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Estimating Prices for Foods in the National Health and Nutrition Examination Survey: The Purchase to Plate Price Tool

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Abstract

The 2018 Farm Bill mandates that the market basket of the Thrifty Food Plan (TFP) be updated every 5 years using current food prices, food composition, food consumption patterns, and dietary guidance. The TFP forms the basis of the maximum allotment for the U.S. Department of Agriculture's Supplemental Nutrition Assistance Program (SNAP) benefits. Current food composition and food consumption data are available through What We Eat in America, the dietary component of the National Health and Nutrition Examination Survey (WWEIA/NHANES). *The Dietary Guidelines for Americans* provides current dietary guidance. However, food price information that aligns with these data are not available, which limits the economic analysis that can be conducted with the survey data. This report details the construction of the Purchase to Plate Price Tool (PPPT), which uses retail or household scanner data to estimate prices for foods reported consumed by participants in WWEIA/NHANES and compares estimated total food expenditure of WWEIA/NHANES participants to other estimates of food expenditure.

Keywords: food prices, scanner data, IRI InfoScan, IRI Consumer Network, What We Eat in America (WWEIA), National Health and Nutrition Examination Survey (NHANES), Flexible Consumer Behavior Survey (FCBS), Food and Nutrient Database for Dietary Studies (FNDDS), USDA National Nutrient Database for Standard Reference (SR), ERS Food Expenditure Series, Purchase to Plate Crosswalk (PPC), Purchase to Plate Price Tool (PPPT)

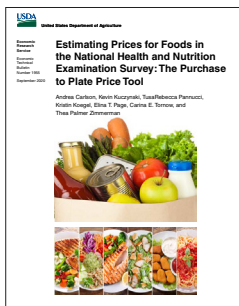
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What Is the Issue?

The 2018 Farm Bill mandates that the market basket of the Thrifty Food Plan (TFP) be updated every 5 years using current food prices, food composition, food consumption patterns, and dietary guidance. The TFP forms the basis of the maximum allotment for the Supplemental Nutrition Assistance Program (SNAP) benefits and uses the same modeling framework as the other three USDA food plans (namely, the Low-Cost, Moderate-Cost, and Liberal food plans). The Department of Defense uses the Liberal Food Plan in setting the Basic Daily Food Allowance for service-members. Current food composition and food consumption data are available through What We Eat in America, the dietary component of the National Health and Nutrition Examination Survey (WWEIA/NHANES). *The Dietary Guidelines for Americans* provides current dietary guidance. However, food price information that aligns with these data are not available.

Researchers and policymakers have used retail and household scanner data for almost 2 decades to estimate food prices. However, many foods in the WWEIA/NHANES are represented as an edible rather than a retail food, making direct use of scanner data to estimate WWEIA food prices difficult. The weight of an edible food does not include inedible parts such as seeds, skins, cores, shells, and bones that are typically included in the retail weight. In addition, foods prepared at home are often combinations of several ingredients. For these reasons, edible food prices must be estimated using standard recipes and conversion factors to convert the retail foods represented in scanner data into the edible foods found in WWEIA/NHANES. This report presents an approach to using scanner data to estimate food prices for WWEIA/NHANES.

What Did the Study Find?

The Purchase to Plate Price Tool (PPPT) is a set of SAS programs that allow users to estimate prices for foods reported consumed by WWEIA participants. Using sales data for more than 350,000 products in the 2013 IRI retail scanner data, InfoScan, we constructed the PPPT. The tool calculates average prices for 97 percent of the food and beverages (measured in grams) reported as eaten by participants in the WWEIA/NHANES 2011–12 wave of the survey. Each price is an average of several products available in stores, and in some cases, a compilation of different types of products. The foods that are not included are those that were reported eaten fewer than 10 times by survey participants. Estimated prices do not include other costs such as the time, energy, and skills needed to buy and prepare food.

We used the PPPT to estimate the individual expenditures for foods reported by participants as food at home (FAH) purchases. The mean and median FAH expenditure estimates were \$4.54 and \$3.84 per day, respectively. Half of the estimates (25th to 75th percentile) were between \$2.13 and \$6.03, but 10 percent (90th percentile) had a 1-day estimated FAH expenditure over \$10.59.

ERS is a primary source of economic research and analysis from the U.S. Department of Agriculture, providing timely information on economic and policy issues related to agriculture, food, the environment, and rural America.

We also compared the PPPT-based food expenditures to two other government estimates of food costs.

USDA's Cost of Food at Home for June 2013 estimated the weekly cost of food at four expenditure levels (Thrifty, Low-Cost, Moderate-Cost, and Liberal). We compared our weekly total expenditure estimates to the Low-Cost, Moderate-Cost, and Liberal estimates by quartile of weekly food expenditures, where the first quartile is the lowest 25 percent of expenditures by individuals and the fourth quartile is the highest 25 percent of expenditures by individuals. The Low-Cost plan is comparable to the second quartile, the Moderate-Cost plan is comparable to the third quartile, and the Liberal Plan is comparable to the top quartile. We did not compare our findings to the TFP because the basis is not based on quartiles of expenditure. Note that our estimates were based on what individuals report eating, whereas the Cost of Food at Home was the cost of a healthy diet.

- Compared to the Low-Cost “Cost of Food at Home” estimates, we estimate that for WWEIA/NHANES individuals, food expenditures in the second quartile of food expenditures were 10 percent lower (\$190.60 vs. \$170.41).
- Expenditures for the third quartile were 3.8 percent higher (\$238.20) than for the Moderate-Cost estimates (\$247.16).
- The Liberal Plan estimate (\$289.30) is lower than the top quartile of expenditure estimates (\$390.83).

The ERS Food Expenditure Series provides annual per capita FAH expenditures estimates for annual household food expenditures in the United States. Data are compiled from the Economic Census, U.S. Census annual surveys, and from other U.S. statistical agencies and trade associations. For comparison, we estimated an annual per capita FAH expenditure using the PPPT and the individual foods reported by WWEIA/NHANES participants.

- The PPPT estimate was about 91 percent of the per capita estimate from the 2013 ERS Food Expenditure Series, or about \$190 less.

Finally, we compared the PPPT-based food expenditures to FAH expenditures contained in the Flexible Consumer Behavior Survey (FCBS) module of NHANES, using self-reported FAH expenditure data from the 2011–12 FCBS/NHANES.

- Mean per capita daily FAH expenditure from the FCBS was estimated to be \$5.29 (95 percent CI \$5.00 to \$5.58). The PPPT mean estimate of 1-day FAH expenditure, including adjustments for food and alcohol taxes and food loss, was \$5.34 (95 percent CI \$5.08 to \$5.62).

How Was the Study Conducted?

To estimate prices for foods that consumers in the United States reported eating, we relied on three data sources: WWEIA/NHANES 2011–12, the USDA Food and Nutrient Database for Dietary Studies (FNDDS) 2011–12, and IRI InfoScan 2013 (the most recent data available). We used the two 24-hour dietary recalls in WWEIA/NHANES data to develop a list of foods eaten at home in the United States. The FNDDS includes recipes used to list the ingredients required to prepare the foods. IRI InfoScan 2013 was used to estimate prices for the recipe ingredients and the foods purchased in ready-to-eat form.

We used the Purchase to Plate Crosswalk (PPC) to transition between the FNDDS and the IRI InfoScan data. The PPC includes a link between the FNDDS and the food items in the IRI data, as well as conversion factors to convert the purchased weight (i.e., retail weight) of each food item to the as-eaten weight. Once we had the quantities and calculated an average price for each ingredient, we summed the ingredient costs to create the average food price for each of the foods reported eaten by WWEIA participants. The Purchase to Plate Price Tool (PPPT) estimates the prices for purchasing foods at a store and putting them on the plates of consumers in the United States; however, it does not include other food-preparation costs such as time, energy to transport, store, and prepare food, and skill level that may impact time and energy use. An update using 2015 IRI data to estimate prices for FNDDS 2013–14 is forthcoming, and future updates are planned in compliance with the 2018 Farm Bill.

Estimating Prices for Foods in the National Health and Nutrition Examination Survey: The Purchase to Plate Price Tool

Introduction

The Agriculture Improvement Act of 2018: Title IV Nutrition, section 4002 states, “By 2022 and at 5-year intervals thereafter, the Secretary shall re-evaluate and publish the market baskets of the Thrifty Food Plan based on current food prices, food composition data, consumption patterns, and dietary guidance.” The Thrifty Food Plan (TFP) (Carlson, Lino, Juan et al., 2007) serves as the basis for the maximum Supplemental Nutrition Assistance Program (SNAP) allotments for low-income households. While the dollar value of the TFP is updated every month using the Consumer Price Indexes (CPI) for food, the change dictated by the Agriculture Improvement Act is that the underlying market basket will be updated every 5 years. As stated in the Act, updating the TFP market basket requires an understanding of current dietary guidance, food composition (nutrition) data, knowledge of consumption patterns, and food prices. Dietary guidance comes from the *Dietary Guidelines for Americans*, which is updated every 5 years by the Departments of Agriculture and Health and Human Services. USDA’s What We Eat in America, the dietary component of the bi-annual National Health and Nutrition Examination Survey (WWEIA/NHANES), collects information on food composition and consumption patterns. However, an important barrier to updating the TFP is a mechanism to regularly update food prices that align with WWEIA/NHANES.

Food prices for WWEIA/NHANES are also an asset for researchers investigating questions such as how and why some consumers choose healthy foods and others choose less healthy options. Consumers consider many factors when selecting food, including how it tastes, how hungry they feel, how much time and energy they have to prepare the food, and how much the food satisfies them. Consumers also account for the price of the food and the total amount they can spend. NHANES provides a wealth of health information, and the NHANES module, the Flexible Consumer Behavior Survey (FCBS) collects information on U.S. consumers’ knowledge, attitudes, and beliefs regarding nutrition and food choices (Restrepo, 2019). Adding average food prices to WWEIA/NHANES will allow researchers to extend their NHANES- and FCBS-based research questions to understand economic factors affecting food choices.

Researchers and policymakers have used household and retail scanner data for almost 2 decades to study consumer decision making, the food environment, and the affordability of a healthy diet. Originally developed for food marketing purposes, scanner data provided researchers with detailed data on individual food items, the date purchased or sold, and the price paid.

However, estimating food prices for WWEIA is not as simple as using grocery store prices. Foods in WWEIA are in the edible form rather than the retail form. For ready-to-eat or ready-to-heat foods such as bread, milk, frozen or refrigerated pizza, and pre-cut produce items, the retail price is the same as the edible price. However, many foods eaten by U.S. households are a mixture of ingredients that need to be prepared, and the retail price includes the weight of non-edible parts such as

bones, skins, shells, peels, and seeds. In these cases, the edible price has to be estimated using standard recipes and adjusted for the inedible parts of the purchased food.

The Purchase to Plate Price Tool (PPPT) aims to bridge the gap by leveraging the specialties of WWEIA and scanner data. Specifically, the tool is a set of three SAS programs that provide a mechanism for users to estimate food prices for the foods reported eaten by WWEIA participants, using retail scanner data. It is an extension of the Purchase to Plate Crosswalk (PPC) (Carlson et al., 2019), which links scanner data to the USDA nutrition databases. Following earlier price estimates for NHANES foods and time-use studies (Carlson, Lino, Juan et al., 2008), the tool assumes that all ingredients are purchased in stores and can be prepared in 30 minutes or less. It is the first price estimation method that allows users to estimate retail food prices for foods reported eaten by NHANES participants using all of the IRI retail or household data (to calculate a national average price) or any subset of either dataset. Since the prices calculated by the PPPT are based on retail data, they provide a baseline for the price of food in its edible form. To obtain food-away-from-home prices, users could adjust these prices to account for the additional labor and other resources used by restaurants.

This report outlines the methods used to create the PPPT, provides guidance on using the PPPT with a subset of the IRI data, and compares food expenditures estimated for WWEIA participants to other government estimates of food expenditures. This report covers the 2013 PPPT, which estimates prices for the WWEIA 2011–12, using IRI 2013 data. Since the 2-year FNDDS is typically released 2 years after data collection, and IRI data are available after 1 year, we chose to use the most current version of each dataset available when the study began to generate prices. An update using IRI 2015 data to estimate prices for WWEIA 2013–14 is forthcoming, and future updates are planned in compliance with the 2018 Farm Bill.

Food Prices and the USDA Food Plans

The USDA Food Plans represent nutritious diets that align with the *Dietary Guidelines for Americans* at four expenditure levels. The market baskets of each Food Plan specify the types and quantities of foods that people could purchase and prepare at home to obtain a nutritious diet. The weekly quantities suggested by the Food Plans are not for specific foods, but groups of foods such as dark green vegetables or red meat. For each of the 4 Food Plans, there are 15 market baskets—1 for each of 15 age-sex groups. Revisions to the Food Plan market baskets reflect current dietary recommendations, food consumption patterns, food composition data, and national average food prices.

Each food plan plays an important role in Federal program support or in the judicial system. The Thrifty Food Plan (Carlson, Lino, Juan, et al., 2007) is the lowest of all cost levels and serves as the basis for the maximum Supplemental Nutrition Assistance Program (SNAP) allotments for low-income households. Some divorce cases use the other Food Plans (Carlson, Lino and Fungwe, 2007) including the Low-Cost, Moderate-Cost, and Liberal Plans to set alimony payments. The value of the Low-Cost Food Plan is used by some bankruptcy courts to determine the portion of a bankrupt person's income to allocate to necessary food expenses. The Department of Defense uses the value of the Liberal Food Plan to determine the Basic Daily Food Allowance rates for all servicemembers. If individual or household food expenditure is ranked from lowest to highest, the Low-Cost estimate is comparable to the second quartile (25th to 50th percentile), the Moderate-Cost to the third quartile, and the Liberal to the highest quartile.

Each month, USDA publishes the weekly and monthly cost of food for 15 age-gender groups at each of the four expenditure levels¹. USDA also publishes the cost for a family of 4—defined as one 6- to 8-year-old child, one 9- to 11-year-old child, an adult female age 19–50, and an adult male age 19–50—and two 2-person households: one containing a male and female age 19–50, and the other a male and female age 51–70. The cost of each basket is adjusted for inflation each month, but the underlying basket is not modified.

The market baskets are established through a mathematical optimization model that accounts for dietary guidance, food composition, and consumption patterns and food prices (Carlson, Lino and Fungwe, 2008, Wilde and Lobrera, 2009). While the Agriculture Improvement Act dictates only that USDA re-evaluate the market baskets for the TFP, the estimation model for all four food plans is the same (Carlson, Lino and Fungwe, 2007). However, each food plan model has a different set of inputs. For example, the TFP is based on the foods that low-income households report eating in WWEIA/NHANES, while the other three food plans are based on the foods that individuals in the expenditure group, rather than income group, report eating in WWEIA/NHANES. In the most recent update to the TFP, researchers used food prices based on low-income households' purchases (Carlson, Lino, Juan, et al., 2007), while national average prices of all consumers were used in the other three plans (Carlson, Lino and Fungwe, 2007). Previous

¹See the USDA Food and Nutrition Service, Center for Nutrition Policy and Promotion webpage, "USDA Food Plans: Cost of Food" (monthly reports).

updates used the same set of prices for all four plans (Carlson et al., 2003, U.S. Department of Agriculture, 1999).

CNPP Food Price Database. Food prices for the most recent update of the Food Plans used the CNPP Food Price Database 2001–02 (Carlson, Lino, Juan, et al., 2008). This database provided prices for every food item reported consumed in NHANES 2001–02 and 2003–04 (Center for Nutrition Policy and Promotion (CNPP), 2009), using Nielsen Homescan data from 2001–02 and 2003–04. While researchers could use the Consumer Price Indexes (CPI) for food to update prices to current price levels, using the CPI assumes that relative prices within a CPI category stay the same—for instance, romaine lettuce and broccoli prices changed at the same rate. In addition, the data do not allow researchers to break down prices by season, market areas smaller than the four census regions, or the type of store.

The PPPT updates the price data and allows for greater flexibility in how prices are estimated. In addition, the Purchase to Plate Crosswalk (PPC) (Carlson et al., 2019) uses machine learning to augment the human effort required to link scanner data to the USDA nutrition databases. This will make updates to the PPPT more efficient than updates to the CNPP Food Prices Database because of the reduced level of effort required to link scanner data to USDA data. However, to the best of our knowledge, revising recipes for price calculation is not possible with machine learning applications.

Food Prices for Economic Research

For economists, the basis of understanding consumer choices is the principle that consumers seek to maximize their utility (or satisfaction) through a series of choices, subject to a budget constraint, that also includes their time; energy to transport, store and prepare food; and skill levels that impact food acquisition and preparation time. In terms of food, households select foods that they like to eat and that will provide their desired level of nutrition and level of preparation. Since the average household spends about 10 percent of its total income on food, the budget constraint means that food prices are an important component of why consumers choose the foods they do. For low-income households, the budget share for food is about 35 percent of total income (Kuhns, 2018), and food prices play a larger role in food choices.

Economists use a variety of data sources to study the relationship between food prices and expenditure and food choices, including the ERS Food Expenditure Series, scanner data, and associated ERS data products such as the Quarterly Food at Home Prices Database (QFAHPD), the Cost of Fruits and Vegetables, and the National Household Food Acquisition and Purchase Survey (FoodAPS). Some researchers also collect their own data for their unique studies. One major limitation of these methods is that most represent purchase prices and thus are not compatible with dietary recall data. However, researchers have and continue to use each of these to contribute to our understanding of the relationship between food prices and food choices.

ERS Food Expenditure Series. The ERS Food Expenditure Series (Okrent et al., 2018) is the most comprehensive measure of the total value of food acquisition in the United States. Data are compiled from the Economic Census, U.S. Census annual surveys, and data from other U.S. statistical agencies and trade associations. The expenditure series measures the total dollar value of all food expenditures by final purchaser, including consumers, governments, institutions, and corporations such as airlines, schools, and hospitals where the food is given (not sold) to the final consumer. The series also breaks down expenditures by type of retail store (e.g., grocery store, supercenter) and type of food-away-from-home (FAFH) establishment (e.g., restaurants, recreation places, school cafete-

rias), and includes the value of home-produced food. While it does not break down expenditures by individual foods, researchers can use it to create an annual or monthly price for food in time-series analysis of consumer choices. In this study we use it to verify estimates of total food-at-home expenditures using the PPPT and WWEIA.

Prices in scanner data. Scanner data includes detailed purchase information from individual households and the weekly sales (dollars and quantity) of products from stores. Scanner data refers to purchase data collected by consumers using handheld scanners or cell phone applications, and store-level sales data collected from scanners used at the check-out. Researchers can estimate prices paid over a period of time, geographic region or type of store. Unlike other sources of price data discussed in this section, these data are not publicly available, and researchers typically obtain scanner data in two ways: They get the data directly from a single retail chain or obtain permission to access data from several stores collected by one of two major market research companies, Nielsen and IRI.

Over the past 15 years, ERS has used scanner data from both Nielsen and IRI to estimate average prices to create a variety of food price databases, including the Cost of Fruits and Vegetables and the QFAHPD. The Cost of Fruits and Vegetables (Stewart et al., 2016) uses retail scanner data to estimate both the national average retail and edible cost for about 150 commonly consumed fruits and vegetables. The database separates the cost of fresh produce items into no-preparation required (e.g., baby carrots) and preparation required (e.g., whole carrots). The QFAHPD (Todd et al., 2011, Todd et al., 2010) used Nielsen Homescan household scanner data to estimate retail prices for 35 retail markets in the country. The database contains an average price of 54 groups of foods for each of the retail markets. The QFAHPD has been used as retail² regional prices for groups of foods in NHANES (Gregory and Coleman-Jensen, 2013).

Prices collected for a specific study. For some research questions, only a small sample of food prices are required, and researchers can use either data from the Bureau of Labor Statistics (BLS)'s calculation of the CPI or collect their own food price data.

The CPI for food (BLS, 2018) is measured by observing the change in price of a basket of about 75 foods. Each year the BLS reviews the list of foods to ensure it consists of items most commonly purchased by U.S. households. Prices for the foods are collected through a monthly survey of randomly selected stores. When the list is revised, the data collector consults with store managers to identify the most common package sizes and brands at each store and refers to those package sizes each month in the survey report. The BLS Mid-Atlantic Information Office uses the prices collected for the 75 foods in the CPI market basket to publish the “Average Retail Food and Energy Prices for the United States” and for each region on its website (BLS, 2018). Since these prices are collected from a limited number of stores and brands, they do not represent the range of prices available to consumers, even for the products selected. However, these data do provide a consistent measure of prices over time.

When the research question covers a small geographic area, researchers can collect their own price data. For example, Cassady, Jetter, and Culp (2007) collected prices for two set market baskets of foods in Sacramento and Los Angeles. One basket contained more healthful food than the other

²Retail prices are per unit purchased weight, so the weight includes inedible parts such as skins, seeds, shells and bones.

basket, and the study compared the prices of both. The team chose the 25 stores to represent a variety of income levels so they could measure the affordability of healthy diets, particularly the cost of fruits and vegetables. At the time of this study, the researchers had to visit each store to collect prices, rather than use online store websites as done by Nansel et al. (2016). In the latter study, researchers obtained food prices from two online grocery store websites for the foods reported consumed by 136 participants in a prospective study of youth with Type I diabetes and their parents. Since all study participants lived in the Boston area, the research question of the cost of diet improvement was best served by collecting local prices. While the Nansel et al. study collected prices for foods that study participants chose, given all available options in the store, studies such as Cassady et al. start with a predetermined market basket of goods.

The major limitation of using prices for a subset of foods is that one does not have access to prices for all available options; the basket might not allow for substitution. For example, if the basket specifies romaine lettuce, but green leaf lettuce is less expensive, a price-conscious shopper might choose the less expensive option. Within each food group, there is a wide range of prices available for both healthy and less healthy foods (Carlson and Frazão, 2012), and in analysis, researchers can account for the fact that consumers can make substitutions without compromising the healthfulness of their purchases. Collecting a limited number of foods could bias conclusions about the cost of a healthy basket of foods.

Total food acquisition in the National Household Food Acquisition and Purchase Survey (FoodAPS). A shortcoming of scanner data is that it covers only retail foods. The ERS Food Expenditure series estimates that about half of all food expenditures are made at non-retail sources such as restaurants, farmer's markets, cafeterias, entertainment venues, and vending machines. In addition, households acquire free food from friends, food pantries, and USDA food assistance programs. To gain a complete picture of food acquisition, USDA collected a week's worth of household food acquisition data from 4,826 households between April 2012 and January 2013 (Page and Kantor, 2020). To our knowledge, FoodAPS remains the only data source that includes detailed food acquisition data for both food at home and food away from home, nutrition data for each food acquired, and the prices paid by consumers. The individual food items also are tied to WWEIA foods so researchers can examine the relationship between the purchase prices paid by households and the healthfulness of food acquisitions.

Economic research using WWEIA/NHANES. In addition to these sources, researchers use dietary recall data such as the What We Eat in America/National Health and Nutrition Examination Survey (WWEIA/NHANES) (Centers for Disease Control and Prevention (CDC) and National Center for Health Statistics (NCHS, 2011-2012a) to study issues such as what U.S. households eat, (Lin et al., 2016), how healthy the food is (Kirkpatrick et al., 2018, Krebs-Smith et al., 2018), and the relationship between dietary health behaviors and chronic diseases (Lin et al., 2016), (Kirkpatrick et al., 2018; Krebs-Smith et al., 2018). When WWEIA/NHANES is combined with the ERS Flexible Consumer Behavior Survey (FCBS) (Restrepo, 2019) – a module of NHANES designed to collect information on U.S. consumers' knowledge, self-reported food expenditures, attitudes, and beliefs regarding nutrition and food choices – researchers can examine the relationship between what consumers know about food and nutrition and their food choices. For example, the FCBS was recently used to study menu labeling impacts (Gregory et al., 2014, Restrepo et al., 2018).

Other than the CNPP Food Prices Database, none of the price sources discussed above allow researchers to estimate the edible cost of individual foods that NHANES/WWEIA participants report eating. Since data reported by Buzby and co-authors (2014) estimate that about 21 percent

of the food available to consumers is not eaten, it is not valid to assume that all foods purchased are actually eaten.

The Purchase to Plate Price Tool. The PPPT uses scanner data, the PPC (Carlson et al., 2019), and USDA-derived recipes used in the development of the food composition data associated with WWEIA to estimate prices for foods – both the as-eaten price and the as-purchased price – that U.S. households report eating in the WWEIA/NHANES. This allows users to use the wealth of data in NHANES and associated modules such as the FCBS to examine the role of food choices and other research questions. When used with the complete InfoScan data available to ERS, the national average prices are estimated from purchases representing about half of all retail food sales (Levin et al., 2018). The tool can be applied to various subsets of the data, allowing users to calculate prices much closer to what an individual spends.

Since the PPPT uses retail or household scanner data, the estimated prices generally do not include purchases made by food service establishments, institutions, or governments, meaning that the estimated food prices are drawn from household purchases. Thus, researchers are advised to use FoodAPS to examine questions covering all foods acquired by households if the research question covers all food purchases. Alternatively, users could adjust the PPPT prices to account for higher prices charged by food-away-from-home sources. The PPPT estimates a price for foods that WWEIA participants report acquiring away from home, but it assumes that the foods or ingredients are purchased from a retail food source and, in the case of foods not ready-to-eat, prepared or heated after paying for the food³. Food prices estimated by the PPPT include only the price of food, and do not include other costs such as the time to purchase and prepare food nor energy used to transport, store, or prepare the food.

The PPPT allows users to combine the wealth of health information in NHANES with edible food prices. This report covers the PPPT using 2013 data, which estimate prices for the WWEIA/ NHANES 2011-12 cycle. ERS expects to release a 2015 version corresponding to WWEIA/ NHANES 2013-14 cycle, and USDA will need to update both the PPC and PPPT to comply with the Agricultural Improvement Act mandate to update the TFP every 5 years.

³The price is the same whether the consumer heats the food at the store after paying for it or prepares the food at home, at work, at someone else's home, or while traveling.

Data

To estimate food prices for foods reported consumed by participants in WWEIA/NHANES 2011–12 (CDC and NCHS, 2012), we relied on two data sources: USDA Food and Nutrient Database for Dietary Studies (FNDDS) 2011–2012b (Martin et al., 2014) and IRI InfoScan 2013 (Levin et al., 2018, Muth et al., 2016). We used WWEIA/NHANES data to develop a list of foods consumed by U.S. households, the FNDDS to develop the types and quantities of purchasable ingredients required to prepare the foods, and the IRI InfoScan data as the basis for prices. We also used the Purchase to Plate Crosswalk (PPC) (Carlson et al., 2019) to transition between the FNDDS and the IRI InfoScan data.

What We Eat in America/National Health and Examination Survey (WWEIA/NHANES).

NHANES has produced vital health statistics for the United States since the 1960s (Johnson et al., 2014) with dietary information collected since the 1970s (CDC NCHS, 2012b). The survey is designed to assess the health and nutritional status of adults and children in the United States and has evolved to a survey with continuous data collection. A nationally representative sample of about 5,000 individuals a year is examined, including two 24-hour dietary recalls and extensive biomedical data. NHANES public data releases are issued in 2-year cycles, with this study focusing on 2011–12 data (CDC NCHS, 2012b), the most recently available data at the start of the study. For this study, WWEIA/NHANES data are used to determine a list of foods consumed in the 2011–12 survey. This study aims to calculate average prices for foods reported eaten at least 10 times by WWEIA/NHANES participants. The foods consumed more than 10 times represent 96 percent of all incidences of reported foods and 97 percent of all grams of food consumed.

Food and Nutrient Database for Dietary Studies (FNDDS). Energy and nutrient values for foods and beverages reported in WWEIA/NHANES 24-hour dietary recalls were provided in the FNDDS (Martin et al., 2014). The 2011–12 FNDDS release contained information on more than 7,500 foods. The FNDDS 2011–12 allowed researchers to review the nutrient profiles for specific foods and beverages in an edible form using standard food weights to obtain moisture and fat changes that occur with cooking/preparation, as well as to determine associated portions and recipes.

Many foods in the FNDDS, particularly those used in the WWEIA/NHANES, were represented in edible rather than retail form. The weight of an edible food did not include inedible parts such as seeds, skins, cores, shells, and bones that were typically included in the retail weight. In addition, edible foods were often cooked, or multiple retail foods were combined, to make a single mixed dish. For this reason, we could not directly apply scanner data retail prices to edible foods.

The FNDDS recipe file provided the relationship between FNDDS codes and the ingredients that make up the recipe. Recipes were based on reviews of popular cookbooks and online sites as well as market analysis. While these recipes do not necessarily indicate how an individual would prepare the food, they represented an average of all individuals' food preparation practices (table 1). For example, the recipe for “mixed salad greens, raw” combines iceberg, endive, spinach, romaine, and green-leaf lettuce in equal parts because there was a wide variety of mixed salad greens on the market, and each one had a different ratio of each lettuce type. The recipe represented an average of all available products, not necessarily how an individual household would prepare the item.

Table 1

Example recipes from the Food and Nutrient Database for Dietary Studies (FNDDS 2011-12)

Food Code	Description	Sequence number	SR code	SR description	Amount (g)
75114000	Mixed salad greens, raw	1	11252	Lettuce, iceberg (includes crisp head types), raw	20
		2	11213	Endive, raw	20
		3	11457	Spinach, raw	20
		4	11251	Lettuce, romaine, raw	20
		5	11253	Lettuce, green leaf, raw	20
75200110	Vegetables, NS as to type, cooked, fat not added in cooking	1	11584	Vegetables, mixed, frozen, cooked, boiled, drained, without salt	100
		2	2047	Salt, table	0.6
73102210	Carrots, cooked, NS as to form, fat not added in cooking	1	11125	Carrots, cooked, boiled, drained, without salt	155.2
		2	2047	Salt, table	0.96
58131110	Ravioli, NS as to filling, with tomato sauce (Includes Ravioli, NFS)	1	1123	Egg, whole, raw, fresh	75
		2	14429	Water, tap, municipal	74.063
		3	20081	Wheat flour, white, all-purpose, enriched, bleached	125
		4	2047	Salt, table	3.75
		5	1036	Cheese, ricotta, whole milk	81.918
		6	21500100	Ground beef or patty, cooked, NS as to percent lean (formerly NS as to regular, lean, or extra lean)	85.05
		7	11282	Onions, raw	26.667
		8	1032	Cheese, parmesan, grated	6.25
		9	4610	Margarine, regular, 80 percent fat, composite, stick, with salt	14.1
		10	11549	Tomato products, canned, sauce	226.8
		11	2003	Spices, basil, dried	0.35
		12	19335	Sugars, granulated	2.083
		13	1125	Egg, yolk, raw, fresh	8.5
		14	2029	Spices, parsley, dried	0.075
		15	18069	Bread, white, commercially prepared (includes soft breadcrumbs)	1.5

Note: SR=National Nutrient Database for Standard Reference; NS=Not specified; NFS=Not further specified; g=gram. All weights represent the weight of the ingredient in the form described (raw, cooked, dried) and do not include refuse such as shells, stems, or seeds.

Source: USDA, Food and Nutrient Database for Dietary Studies 2011–12.

The recipes were created to calculate the nutrient content, but they presented two major challenges for calculating food prices: Not all recipes included retail ingredients, and a few recipes separated commonly used short-cut products such as ravioli into more basic ingredients such as flour, spinach, and cheese. Following Carlson, Lino, Juan, et al., (2008), we assumed that most households did not have time to prepare ravioli from scratch each time they ate it, and we modified the recipe to include purchased ravioli. In the FNDDS, non-purchasable ingredients were used when several recipes use a similar ingredient that is prepared at home; this maintained consistency across recipes. For example, in the recipe for cooked carrots, the main ingredient was “carrots, cooked, boiled, drained, without salt.” While some retailers sold carrots in this form in the refrigerated section, most consumers likely prepared it from fresh, frozen, or canned carrots. Cooked carrots are generally not a purchasable ingredient, but are used in several recipes such as soups, casseroles, and pasta dishes, and WWEIA participants reported eating them. To address this issue, we modified the recipe to account for the other three forms of carrots. The Recipe Development section discusses how we modified recipes to overcome these challenges.

The foundation of the FNDDS 2011–12 was the USDA National Nutrient Database for Standard Reference (SR) 26 (U.S. Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory, 2013). At the time the PPPT was developed, SR was the primary source of nutrient data in the United States. SR-26 contained cooking yields from changes in food weight caused by refuse (i.e., removing the peel of a banana), moisture loss, water absorption, or net fat gains/losses during food preparation and cooking. This study used the recipes, moisture and fat changes, and refuse factors from both the FNDDS and the SR.

IRI InfoScan. The IRI data purchased by USDA consists of both store-based scanner data (InfoScan) and household-level scanner data (the Consumer Network). The Consumer Network provides demographic and purchase data for a nationwide panel of about 60,000 households that report almost 60 million purchases annually (Muth et al., 2016). The Consumer Network draws from The National Consumer Panel, which is a partnership of IRI and Nielsen. The CNPP Food Price Database used Homescan, Nielsen’s version of The National Consumer Panel (Carlson, Lino, Juan, et al., 2008).

In this report, we focus primarily on InfoScan, but the tool could be applied to the Consumer Network. The statistical properties of both datasets are discussed in a series of ERS reports (Levin et al., 2018; Muth et al., 2016; Sweitzer et al., 2017). InfoScan provides weekly transaction data from retail food outlets such as grocery stores, club stores, convenience stores, and supercenters. There are 60,000 reporting units—either an individual store or data summarized at each of the chain’s Retail Market Areas (RMAs). Each observation, or transaction record, is the weekly quantity and revenue for an individual item sold in one reporting unit (either the store or RMA). The data available to USDA include a mix of both brand-name and private-label products; a limited number of stores do not provide transaction data for their private-label products. In the 2013 data, there are 6.6 billion transaction records.

Both IRI datasets record transactions at the product level and products are identified by a Universal Product Code (UPC) or barcode. Other than barcodes used only within the store – such as random-weight items sold at the deli counter, loose produce, or a few private-label items – most UPCs are also Global Trade Identification Numbers (GTIN), an international set of codes for every good and service sold. Private companies maintain GTIN databases that contain detailed information on the products needed to conduct business, and each unique number represents a specific product. For example, two packages of the same food might have two different GTINs if the packages are different sizes, have

different flavors, or are packaged with different materials, such as cans or pouches. IRI creates barcodes for random weight products without a GTIN, and items sold by weight are included in the price estimation. Users should consult the IRI statistical properties reports and IRI user’s guides for more information on how these items are recorded. There are more than half a million barcodes used in either the 2013 InfoScan or the Consumer Network.

Purchase to Plate Crosswalk (PPC). To use InfoScan to estimate prices for the FNDDS recipe ingredients, we use the newly created PPC linking database and conversion factor files (Carlson et al., 2019). The 2013 PPC linking database provides a mapping between 4,390 USDA food codes and 650,592 UPCs, representing 5.9 billion transactions in InfoScan 2013. The PPC conversion factor table provides a multiplier for each UPC to convert the purchased weight in the scanner data to the same form as the USDA food the UPC is linked to. The multiplier removes the weight of inedible parts such as skin, bones, seeds, and shells that are included in the purchase weight, and adjusts the weight for cooking loss or gain if the USDA food code represents a cooked food. Not all UPCs linked to the same USDA food have the same conversion factor. For example, baby carrots have no refuse; whole carrots have refuse, but both are linked to the same USDA food, raw carrots. For this reason, conversion factors are developed manually, rather than the more automated methods used to develop matches⁴. Thus, the conversion factor table covers only the 359,746 UPCs that represent 95 percent of sales in the four InfoScan transaction files listed in table 2 that are included in this study.

Table 2
IRI transaction files used in the study

Data	IRI Transaction File Name	Included in 2013 PPC
InfoScan	POS_RMA	2013 Data
InfoScan	POS_store	2013 Data
InfoScan	RW_RMA	2013 Data
InfoScan	RW_store	2013 Data
Consumer Network	Trip	2013 Data except UPCs in the product_dictionary_rwpanel, and UPCs not included in the InfoScan POS and RW transaction files
InfoScan	PrivateLabel_RMA	Not included
InfoScan	PrivateLabel_store	Not included

Notes: POS-point of sale; RMA-retail market area; RW-random weight. PrivateLabel_RMA and PrivateLabel_store contain information for private-label products from stores that do not release their private-label data to USDA in InfoScan. The private-label data from other stores are included in the POS and RW transaction files. The Trip data files contain transactions for all products purchased by Consumer Network participants, including all private-label products.

Source: Compiled by the authors.

⁴Conversion factors were drawn from the FNDDS or Agriculture Handbook 102, Matthews, R.H., and Y.J. Garrison. 1975. *Food Yields Summarized by Different Stages of Preparation Handbook 102*, U.S. Department of Agriculture, Agricultural Research Service.

Purchase to Plate Price Tool Development

The main goal of the price tool is to estimate national average prices for foods reported consumed by participants in the WWEIA/NHANES survey using InfoScan. The price tool also provides a mechanism for users to estimate prices for these foods using subsets of InfoScan and the Consumer Network. For example, users could create a subset of supercenter transactions, transactions over a limited time frame, or by geographic region.

To begin, we identified a list of 5,706 FNDDS foods that were reported consumed by participants in WWEIA/NHANES 2011–12. Because of resource limitations, we focused on the 3,518 foods reported eaten more than 10 times, and the 24 that were modifications of these frequently reported foods. The final list of 3,542 food codes represented 219,171 reports of individual foods and beverages reported consumed by WWEIA/NHANES participants, or 96 percent of all reported food and beverage eating and drinking occasions.

Recipe Development and Price Estimation

We reviewed the 3,542 codes and identified five different pricing methods, which are explained below (table 3). We used direct or alternative matches (methods 1 and 2) for foods typically consumed raw or ready-to-eat such as breads, cold cereals, beverages, some fruits and vegetables, and frozen entrees. The original or modified FNDDS recipes (methods 3-5) were used for foods prepared away from the store, such as cooked vegetables and grains and mixed dishes such as burritos, casseroles, and stir-fried dishes. Since many of these foods were prepared from more than one purchased ingredient, we used and modified recipes for these FNDDS foods. The modified recipe specified the amounts of each ingredient needed to make 100g of the food. FNDDS was the starting point for each recipe. The IRI data were the basis for the average ingredient price, and the price of the food was the sum of each ingredient price multiplied by the quantity specified in the recipe. Tap water was assumed to be free.

Table 3
Number of WWEIA/NHANES foods using each price calculation method

Method		Number of WWEIA/NHANES foods
	Tap water (free)	1
1	Direct map of FNDDS food to ingredient in IRI data	1,613
2	Map to alternative FNDDS Food(s)	738
3	Use original FNDDS recipe	36
4	Modify recipe by replacing some ingredients with codes to allow for different forms of an ingredient	1,082
5	Modify recipes to account for convenience foods.	72
	Total foods	3,542

Source: Author calculations using data from the Food and Nutrient Database for Dietary Studies (FNDDS) 2011-12 and What We Eat in America/National Health and Nutrition Examination Survey (WWEIA/NHANES) 2011-12.

Regardless of price calculation method, the PPPT begins by estimating the average price per edible kilogram for every USDA food code in the PPC Linking Database⁵, using the transaction data submitted by the user. The user can choose all InfoScan transactions for a national average price, the Consumer Network Trip file, or a subset of either dataset. When using a subset of the data, the user will need to verify coverage of final price estimates because the tool will not calculate a price if an ingredient price is missing.

The first step is to calculate the edible weight—i.e., the weight of the food that is edible excluding the skins, peels, seeds, bones, and shells. Because some USDA food codes are linked to different purchase forms (e.g., fresh, fresh-cut, frozen, canned, dried, boneless), the edible weight sold must first be calculated at the UPC level and then summed over all UPCs that link to the USDA food code. For each UPC, i , the total edible weight sold is:

$$(1) \text{ Edible_Weight_Sold}_i = \left[\sum_{t=1}^T \text{Quantity_Sold}_{it} \right] (\text{IRIweight}_i)(\text{Conversion_Factor}_i)$$

where T is the number of transactions in the data chosen by the user for the tool for UPC i , Quantity Sold is the number of packages of UPC i sold in transaction t , the IRI weight is the kilogram weight of the package (or unit) for UPC i , and the conversion factor is from the PPC conversion factor table for UPC i . Note that the conversion factor takes on values from 0 to <1 when the retail weight includes inedible parts and >1 when preparation includes weight gain from water such as cooking dried pasta or rice. When using the Consumer Network data, the tool also applies the household projection factors to equation 1. After calculating the edible weight for each UPC, we sum the edible weight sold for all M UPCs assigned to a USDA food code and divide the total sales of these same UPCs by the total edible weight to get the price per edible kilogram of ingredient j used in the recipe:

$$(2) \text{ ingredient_price}_j = \frac{\sum_{i=1}^M (\text{sales})_i}{\sum_{i=1}^M (\text{edible_weight_sold})_i}$$

This is equivalent to a weighted average calculation where the UPCs with greater sales volume contribute more to the calculated average.

Using the average prices for each ingredient represented by a USDA food code, the price tool calculates prices for foods in WWEIA/NHANES using one of five methods.

Method 1: Direct map to FNDDS Food. This is the simplest of the five methods and is used when the PPC linking database linked IRI foods to FNDDS foods that are the same, or that are the same after using a conversion factor. For example, the price for most crackers, bread, frozen or canned

⁵The PPC uses a combination of SR and FNDDS codes, but all are found in the FNDDS-SR links table.

fruits and vegetables, and frozen entrees is the price of the USDA food code in the linking database. That is, the ingredient price is the price of the food.

Method 2: Map to alternative FNDDS Food(s). The PPC linking database links the UPCs in the scanner data to the best match among the USDA foods. As a result, some WWEIA/NHANES food codes do not have a direct link, but a similar code does. For example, low-fat vanilla yogurt with low-calorie sweetener (11422100) is similar in price to non-fat vanilla yogurt with low-calorie sweetener (11424000). The PPPT uses the non-fat yogurt to estimate an average price for the low-fat yogurt.

Additionally, during development of the PPC linking database, it was more efficient to work with just FNDDS codes. Some of these were later replaced by SR codes to establish a better match. Unfortunately, there are a few instances of the linking database containing both the SR and the FNDDS code for the same food. For example, some raw carrot UPCs were matched to the SR code (11124) and others linked to the FNDDS code (73101010). To make use of all available price data, the PPPT estimated the price by dividing the total dollars sold of the alternative FNDDS code (including UPCs matched to both the original FNDDS and SR codes) by the total edible kilograms sold for the codes.

Method 3: Use the original FNDDS recipe. Some of the WWEIA/NHANES codes do not have a direct link or an alternative map, but all the ingredients in the FNDDS recipe are in the PPC linking database and conversion factor table. In this case, the PPPT uses the FNDDS recipe directly. For example, table 1 shows that “Vegetables, NS as to type, cooked, fat not added in cooking” (FNDDS Code = 75200110) is a combination of frozen mixed vegetables, cooked, and salt. Since both frozen mixed vegetables and salt are included in the PPC linking database, the price is calculated directly from the recipe quantities. Before including the recipe in the Price Tool, we adjusted the quantities of each ingredient so that the FNDDS recipe made 100 grams of the food using the same methods as the developers of the FNDDS (Martin et al., 2014).

To estimate the price of food j , the Price Tool multiplies the average price per edible gram of ingredient code i (equation 2) by the number of grams in the FNDDS recipe for each ingredient, and sums over all N ingredients in the recipe:

$$(3) \quad Price_j = \sum_{i=1}^N (ingredient_price)_i (adjusted_recipe_quantity)_i$$

Method 4: Modify recipe by replacing some ingredients with codes to allow for different forms of an ingredient. Most of the FNDDS recipes for home-prepared foods required modifications because the recipe ingredient is more general than the codes used in the PPC linking database. For example, table 1 shows that the main ingredient in cooked carrots is boiled carrots. Since boiled carrots might be prepared from whole carrots, baby carrots, frozen, or canned carrots, we replaced the single ingredient “boiled carrots” with multiple retail ingredients representing the different forms of the carrot (table 4). Note that the number of edible KG of raw carrots is calculated using equation 1 and includes both baby and whole carrots. An ingredient-based conversion factor shown in table 4 accounts for the moisture gain when raw carrots are boiled. The recipe also includes cooked carrots, which is matched to a convenience product—carrots sold in the cooked form—but the original form (fresh, frozen, canned) used by the manufacturer of the product is not clear in the IRI data. Most of these carrots are purchased in standard weight packages with a UPC, generally found in

the refrigerator section, rather than at a deli counter. Since the IRI data does not include standard weights for most deli items, the PPPT cannot use in-store prepared foods sold at deli counters in estimating prices. While an individual likely will use only one form of carrots in a recipe, this is a statistical recipe that represents the average of all purchased forms.

Table 4

Example recipe using boiled carrots

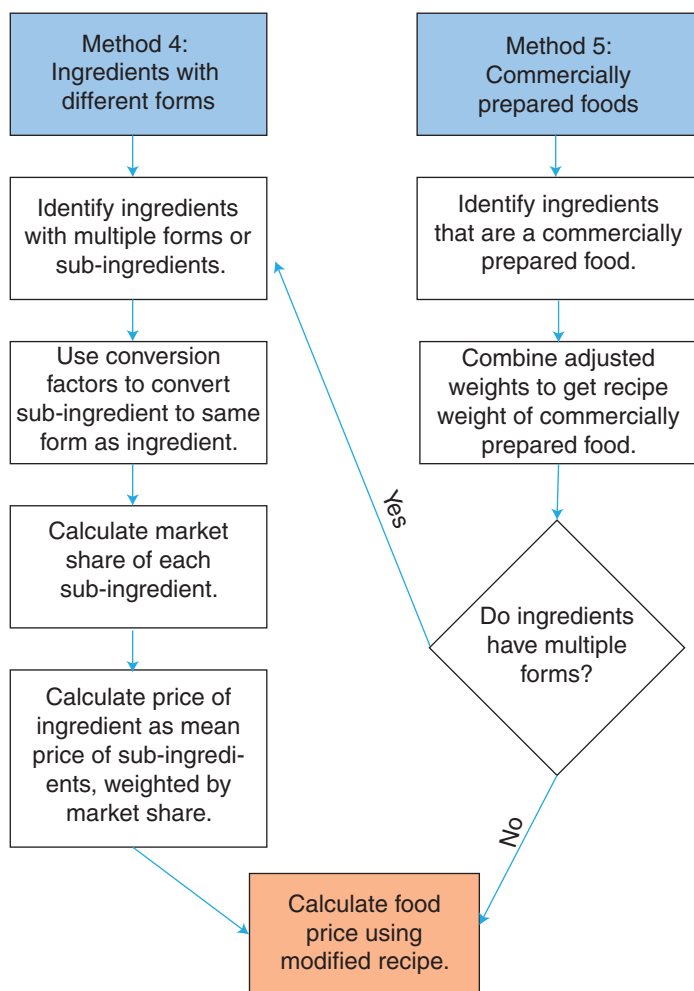
Sub ingredient	Amount Sold (edible KG)	Conversion factor	Amount boiled carrots (edible KG)	Amount in recipe (percent edible KG)	Price per edible KG, prepared (dollar)
Carrots, raw	305,961,446	1.23	377730180.2	98.332	1.43
Carrots, frozen, unprepared	4,426,149	1.37	6063217.808	0.683	3.94
Carrots, cooked, from canned, fat not added in cooking	6,319,952	1	6319952	0.976	3.87
Carrots, cooked, NS as to form, NS as to fat added In cooking	59,348	1	59348	0.009	12.38
Total	316,766,895		390,172,698		

Note: The percent of edible KG and the price per KG are based on the market share using 2013 transactions in the pos_rma and pos_store as of late 2015, when this part of the tool was developed. Updated IRI data for 2013 may produce different results. The PPPT calculates the percent based on transaction data selected by the user. "Carrots, cooked, NS as to form, NS as to fat added in cooking" represents pre-cooked carrots, whereas the IRI data does not indicate the form (fresh, frozen, canned), but does include a package size. KG=kilogram, NS=Not specified.

Source: Compiled by authors using data from IRI InfoScan 2013 and the Food and Nutrient Database for Dietary Studies (FNDDS) 2011—12.

Figure 1 shows the steps to estimate the price of the food. First, note that the raw and frozen carrots are not cooked and require a conversion factor to adjust the weight to that of cooked carrots in the recipe. We also estimate the market share of each form of the ingredient using the total edible grams sold of each ingredient, adjusted by the conversion factor. The price of the ingredient is the mean of all forms, weighted by the market share. We calculated the price of the FNDDS food following the revised recipe using equation 3.

Figure 1
Steps to estimate food price using modified recipe



Source: Compiled by the authors

Method 5. Modify recipes to account for convenience foods. Early editions of the FNDDS recipes broke foods down into the most basic ingredients such as flour, individual spices, and raw meat and vegetables to facilitate calculating the nutrient content. The FNDDS recipes were based on common cookbooks at the time, and these recipes required more time than most U.S. households now spend cooking. In 2014, households spent about 51 minutes in preparation and clean-up if they prepared meat, and 26 minutes if they did not prepare meat (Hamrick and McClelland, 2016), and most consumers used prepared and convenience foods to save time (Kuhns and Saksena, 2017). While each update of the FNDDS modifies recipes to use convenience foods, there were a few recipes with complex sets of ingredients in the FNDDS 2011-12.

When an FNDDS recipe contained more than 10 ingredients, or when the Westat, Inc. and USDA nutritionists reviewing the recipes determined the recipe would take more than 30 minutes to prepare, we modified the recipes to use convenience foods. For example, the ravioli recipe in table 1 included 15 ingredients because it assumed the ravioli were prepared from scratch, and the sauce was prepared from stewed tomatoes and spices. We replaced these 15 ingredients with commercially prepared ravioli and spaghetti sauce (table 5). As with method 4, the linking database contained

different types of ravioli and tomato sauces. We used the method 4 steps to adjust quantities and prices and calculated the price of the FNDDS food following the revised recipe using method 3 (figure 1).

Table 5

Modified recipe for ravioli

Original FNDDS recipe		Modified recipe	
Ingredient	Amount (edible g)	Ingredient	Amount (percent edible g)
Ravioli, NS as to filling, no sauce			
Egg, whole, raw, fresh	75	Ravioli, NS as to filling, no sauce	2.006
Water, tap, municipal	74.063		
Wheat flour, white, all-purpose, enriched, bleached	125		
Salt, table	3.75	Ravioli, meat-filled, no sauce	15.525
Cheese, ricotta, whole milk	81.918	Ravioli, cheese-filled, no sauce	75.548
Ground beef or patty, cooked, NS as to percent lean	85.05	Ravioli, cheese-and spinach-filled, no sauce	6.921
Onions, raw	26.667		
Cheese, parmesan, grated	6.25		
Margarine, regular, 80 percent fat, composite, stick, with salt	14.1		
Egg, yolk, raw, fresh	226.8		
Bread, white, commercially prepared (includes soft bread-crumbs)	0.35		
Spaghetti sauce, meatless			
Tomato, canned, sauce (stewed tomatoes)	2.083	Spaghetti sauce, meatless	99.961
Spices, basil, dried	8.5		
Sugars, granulated	0.075	Spaghetti sauce, meatless, fat-free	0.039
Spices, parsley, dried	1.5		

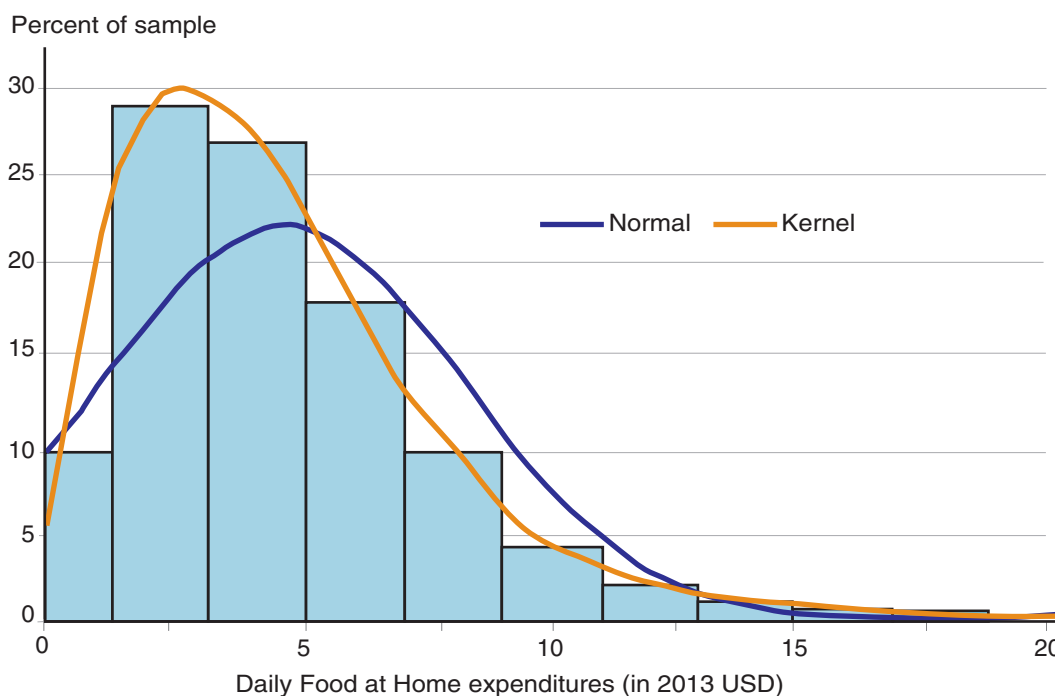
Note: The percent of edible grams is the percent of edible grams sold of ravioli (top part of chart) and spaghetti sauce (bottom part of chart) The percent of edible grams is based on the market share using 2013 transactions in the pos_rma and pos_store as of late 2015, when this part of the tool was developed. The PPPT calculates these percentages based on transaction data selected by the user. Updated IRI 2013 data may produce different results. g=grams; NS=not specified.

Source: Compiled by the authors using data from IRI InfoScan 2013 and the Food and Nutrient Database for Dietary Studies (FNDDS) 2011-12.

The Purchase to Plate Price Tool

The Purchase to Plate Price Tool is a set of three SAS programs that calculates the price for each of the 3,542 WWEIA/NHANES foods, using one of the five methods. The first two programs calculate a price for each code in the PPC linking database and the alternative FNDDS code used in method 2, while the third program uses the recipes to calculate a national average price for most WWEIA/NHANES foods. Foods that WWEIA participants reported from FAFH sources are priced as if ingredients (or a prepared food) were purchased in a store and do not include the additional costs charged by restaurants to cover labor, energy, and capital costs such as the building and equipment. The tool does not calculate prices for the 2,180 foods reported consumed fewer than 10 times by WWEIA/NHANES participants. The prices draw from a broad base of grocery items whose sales data are available to USDA at the barcode level. Sales of private-label items from stores that do not release detailed information on their products are not included in price estimates because the data do not include package sizes, but private-label sales are included for stores that do release these data at the UPC level (table 2). The PPPT prices do not represent economic costs, which would include the time to obtain and prepare the food, energy to travel to stores and to cook, skills to prepare food, and other associated costs.

Figure 2
Distribution of estimated daily Food at Home (FAH) expenditures for NHANES/WWEIA respondents



Notes: Prices estimated are national average prices. The normal distribution (blue line) shows what the histogram would look like if estimated daily food prices have a normal distribution. The kernel distribution (orange line) shows that prices are concentrated at the lower end but have a long tail.

Source: Author estimates using data from WWEIA/NHANES 2011-12 and food prices estimates using IRI InfoScan, 2013. Estimates control for the NHANES complex sample design.

We used national average prices to estimate the daily expenditure for foods reported consumed by NHANES/WWEIA participants when they stated the food was purchased at a store (Food at Home, FAH). The results discussed in this paragraph were for the entire 1-day sample, across all ages, including both male and female participants, and they accounted for the complex sample design. The mean total expenditure was \$4.54 (95 percent CI \$4.431 to \$4.77), and the median was \$3.84 (95 percent CI \$3.57 to \$4.12). In figure 2, the kernel density (orange line) shows that estimated expenditures were concentrated to the left of the normal distribution (blue line), but there was a significant number of individuals whose estimated expenditure was significantly above the mean (top of the normal curve), or in statistical terms, the right tail of the distribution was long. The 90th percentile was \$8.54 (95 percent CI \$8.12 to \$8.98), and the 99th percentile was \$17.14 (95 percent CI \$15.88 to \$18.40). All estimates controlled for the complex sample design used in NHANES.

Optional User Tools

The price tool allows researchers either to modify the price calculation method or change the input transaction files to suit individual research needs, such as subsetting by geographic region, season, or store type. Changing the price calculation method may be best suited to research questions involving a limited number of foods, since it requires the researcher to examine each individual recipe and may require the user to create new links and conversion factors to supplement the ones in the PPC. FNDDS recipe modification requires careful attention to yield factors, existing matches, and an understanding of how FNDDS recipes are developed. The methods used in the PPPT are based on available links and conversion factors in the PPC, and only one method is validated for each WWEIA/NHANES code. Users who choose to change the price calculation method will need to carefully document how they modified the recipes and evaluate the individual prices.

On the other hand, changing the input transaction files is relatively straightforward. While the price tool is designed using all InfoScan UPC-level transaction data, researchers either can create a subset of InfoScan transactions, such as different store types, or use the Consumer Network trip file. We include an important safeguard in the price tool: The tool will not calculate a price for a WWEIA/NHANES food if the price of an ingredient is missing. For recipes using ingredients with different forms (method 4 and 5), the ingredient price is based on the share of sub-ingredients available in the subset of transaction data.

Coverage of WWEIA/NHANES 2011–12

Coverage—or how much of the food reported consumed by WWEIA/NHANES participants has a price—is measured in terms of the number of individual foods reported eaten by WWEIA/NHANES participants, the number of occasions eating each food or the incidences of reported food intake, and the share of all food by weight that study participants report eating. The PPPT estimates a price only for foods consumed more than 10 times, or about 60 percent of the 5,734 foods reported consumed by WWEIA/NHANES participants on both days of the survey (table 6). While this may seem low, these foods with prices represent 96 percent of all incidences of reported foods and beverages, and 97 percent of all grams of foods and beverages reported eaten. Although the price tool was not originally designed to use with the Consumer Network, using these data will generate a price for 57 percent of all foods and beverages reported eaten, 94 percent of the eating occasions, and 96 percent of all grams of food reported consumed. Foods without a price tend to be variations of other foods that have a price. For example, there are 48 codes for the pizzas that NHANES/WWEIA participants reported eating. Of these, 42 pizzas have prices and 6 do not. The maximum number of times a food without a price generated by the Consumer Network data was reported was 359 times in NHANES. In comparison, tap water was reported 13,412 times, and all foods with prices represent 219,171 total reports.

Coverage varies by the subset of data used. Users may choose any subset but should verify that the coverage is adequate for the research question. For example, we estimated prices using transaction data from different store types as subsets (table 6). Using transactions from grocery stores to estimate prices produces very similar levels of coverage as using all transactions. Transactions from defense commissaries and club and mass-merchandise stores are only slightly lower. While coverage calculated using transactions from convenience, drug, and dollar stores are lower than the other types of stores, these transactions still produce prices for 90 percent of eating and drinking occasions for the 2-day sample of WWEIA/NHANES. It is important to note that stores in the IRI data tend to be chain stores, rather than independent stores. Independent stores may have different types of foods available than chain stores, and these results should not be used to assess food availability at different types of stores.

Table 6

Coverage of the Purchase to Plate Price Tool

	Number of foods	Eating occasions	Grams of food
	(Percent of all WWEIA foods)	(Percent of all eating occasions in WWEIA)	(Percent of all grams reported consumed in WWEIA)
Transaction source			
InfoScan	60	96	97
The consumer network	57	94	96
Type of store			
Grocery	60	96	97
Club and mass merchandise	56	94	96
Defense commissary	55	93	96
Convenience, drug and dollar	50	91	93

Note: All foods are priced as if the ingredients or prepared foods were purchased in a store. This includes foods that WWEIA participants report obtaining from Food Away From Home sources.

Source: Calculated by the authors using What We Eat in America/ National Health and Nutrition Examination Survey (WWEIA/NHANES) 2011–12 and the Purchase to Plate Price Tool (PPPT). All calculations control for the complex sample design of NHANES and use the dietary recall weights for the 2-day sample.

Purchase to Plate Price Tool Validation

We evaluated the price tool by comparing estimated expenditures derived from it to estimated expenditures from other government sources, including the USDA Food Plans, self-reported monthly expenditures from the Flexible Consumer Behavior Survey in NHANES, and the ERS Food Expenditure Series.

We used the PPPT’s national average prices and the reported Day 1 dietary intake by individuals in WWEIA/NHANES to estimate the weekly cost of food for the family of 4 (one child age 6–8, one age 9–11, and two adults age 19–50, one male and one female) in the USDA Cost of Food at Home as found on the USDA Food and Nutrition Service, Center for Nutrition Policy and Promotion

website (table 7)⁶. Since these were prices from 2013, we compared them to the USDA Cost of Food at Home for June 2013. The USDA Cost of Food at Home estimates were based on the USDA Food Plans, which assumed that not all food purchased is eaten, and the amount that goes uneaten varies by expenditure level (10 percent for the Low-Cost Plan, 20 percent for the Moderate-Cost Plan, and 30 percent for the Liberal Plan) (Carlson, Lino and Fungwe, 2007). The Low-Cost Food Plan (\$190 per week) was the midpoint of the second quartile of expenditures, or the 37th percentile of expenditures. Our estimate for the 37th percentile of expenditures, including a multiplier of 1.10 to account for the food that goes uneaten (\$170.41) was lower than the Low-Cost Food Plan (\$190.60), but the 62nd and 87th percentiles were higher than the Moderate-Cost and Liberal Food Plans, respectively⁷. It was not surprising that there is some variation since USDA does not have access to data on all food sold, particularly the private-label or store-brand data for all retailers. This omission may have caused a slight upward bias in PPPT prices. In addition, the base of the USDA Food Plans was last updated using prices from the 2001–03 Nielsen Homescan data (Carlson, Lino and Fungwe, 2007). USDA used the CPIs for food to inflate the cost each month for its published costs. The USDA Food Plans represented the cost of a healthy diet, and our estimates were based on the foods U.S. households actually report eating. Previous research showed that the total amounts and types of foods consumers purchase in stores are not in alignment with the *Dietary Guidelines for Americans* (Carlson et al., 2019). However, the calculations used in this report were not sufficient to draw conclusions about the relative costs of a healthy versus a less healthy diet.

Table 7

Weekly cost of food for a family of four

	USDA cost of food at home estimate	Purchase to Plate Price Tool estimate of expenditure
	(Dollar)	(Dollar) (95 percent CI)
Low-cost/37th percentile	190.6	170.41 (159.88–180.85)
Moderate-cost/62nd percentile	238.2	247.16 (233.18–261.14)
Liberal/87th percentile	289.3	390.83 (365.84–415.82)

Note: Family of 4 consists of 2 children (one age 6–8 and one age 9–11), 1 adult female (age 19–50) and 1 adult male (age 19–50). Following the estimation of the USDA Food Plans, the Purchase to Plate Price Tool (PPPT) assumes that 10 (20, 30) percent of purchased food is not eaten for the Low-Cost (Moderate-Cost, Liberal) Food Plans, respectively.

Sources: Center for Nutrition Policy and Promotion (CNPP), Cost of Food at Home (June 2013), and author estimates using data from IRI InfoScan 2013, the PPPT, and What We Eat in America/National Health and Nutrition Examination Survey (WWEIA/NHANES) 2011–12.

The Food Plans estimated the cost of a healthy diet, while the Flexible Consumer Behavior Survey (FCBS) (Restrepo, 2019) estimated FAH expenditures, and the ERS Food Expenditure Series (Okrent et al., 2018) estimated what households, private companies, institutions, and governments spent on food, including food purchased from stores (FAH) and Food Away from Home (FAFH)

⁶The Low-Cost, Moderate-Cost, and Liberal Food Plans are based solely on food expenditure levels, and cut across income, education, household size, and other factors that impact food choices. However, to make a comparison with the Thrifty Food Plan, we would need to isolate the low-income NHANES participants. This isolation means we would need to control for other factors that impact food expenditure, and that is beyond the scope of the paper. This could be an area for future research.

⁷The expenditures for the third and fourth quartiles were also adjusted by a multiplier to account for food that is not eaten. For the third quartile, we used 1.2 and for the fourth quartile we used 1.3.

foods purchased from restaurants, cafeterias, entertainment venues, and provided by institutions such as hospitals and school cafeterias. Since the price tool calculated prices only for FAH, we estimated the daily and annual expenditures for foods that WWEIA/NHANES participants reported having obtained from stores (FAH) and compared those estimates to the FCBS and Food Expenditure Series estimates. Following the estimates for the USDA Food Plans, we assumed that 15 percent of all food purchased is not eaten. We chose 15 percent because the Low-Cost (assumes 10 percent food loss) and Moderate-Cost (20 percent food loss) Food Plans straddle the midpoint of food expenditures. However, estimates of consumer food loss range from 1 percent to 55 percent, depending on the type of food (Muth et al., 2011). The ERS Food Expenditure Series also assumed an average sales tax of 2.2 percent for food and 7.1 percent for alcohol, which we added to our estimate.

The daily per capita expenditure was comparable to the FCBS self-reported estimate for FAH. To derive a per capita expenditure for the FCBS, we divided the monthly household food expenditure (\$ spent on food from grocery stores + \$ spent on food from other stores – \$ spent on nonfood purchases from grocery stores) by the number of persons in the family and 30 days. We used the number of persons in the family rather than the household because the FCBS question specifically stated “family.” The daily FCBS self-reported per capita estimate was \$5.29 (95 percent CI \$5.00 to \$5.58), which was about the same as the daily per capita FAH expenditure using the PPPT with all InfoScan transactions, \$5.34 (95 percent CI \$5.07 to \$5.62). It is remarkable that estimates were so similar because the FCBS estimate was based on self-reported expenditures on food throughout a month, and our estimates were based on national average retail scanner data prices and self-reported food intake.

Our annual per capita estimate for FAH was \$1,949.10 (95 percent CI \$1,850.55 to \$2,051.30), slightly lower than the ERS Food Expenditure Series 2013 per capita Nominal FAH expenditure estimate of \$2,139.45 (Elitzak and Okrent, 2018). Differences in the two estimates might be due to differences in the assumed consumer food loss from the PPPT versus actual consumer food loss reflected in the Food Expenditure Series, methodologies, and measurement error. Food Expenditure data were estimated using sales surveys collected by the U.S. Census and other industry sources, while the PPPT estimate relied on the IRI InfoScan data and WWEIA/NHANES.

Limitations

There are several limitations with both the price tool and the underlying data. First, the price tool estimates average prices, which will not reflect the prices all consumers face in the grocery store. Average prices are based on the type of store, package size, and brands that are included in the chosen subset of data. Second, the chosen price calculation method will also impact the price. When using the tool to estimate average prices, the price for an individual food also will be based on these item variations and assumptions. While future research will develop statistical properties for the prices, researchers should review prices with their research question in mind to ensure they are valid. Minor variations in individual prices are not meaningful, and researchers are advised not to draw conclusions based on the prices of individual food items (e.g., different flavors of yogurt) but to examine groups of foods appropriate for the research question (e.g., yogurt or all foods purchased). Finally, the prices do not adjust for consumer food loss of edible food; researchers should consider whether edible food loss is important to the research question and adjust prices accordingly.

In addition, both InfoScan and the Consumer Network have limitations that impact price estimation. For example, when using the PPPT with InfoScan data, some private-label data are not included because not all stores release their private-label data at the UPC level to USDA. This may cause a slight upward bias in food prices. While users have access to expenditures for these private-label items, the quantity is not available, and a price cannot be calculated. Also, when using the tool with the Consumer Network, users should note that the 2013 PPC and PPPT are designed for InfoScan, rather than the Consumer Network. As a result, not all UPCs in the Consumer Network are included, and the random-weight purchases made by Consumer Network participants are not included because participants record only expenditures, not quantities. Users will need to use InfoScan to generate these prices.

Finally, since the 2013 PPPT's creation, there have been some changes to the IRI data that may impact price calculations. Unless otherwise noted, statistics in this report reflect these changes as of April 2019. Researchers should consult the three IRI reports (Levin et al., 2018; Muth et al., 2016; Sweitzer et al., 2017) and the previous PPC report (Carlson et al., 2019) as well as the IRI user guides to determine the suitability of the data for price estimates for the individual research question.

Conclusion

The Purchase to Plate Price Tool (PPPT) is available to researchers using USDA's proprietary IRI scanner data. The tool allows researchers to estimate prices for foods reported consumed by participants in the 2011–12 WWEIA/NHANES survey. Users have the option to use any subset of the IRI data as long as the subset includes at least one UPC for each ingredient used to prepare the food. Using the 2013 InfoScan data, the PPPT estimates prices for 3,542 FNDDS foods, which represent about 97 percent of all the grams of food reported consumed by WWEIA/NHANES participants. When the InfoScan data are divided into store type (grocery stores; club and mass merchandise stores; defense commissaries; convenience, drug and dollar stores), the percent of grams with prices are 97, 96, 96, and 93 percent, respectively. Although the 2011–12 PPPT was not designed to be used with the Consumer Network, the Consumer Network data can be used to calculate a price for about 96 percent of the grams reported consumed by WWEIA/NHANES participants. Bear in mind that these are food prices, not food costs, which could include factors such as time, energy, and other resources.

Using national average prices generated by the PPPT to estimate the total annual FAH expenditure of WWEIA/NHANES participants, the expenditure was \$1,947.41, about 91 percent of the 2013 per capita Nominal Food At Home expenditure from the ERS Food Expenditure Series (\$2,139.45). The 95 percent CI of the daily per capita expenditure (\$5.08 to \$5.61) overlapped an estimate confidence of the daily per capita estimate from the FCBS (\$5.00 to \$5.58). For these comparisons, we added the cost of food purchased but not eaten and average sales taxes to the WWEIA/NHANES estimated expenditure because the ERS Food Expenditure Series and the FCBS self-reported expenditures included these factors. Similarly, we compared the WWEIA/NHANES total food expenditures to the USDA Cost of Food at Home estimates of a healthy diet. For individuals in the 25th to 50th percentile of food expenditure, the median expenditure was lower than the Low-Cost estimates, similar to the third quartile and the Moderate-Cost estimate; but the WWEIA/NHANES expenditures for the fourth quartile of food expenditure were higher than the Liberal cost estimates. It is important to remember that the USDA Cost of Food at Home is the cost of a healthy diet, while the estimates using WWEIA/NHANES data are for foods that participants reported eating. However, these estimated price differences between the Food Plans and recorded consumption are not sufficient evidence to draw conclusions about the cost of a healthy diet versus a less healthy diet.

The PPPT allows researchers to examine the relationship between food choices, nutrition knowledge, and food prices because it ties the extensive data in WWEIA/NHANES and the Flexible Consumer Behavior Survey (FCBS) to individual food prices. For example, a researcher could examine the cross-price elasticities of sugary beverages and other beverages chosen by individuals with blood-fasting levels in the diabetic range, who report that they have not been told they are diabetic, compared with the beverage choices of other NHANES participants. In addition, the Purchase to Plate Price Tool allows researchers to estimate the cost of a healthy diet or compare prices of healthy and less healthy diets using updated food prices. Future updates to the tool will draw from additional years of the IRI data.

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Appendix A: List of Acronyms

FAH – Food at Home

FAFH – Food Away From Home

FCBS – Flexible Consumer Behavior Survey

FNDDS – USDA Food and Nutrient Database for Dietary Studies

FoodAPS - Food Acquisition and Purchase Survey

GTIN – Global Trade Identification Number

NHANES – National Health and Nutrition Examination Survey

PPC – USDA Purchase to Plate Crosswalk

PPPT – USDA Purchase to Plate Price Tool

RMA – Retail Market Area

QFAHPD – USDA Quarterly Food at Home Prices Database

SR – USDA National Nutrient Database for Standard Reference

UPC – Universal Product Code

WWEIA – USDA What We Eat in America