"Retrospective Evaluation of the WIC Program Changes: Dairy Nutrient Delivery"

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Introduction

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) provides supplemental foods, referrals to health care, and nutrition education to low-income pregnant, breastfeeding, and postpartum women, infants, and children up to age five. The program has been administered by USDA’s Food and Nutrition Service (FNS) since its inception in 1972. In 2010, the program served approximately 9 million participants (including 4.8 million children) per month through 10,000 local clinics across the country. WIC participants receive food prescription vouchers that can be redeemed at 46,000 authorized retailers in exchange for foods specified on the voucher. In total, seven WIC food packages are available, depending on the participation category (e.g., pregnant woman, postpartum woman, infant). The packages include specific authorized foods containing nutrients that have been shown to be lacking in the diets of the WIC population. The five central nutrients are: protein, calcium, vitamin A, vitamin C, and iron.

The foods available in the WIC food packages changed only modestly over time, with a few notable exceptions. In 1992, tuna and carrots were added and juice amounts were increased to enhance a package for fully breastfeeding women. More significant changes took place in 2007 to align the WIC food packages with the 2005 Dietary Guidelines for Americans. More specifically, the changes included: adding whole grains, and fruits and vegetables to food packages for children, and pregnant and breastfeeding women; reducing the maximum monthly allowances of milk and cheese; and revising substitution rates and allowing additional foods as alternatives to dairy products (e.g., soy beverages, tofu prescribed with medical documentation only). Yogurt was considered as an alternative but not allowed for cost reasons.

In this paper, we examine changes in dairy nutrient delivery in packages prescribed for children (IV), pregnant and partially breastfeeding women (V), postpartum women (VI), and fully breastfeeding women (VII) using empirical data on the WIC Participant and Program Characteristics from 2002 and 2010. We also evaluate whether allowing yogurt as a milk substitute is too costly. As a method of analysis of the WIC program changes, we design deterministic as well as stochastic mathematical programing models that optimize the effectiveness of dairy nutrient delivery and minimize program cost. Mathematical programing methods provide the best framework for our analysis. We specify the objective function, nutrient standard constraints, and model explicitly nutrient concentration in dairy products prescribed to WIC participants (packages IV, V, VI, and VII) in the 2002 and 2010 participant surveys. We estimate the optimal amounts of dairy products (and nutrients), implicit prices of dairy nutrients, and minimal cost of optimal delivery. We compare the estimated optimal amounts of dairy to the amounts actually delivered in 2002 and 2010.

Our methods of analysis differ from but also complement the methods that FNS used to evaluate the changes in the WIC Program (2007 Interim Rule). Methods that do not explicitly consider nutrient concentration in food products can introduce bias due to imprecise measure of nutritional equivalence of food products. Furthermore, methods that do not utilize rigorous cost optimization techniques can also introduce bias. Our paper is first in the food economics literature to apply a stochastic mathematical programming model to thoroughly evaluate the retrospective WIC program changes and is consistent with the line of research on how to measure the cost of healthy foods (e.g. Andrea Carlson at al. 2012).

We utilize the 2002 and 2010 WIC Participant and Program Characteristics (WIC PC) data that provide information on the type and quantities of foods prescribed to WIC participants by food package. We also utilize the USDA National Nutrient Database for Standard Reference that provides information on the nutritional profiles of dairy products. Finally, we match the information obtained from the two former data sources with the Nielsen Home-Scan Panel Data that provide information on prices of dairy products considered in our analysis.

A simple statistical analysis of the WIC PC 2002 and 2010 dairy data reveals that the amounts of milk and cheese prescribed decreased significantly (mostly due to lower maximum amounts allowed); the number of participants receiving whole milk also decreased significantly; more partially breastfeeding women received no food benefits (including dairy), and new foods appeared as substitutes for milk (soy beverages and tofu). The number of dairy servings prescribed in 2002 and 2010 decreased significantly especially for children (package IV) and postpartum women (package VI). The decline was somewhat smaller for pregnant and partially breastfeeding women (package V), and the smallest decline took place for fully breastfeeding women (package VII). As a result, the number of dairy servings prescribed in 2010 was consistent and in line with the Dietary Guidelines servings recommended for packages IV through VI, but not consistent with dairy serving recommendations for package VII.

The results from the programing models also support the significant improvement in the effectiveness of dairy nutrient delivery. The results also demonstrate that yogurt is cost-competitive with milk in terms of delivery of calcium and other nutrients such as protein, magnesium, phosphorus, and potassium. By contrast, the analysis shows that providing nutrients from tofu and cheese is more costly than from yogurt. In this case, our analysis suggests that it would be possible to include yogurt as an additional alternative to milk (at least for some the best suited WIC participant groups) without significantly increasing program costs.

In summary, we provide an analysis and methods that allow for an integrated evaluation of the economic efficiency and effectiveness of the WIC program nutrient delivery system. The methods utilized in this work can be extended to analyses of other food groups and nutrients delivered to WIC Program participants, in order to evaluate the overall efficiency and effectiveness of the Program. The other food groups of great importance for further analyses include baby formula (the most costly food group in the WIC program) and fruits and vegetables (possibly the most lacking food group in diets of WIC program participants).

Mathematical Programing Model Design

First to formulate the diet problem (how to provide optimal nutrition at minimum cost) was an economist George J. Stigler in the early 1940s. Stigler formulated a 77-food, nutrient-diet problem, and determined the types and amounts of each food that would satisfy the daily nutrient requirements at low cost. His solution called for the use of only five foods at a total annual cost of $39.93 (expressed in 1939 food prices). The foods were wheat flour, evaporated milk, cabbage, spinach, and dried navy beans. As even Stigler pointed it out, such diets, although quite inexpensive, could not have been really recommended to anyone and were certainly unpalatable over any period of time.

More recent attempts at constructing diets using mathematical programing have met with much greater acceptance due to the diet formulators being able to incorporate, via model constraints, important factors (characteristics) like flavor, taste, and variety. Such techniques of menu planning are now being applied by school meals providers as well as other large institutions that are able to realize reasonable cost savings while serving nutritious, flavorful, and tasty meals.

In this paper, our goal is to examine effectiveness and economic efficiency of the changes in WIC dairy nutrient delivery in packages prescribed for children, pregnant and partially breastfeeding women, postpartum women, and fully breastfeeding women using empirical data on the WIC Participant and Program Characteristics from 2002 and 2010. As a method of analysis of the WIC program changes we propose a mathematical programing model that optimizes the effectiveness of dairy nutrient delivery and minimizes program cost. In the model, we specify the objective function, nutrient constraints, and model explicitly nutrient concentration in dairy and dairy substitute products prescribed to WIC participants as revealed in the 2002 and 2010 data.

Specification of the model:

$$\min C_{ch,m,y,sb,t} = \sum_{ch,m,y,sb,t} f(q(n)) \times f(p)$$

s.t

$$n_{ch,m,y,sb,} = \sum_{ch,m,y,sb,t} n \geq ns$$

where

$C_{ch,m,y,sb,t}$ is cost function

$f(q(n))$ is quantity of nutrient n delivered by one unit of product

$f(p)$ is product price per unit

ns is nutrient standard requirement

Our objective function is a cost function of dairy products (cheese, milk, and yogurt) and dairy products' substitutes (soy beverages and tofu) delivered each month to all of the WIC program participants nationwide. The cost function is also a function of quantities of nutrients delivered by one unit of a dairy product or dairy product substitute. The cost function is then minimized subject to dairy nutrient standard constraints and the constraints on the maximum amounts of dairy products and dairy product substitutes allowed by the WIC program. Additional constraints can also be incorporated, including those related to WIC participants' tastes or any other preferences. We assume linear relationships with respect to combinations of the dairy and dairy substitute products. First, we assume that the amount of nutrients provided is proportional to the amounts of foods (e.g., one unit of a food will deliver a certain amount of a nutrient while two units of the same food will deliver twice as much of the nutrient in question). Second, we assume that the amount of nutrient contained in one food is additive to the amount of nutrient contained in the other foods.

The 2002 and 2010 WIC Participant and Program Characteristics Data and Other Data Utilized

The 2002 and 2010 WIC Participant and Program Characteristics data provide information on the foods prescribed to WIC participants based on their certification category (collected and processed every other April, by ABT Associates for Food and Nutrition Service, FNS, of the U.S. Department of Agriculture) and maintained by the WIC State Agencies and Indian Tribal Organizations. These data sets do not provide information on redemption of the food prescriptions, or on actual food consumption; detailed data for the whole nation are available only on foods prescribed. Participant information is collected on demographics, income, and nutritional risk factors. Program information is collected on the types and amounts of foods prescribed within the WIC food package for each category of participants.

In 2002, milk and cheese were offered within food packages IV, V, VI, and VII for all women and children without special medical needs. Several forms of milk were available including fluid whole milk, fluid non-fat milk, fluid low-fat milk, cultured butter milk, evaporated skim milk, dry whole milk, non-fat dry milk, and low-fat dry milk. Fluid milks were allowed to be substituted on a quart by quart basis, while evaporated milk was allowed to be substituted at a rate of 13 ounces per quart of fluid milk, and dry milk was allowed to be substituted at a rate of 1 pound per 5 quarts of fluid milk. Cheese was also available and was allowed to be substituted for milk at the rate 1 pound per 3 quarts of fluid milk, up to the maximum allowable amounts for each category of participants. In addition, exclusively breastfeeding women were allowed to receive prescriptions for an extra 1 pound of cheese monthly.

Pregnant and breastfeeding women were permitted to receive up to the equivalent of 28 quarts of fluid milk per month, while postpartum, non-breastfeeding women and children were permitted to receive up to the equivalent of 24 quarts of fluid milk. Exclusively breastfeeding women were permitted to receive prescriptions for up to 5 pounds of cheese per month and all other participants were permitted to receive prescriptions for up to 4 pounds monthly, these totals included the cheese that was substituted for milk.

All fluid milk had to be pasteurized, and flavored milk was also eligible. In addition, all milks had to contain at least 400 IU of Vitamin D and 2000 IU of Vitamin A per quart of fluid or reconstituted milk. Fluid cow's milk was the most commonly prescribed but other types of milk, goat, lactose-reduced, kosher, acidophilus were proscribed as well for some participants.

In 2010, the WIC Participant and Program Characteristics data reflect the WIC Program Interim Rule changes implemented in 2007. The Interim Rule reduced monthly maximum allowable amounts of milk for children to 16 quarts, for pregnant and partially breastfeeding women to 22 quarts, for postpartum women to 16 quarts, and for fully breastfeeding women to 24 quarts. The amounts of monthly maximums for cheese were also implemented with a three pound maximum for fully breastfeeding women and a one pound maximum for the rest of the participant categories. As a result, the 2010 dairy data reveal that the amounts of milk and cheese prescribed decreased significantly (mostly due to lower maximum amounts allowed); the number of participants receiving whole milk also decreased significantly; more partially breastfeeding women received no food benefits (including dairy), and new foods were allowed as substitutes for milk (soy beverages and tofu). Soy beverages had to be fortified to meet nutrient standards for calcium, protein, Vitamins A, D, and B12, magnesium, phosphorus, potassium, and riboflavin according to FDS's fortification of food guidelines.

For our analysis, we also utilized The USDA National Nutrient Database for Standard Reference that provides information on the nutritional profiles of dairy and dairy substitute products as well as the Nielson Home-Scan Panel Data that provide information on prices of dairy and dairy substitute products. We created weights for nutrient contents and prices of food products. Nutrient amounts and prices are averages over all food product varieties weighted by the number of servings purchased by food product variety.

Statistical Analysis of the Changes in the WIC Dairy Nutrient Delivery (2002-2010)

In 2002, most women and children received prescriptions for milk. An average of only 0.1% of participants did not receive prescriptions for milk. The majority of pregnant (69%), partially breastfeeding (70%), exclusively breastfeeding (79%) and postpartum, non-breastfeeding women (58%) and children (52%) received prescriptions for at least 75% of the Federal maximum allowance of fluid milk equivalents. About 8% of exclusively breastfeeding women received prescriptions for the Federal maximum of milk, while 1-2% of participants in other eligible categories received prescriptions for the maximum amount. The prescription rates for reduced-fat and non-fat milk were very close to those of whole milk among all categories of women WIC prescriptions. Reduced-fat and non-fat milk was less frequently prescribed for children (children from 12 to 24 months of age receive whole milk as a requirement based on current nutrition science).

The amount of cheese prescribed to women and children remained steady over time and across participant categories until the implementation of the WIC Program 2007 Interim Rule. Prior to the Interim Rule, women and children received an average of 2 pounds of cheese per month. Considering the 4 or 5 pound of Federal maximum allowance of cheese per month at that time, most pregnant women (69%), exclusively breastfeeding women (67%), partially breastfeeding women (72%), postpartum non-breastfeeding women (62%), and children (57%) received prescriptions for 50 to 74.9% of the maximum amount of cheese.

In 2010, as in 2002, most women and children received prescriptions for milk. However, a larger number of participants, 0.8%, (0.7% increase) did not receive any prescriptions for milk. The majority of pregnant (80.3%), exclusively breastfeeding (69.8%) and postpartum, non-breastfeeding women (75.8%) and children (79.2%) received prescriptions for at least 75% of the Federal maximum allowance of fluid milk equivalents. About 27.3% of exclusively breastfeeding women received prescriptions for the Federal maximum of milk, while 7% of partially breastfeeding women received prescriptions for the maximum amount. The prescription rates for reduced-fat and non-fat milk increased considerably to those of whole milk among all categories of women WIC prescriptions. As in 2002, reduced-fat and non-fat milk was less frequently prescribed for children.

The amount of cheese prescribed to women and children in 2010 noticeably decreased. Maximum amount of cheese allowed was only one pound for all of the participant categories with just one exception of fully breastfeeding women that were allowed to be prescribed up to three pounds of cheese per month. Most pregnant women (83.7%), partially breastfeeding women (72.6%), postpartum non-breastfeeding women (78.2%), and children (78.4%) received prescriptions for the maximum amount of cheese allowed. The percentage of participants receiving no prescriptions for cheese increased significantly for all including for partially breastfeeding women to 27.4% and for children to 21.6%.

In our analysis we also compare the daily WIC servings of dairy in 2002 and 2010 to the recommended daily servings of dairy.

Table 1. Daily WIC servings of dairy in 2002 and 2010

Food Package	2002	2010	Recommended
IV	3.2	2.1	2
V	3.7	3.2	3
VI	3.2	2.1	2
VII	3.7	3.4	3

The above Table compares the number of daily servings of dairy prescribed in 2002 and 2010, to the recommended number of daily servings. During the eight year period examined, a significant decline was observed for packages IV and VI. On the other hand, for package V the decline was somewhat smaller however the smallest decline took place for package VII.

Table 2 compares changes in dairy nutrient delivery for package IV. From 2002 to 2010, the largest change (decline) took place in both the number of dairy servings (as illustrated in

Table 1) as well as the amounts of nutrients delivered from dairy products (as illustrated in Table 2).

Table 2. Change in dairy nutrient delivery (package IV)

Nutrient	2002	2010	Recommended
Protein g	688	503	559
Calcium mg	24,182	17,858	18,720
Magnesium mg	3,149	1,652	1,590
Phosphorus mg	18,639	13,866	13,710
Potasium mg	25,362	19,798	13,290
Riboflavin mg	30	23	19
Vit A IU	33,117	24,724	25,200
Vit D IU	6,944	5,408	6,180
Vit B12	75	56	50

The results presented still need to be verified and are not available for citation. The nutrient values for 2010 could be slightly underestimated or the recommended monthly values of nutrient intakes could be slightly overestimated (as these values were calculated from the recommended daily number of dairy servings).

Mathematical Programing Model Analysis of the Changes in the WIC Dairy Nutrient Delivery (2002-2010)

The results from the programing model show a significant change (improvement) in effectiveness and efficiency of dairy nutrient delivery. The results also show that yogurt is cost-competitive with milk in terms of delivery of calcium and other nutrients such as protein, magnesium, phosphorus, and potassium. By contrast, the analysis shows that providing nutrients from tofu and cheese is more costly than from yogurt.

Table3. Optimal model of dairy product and nutrient delivery for package IV

Decision Variables	Cheese lb	Milk qt	Yogurt qt	Soy B. qt	Tofu lb
Amounts	0.6	12.09	1.9	0.6	0.1
Constraints	0.8	12.09			0.1
Cost	$3.8	$0.88	$2.0	$1.79	$2.06
Total Cost $17.60					

Table 3 presents an example of an optimal model for package IV that contains a combination of the quantities of dairy and dairy substitute products that deliver recommended values of nutrients at minimum cost. Constraints on quantities of yogurt and soy beverage were not applied in this case allowing for an unconstrained variation of the respective quantities. As evidenced by the results of the model, much higher quantities of yogurt would be recommended, as optimal, than the quantities of cheese, soy beverage, and tofu. The reason for a favorable position of yogurt is that one serving of yogurt delivers up to 40% of calcium and other important to the WIC program nutrients and is relatively inexpensive. The implicit (shadow) prices of important nutrients are lower than for other dairy and dairy substitute products except for milk. The estimated model resembles the California WIC Agency preference (with 32 oz. store brand plain yogurt that has 40% of DRV of calcium, plus other important nutrients and no added sugar).

Table 4 shows an example of a suboptimal (actually delivered in 2010) model for package IV that contains again a combination of the quantities of dairy and dairy substitute products that deliver suboptimal amounts of recommended values of nutrients at suboptimal cost.

Table 4. Suboptimal model of dairy product and nutrient delivery for package IV (actually delivered in 2010)

Decision Variables	Cheese lb	Milk qt	Yogurt qt	Soy B. qt	Tofu lb
Amounts	0.96	13.01	0	1.34	0.1
Constraints	1.0	16.00			0.1
Cost	$3.8	$0.88		$1.79	$2.06
Total Cost $17.49					

The model shown in Table 4 is suboptimal because the actually delivered amounts of dairy and dairy substitute products are not optimal as well as the amounts of nutrients delivered by the products are not optimal and do not conform to the recommended values of nutrient consumption. Analysis that does not explicitly consider nutritional content of products usually cannot find (arrive at) optimal solutions for the nutrient delivery system. It is worth noting that the $0.11 price difference between the optimal package IV (Table 3) and the package IV actually delivered (Table 4) is not statistically significant. Therefore, we have shown that it is possible to design a system of nutrient delivery that delivers recommended values of important nutrients at minimum cost.

Conclusions and Extensions

Economics and nutrition science can jointly be used to determine the optimal mix of foods in WIC packages. We provide methods that allow for integrated analysis of economic efficiency and effectiveness of WIC program nutrient delivery. Accounting explicitly for nutrient concentration and implicit nutrient prices gives useful results that can be applied for policy analysis. The methods can also be useful to State WIC Authorities

Extensions of this work include:

1. Estimation of a stochastic mathematical programing model of an efficient and effective WIC nutrient delivery system.

2. Estimation of complete (monthly) food choices of WIC participants based on the NHANES data.

3. Evaluating the true supplemental nature of the WIC program.

References

Andrea Carlson, et.al, 2012, *Is Healthy Food More Expensive?* ERS USDA Report, Washington DC.

ABT Associates, 2012, *Study of WIC Participant and Program Characteristics*, 2010. Prepared for Office of Research and Analysis, Food and Nutrition Service, USDA, Washington DC.

ABT Associates, 2006, *Study of WIC Participant and Program Characteristics*, 1998-2002. Prepared for Office of Research and Analysis, Food and Nutrition Service, USDA, Washington DC.

Dietary Reference Intakes (DRIs): Estimated Average Requirements, Food and Nutrition Board, Institute of Medicine, National Academies, Washington DC.

Federal Register, 2006, WIC: *Revisions in the WIC Food Packages*, Proposed Role, Vol. 71, No. 151.

USDA National Nutrient Database for Standard Reference, 2002 and 2010, USDA Food and Nutrient Database for Dietary Studies.