerum.
Zemel, MB, J Richards, S Mathis, A Milstead, L Gebhardt, and E Silva. 2005. "Dairy augmentation of total and central fat loss in obese subjects." *International journal of obesity* 29 (4):391-397.

Tables

Table 1. Regional Average Monthly Nominal Salary in 2016, AMD

Region	AMD
Aragatsotn	115,549
Shirak	128,953
Vayots Dzor	132,475
Gegharkunik	138,501
Lori	144,919
Ararat	145,431
Tavush	146,475
Armavir	150,680
Kotayk	152,886
Yerevan	189,393
Syunik	200,693

Table 2. Food items and their respective prices included in the model.

Vegetables	**Price**	**Price Source**	**Fruits**	**Price**	**Price Source**
Cabbage	140 AMD/kg	SAS	Apple	525 AMD/kg	Numbeo
Cucumber	350 AMD/kg	SAS	Pear	1200 AMD/kg	SAS
Carrot	330 AMD/kg	SAS	Peach	350 AMD/kg	Globalprice
Tomato	420 AMD/kg	Numbeo	Apricot	500 AMD/kg	Numbeo
Eggplant	800 AMD/kg	SAS	Plum	420 AMD/kg	Globalprice
Mushroom	1500 AMD/kg	SAS	Cherry	800 AMD/kg	Numbeo
Green pepper	950 AMD/kg	SAS	Strawberry	1000 AMD/kg	SAS
White potato	180 AMD/kg	SAS	Grapes	300 AMD/kg	Globalprice
Grape leaves	920 AMD/kg	SAS	Pomegranate	2100 AMD/kg	SAS
Spinach	560 AMD/kg	SAS	Orange	660 AMD/kg	Numbeo
Green beans	770 AMD/kg	SAS	Banana	830 AMD/kg	SAS
Onion	240 AMG/kg	Numbeo	Watermelon	150 AMD/kg	Globalprice
Garlic	1550 AMD/kg	SAS	**Dairy**	**Price**	**Price Source**
Cauliflower	130 AMD/kg	SAS	Whole milk	400 AMD/l	Numbeo
Protein Products	**Price**	**Price Source**	Plain yogurt	430 AMD/kg	SAS
Ground beef	2430 AMD/kg	Numbeo	Light sour cream	1440 AMD/kg	SAS
Lean pork loin	2640 AMD/kg	SAS	Cottage cheese	2000 AMD/kg	SAS

Lean lamb loin	2740 AMD/kg	SAS	Light butter	3500 AMD/kg	SAS
Chicken breast	1820 AMD/kg	Numbeo	Lori cheese	2400 AMD/kg	SAS
Pork sausage	1500 AMD/kg	SAS	**Grains and Co-Products**	**Price**	**Price Source**
Whitefish	1500 AMD/kg	SAS	Rice	860 AMD/kg	SAS
Trout	2000 AMD/kg	SAS	Buckwheat	1100 AMD/kg	SAS
Egg	65 AMD/pcs	Numbeo	Wheat bread	500 AMD/kg	Numbeo
Walnuts	4500 AMD/kg	SAS	Pasta	470 AMD/kg	SAS
Lentils	1260 AMD/kg	SAS	Lavash	1000 AMD/kg	SAS
Black beans	1590 AMD/kg	SAS			
Others	**Price**	**Price Source**			
Sunflower oil	1000 AMD/l	SAS			
Sugar	370 AMD/kg	SAS			

Table 3. Costs of model-recommended food baskets.

Age/Sex Group	Cost USD/day
14-18 male	2.48
14-18 female	2.09
19-50 male	2.07
General Recommend	2.00
51-70 male	1.81
19-50 female	1.72
51-70 female	1.67
9-13 male	1.42
9-13 female	1.32
4-8 years old	1.05
1-3 years old	0.76

Appendices

Appendix A

Vitamins, elements, and macronutrients used in the model			
Energy	Vitamin A	Riboflavin	Magnesium
Protein	Vitamin B6	Niacin	Manganese
Fat	Vitamin B12	Folate	Phosphorus
Saturated fat	Vitamin C	Pantothenic acid	Selenium
Cholesterol	Vitamin E	Calcium	Zinc
Carbohydrates	Vitamin K	Copper	Potassium
Dietary fiber	Thiamine	Iron	Sodium

Appendix B: Model-Recommended Daily Portions of Food Products in Grams

Population Group	Cabbage	Carrot	Grape leaves	Spinach	White potato	Garlic	Cauliflower	Apricot	Grapes	Orange	Watermelon	Ground beef	Pork sausage	Trout
General	0	18	0	210	0	0	412	0	0	0	160	71	0	114
1-3 y.o.	165	0	12	11	414	0	38	0	0	12	148	0	3	0
4-8 y.o.	48	0	6	19	567	0	0	0	4	99	58	0	3	0
9-13 male	30	5	0	17	588	0	0	0	90	70	0	0	3	0
14-18 male	55	13	0	44	356	5	0	328	0	0	0	0	0	0
19-50 male	90	54	0	32	464	0	0	0	160	0	0	3	0	0
51-70 male	105	1	0	25	509	0	0	109	51	0	0	19	0	14
9-13 female	16	5	0	33	585	0	0	0	160	0	0	0	0	0
14-18 female	60	4	0	43	295	5	0	392	0	0	0	0	0	0
19-50 female	69	1	7	15	548	0	0	64	96	0	0	0	0	0
51-70 female	81	35	1	55	468	0	0	160	0	0	0	0	0	0

Population Group	Lentils	Lori Cheese	Granulated sugar	Rice	Buckwheat	Wheat bread	Lavash	Pasta
General	0	0	0	0	169	329	0	0
1-3 y.o.	0	0	36	0	0	79	0	0
4-8 y.o.	0	0	36	0	0	141	0	0
9-13 male	49	0	35	0	0	217	0	0
14-18 male	116	0	36	337	0	203	110	0
19-50 male	218	0	36	0	0	146	152	219
51-70 male	195	0	36	0	0	305	61	0
9-13 female	28	0	0	0	2	224	0	0
14-18 female	193	6	25	0	0	88	89	0
19-50 female	226	0	25	0	0	112	52	0
51-70 female	151	0	9	0	0	109	37	0

Appendix C: Republic of Armenia National Food Balances by Food Commodity, 2016

Product	Per capita consumption, g/day
Rice	9.5
Potatoes	189.9
Cabbage	29.6
Cucumber	66.2
Tomato	190.7
Carrot	14.5
Eggplant	50.5
Pepper	54.8
Green beans	15.4
Apple	72.2
Pear	12
Apricot	66.4
Peach	42.7
Plum	15.3
Cherry	3
Nut	4.4
Berry	8.8
Beans	4.7
Lentils	1.5
Vegetable Oil	26.1
Eggs	35
Milk	738.3
Beef	70.9
Pork	27.3
Mutton and goat meat	7.3
Poultry	33.2
Fish	17
Grapes	12.2