# Beyond calories: The new economics of nutrition

Amelia B. Finaret[1] and William A. Masters*[2]

Prepared for *Annual Review of Resource Economics*,, rev. 8 February 2018

DOI: 10.1146/annurev-resource-100518-094053

**Abstract**

The economics of human nutrition has changed greatly in recent years, as researchers have moved beyond the demand for food and daily energy to other aspects of dietary intake such as macronutrient quality, micronutrients and other attributes of a healthy diet. New findings have followed developments within the food system, with new kinds of data and methods that allow researchers to focus on particular beneficial or harmful attributes of individual foods and overall diets. This review describes some of the recent literature in nutrition economics and its implications for food policy around the world. The new economics of nutrition is benefiting from a strong foundation in the behavioral and social sciences, using evidence from the natural and health sciences to address fundamental aspects of human well-being and sustainable development.

**Keywords:** nutrition, food economics, dietary intake, human development, human capital

[1] Allegheny College (afinaret@allegheny.edu)

[2] Tufts University (william.masters@tufts.edu)

* Corresponding author: 150 Harrison Ave., Boston MA 02111

## Beyond calories: The new economics of nutrition

## 1. Introduction

Economics, whose name derives from the ancient Greek term for household management, has long been concerned with food and nutrition. Modern economics was developed in part through debates about how best to meet our food needs, including arguments by Adam Smith over the British Corn Laws in *The Wealth of Nations* (1776), by Thomas Malthus over aid to the poor in his *Essay on Population* (1798), and by David Ricardo on food trade in *Principles of Political Economy and Taxation* (1817). Since these early works, the economics of nutrition has evolved away from examining outcomes such as total calorie or protein intake, towards a richer understanding of the multidimensionality of nutritional status and the etiology of disease. More recent research reveals the profound effects of nutritional deprivation (e.g. Alderman et al. 2006), and the many diverse aspects of diet quality as well-being improves (e.g. Beatty et al. 2014).

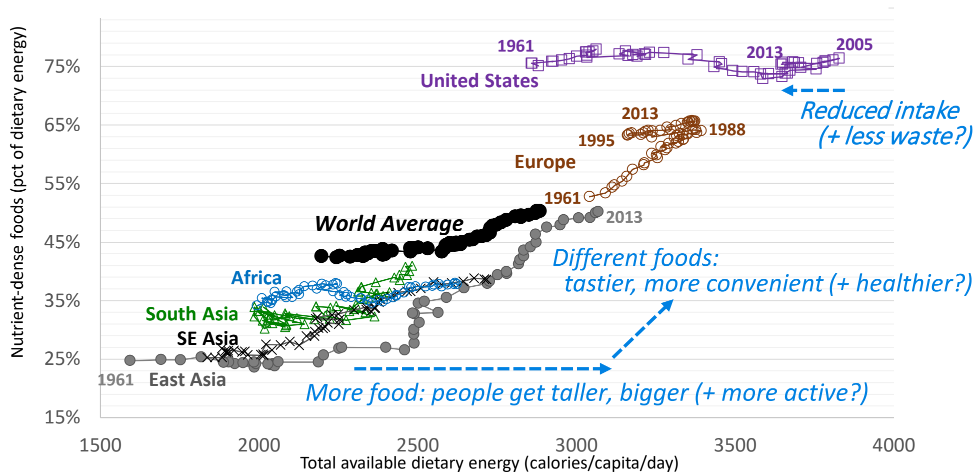
In this literature review, we describe and synthesize recent work in applied economics that examines how the dietary patterns of individuals, families and communities respond to changes in incomes, prices, and preferences. We define the field as going deeper than the task of estimating the costs and benefits of nutrition interventions, or estimating the economic costs of malnutrition, such as described in Lenoir-Wijnkopp et al. (2011). Through this literature review, we demonstrate that:

1. Nutrition research can benefit from economic explanations of individual behavior and societal outcomes;
2. The field of nutrition economics has evolved from focusing on the supply of foods and calories towards a multidimensional understanding of nutritional status and the mechanisms for changing nutritional status; and
3. There is great potential for future research using new data, new estimation methods, and interdisciplinary, cross-national collaboration for solving intractable nutrition problems around the world.

Nutrition, defined broadly by the Oxford Dictionaries (2018) as "the process of providing or obtaining the food necessary for health and growth", has attracted a growing range of scholars and analysts from diverse disciplines and institutions, examining many different aspects of the food system from production to consumption and back. In their recent review of how food systems can become more sensitive to health concerns, Pingali and Sunder (2017) describe the great variation among countries in how different policies influence food production and trade, processing and formulation as well as retail marketing and food consumption. Despite recent advancements in understanding the determinants of nutritional status around the world, knowledge of what shapes dietary choices around the world is limited, especially in low- and middle-income countries.

This literature review describes how economists explain, predict and interpret nutritional differences, including the many changes associated with economic development that are collectively known as the *nutrition transition* (Popkin 2017). The nutrition transition can be succinctly illustrated using FAO (2018) estimates of the foods available for human consumption in every country, shown in Figure 1 below. These estimates are obtained from national statistical agencies' estimates of total production for each type of food, plus recorded imports, minus exports and an estimate of the quantity used as seed, feed, fuel and other uses including loss and waste outside the household, divided by the official UN estimate of total population since 1961.

Figure 1. Dietary transformation towards more and more diverse foods, 1961-2013




Vertical axis shows percent of energy from foods other than cereal grains, white roots and other starchy staples, from FAO Food Balance Sheets, downloaded 14 July 2018 http://www.fao.org/faostat/en/#data/FBS. Europe includes all of the former Soviet Union.

Figure 1 reveals how the world has shifted over time from increasing calories per capita on the horizontal axis, to more dietary diversity beyond cereal grains and other starchy staples along the vertical axis. These administrative and census data differ somewhat from survey measures of household food use and individual dietary intake (Del Gobbo et al. 2015), and also differ from modeled estimates of human energy use based on anthropometric data (Hic et al. 2016), as total food use shown in Figure 1 may differ from dietary intake due to variation in the degree to which food is discarded or fed to domestic animals. There is also wide variation in direct measures of dietary intake, due to sampling errors and recall methods that affect survey data (Micha et al. 2017). The dietary transition can be seen in Figure 1 in its different stages around the world as defined by Popkin & Gordon-Larsen (2004). Regions with a steeper slope in this figure reflect faster increasing nutrient density of the diet with slower increasing total calories, indicating that they are in the midst of Stages 3 and 4 of the nutrition transition: receding famine and increased prevalence of non-communicable disease (Popkin & Gordon-Larsen 2004). In the United States and Europe, total calorie intake is beginning to decrease but with no noticeable change in the overall nutrient density of the diet at the national level. This reflects entering Stage 5 of the nutrition transition: less overconsumption (Popkin & Gordon-Larsen 2004).

The causes and consequences of nutritional change are of interest to economists and policymakers for two main reasons. The first is health, through which nutrition affects education, labor productivity and human capital formation. Poor diet quality has long been the greatest avoidable cause of death and disability, first through the increased vulnerability to infectious disease especially in childhood (Black et al. 2013), and then through cardiometabolic or other non-communicable diseases in later life (Imamura et al. 2015). All forms of malnutrition coexist at various levels, and are linked to a wide range of health disparities (Perez-Escamilla et al. 2018). A second set of concerns about human nutrition are environmental, given that food production is the largest single contributor to natural resource use, pollution and especially carbon emissions (Blackstone et al. 2018; Tilman and Clark 2014). Climate change and other environmental factors affect food supplies, through both long-term trends and more frequent extremes such as droughts and floods.

Understanding the roles of income, prices, and preferences in dietary patterns can help address many of the most important risk factors for both human health and the environment.

This review aims to inform not only economists, but also nutritionists and public health professionals with training from other disciplines. In the U.S. and elsewhere, the term *nutritionist* is linked to the practice of dietetics, meaning the provision of nutritional advice to individuals and groups (Bureau of Labor Statistics, 2018). The economics of nutrition addresses outcomes for entire communities or populations, which is generally called *public health nutrition*. Professional training in nutrition and public health includes courses based on biochemistry, metabolism, physiology and epidemiology, in addition to courses in health behavior and social determinants of health. Professional associations such as the Academy of Nutrition and Dietetics or the American Society for Nutrition typically have few members with advanced training in economics. Economists who study nutrition use the same data as nutritionists, but interpret it in different ways as described in this review.

Scientific collaboration between economists and nutritionists can advance understanding on many fronts. Much has already been done, but as noted by Angus Deaton in his Nobel Prize acceptance lecture: "Even on the subject of food and well-being, one of the oldest topics in economics, much remains unresolved" (Deaton 2016). This review describes how economics applied to nutrition has progressed from demand for food and the supply of calories towards a multidimensional understanding of macronutrients, micronutrients, and non-nutrient attributes of foods, as they interact with disease and the environment to influence well-being. Given the vast size of the underlying literature, we focus primarily on articles and systematic reviews regarding overall diet quality and dietary patterns (Hu 2002), rather than studies of single foods or nutrients. We do not aim to review the literature comprehensively within each of the sub-fields of nutrition economics. The paper is organized as follows. Section 2 motivates the inclusion of nutrition in the field of resource economics and provides necessary definitions. Section 3 reviews the literature on the biomedical determinants of nutritional status. Section 4 reviews the literature on the economic influences on dietary choices, split into three sub-sections: incomes, prices, and preferences. Section 5 describes new areas of promising research for nutrition economics. Finally, we conclude.

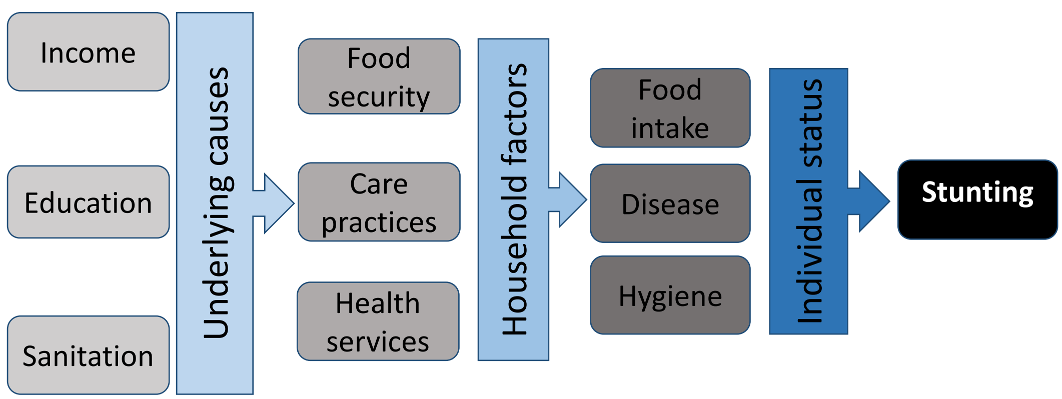
## 2. The new economics of nutrition

This section will provide necessary definitions, a description of the nutrition economics field, and outlines how nutrition is a resource economics issue. Adequate nutrition is a major determinant of health and socioeconomic outcomes, and draws on a multitude of resources from the natural and built environments, as well as human factors in agriculture and the food system. The *economics of nutrition* concerns how peoples' choices influence the use of those resources to meet human needs, for health and other objectives involved in the food system from agricultural production through processing to dietary intake and waste disposal. Understanding the consequences of each choice for human health depends heavily on findings from *nutrition science*, meaning laboratory studies of how nutrients and other attributes of food are transformed in living organisms, as well as *nutritional epidemiology,* meaning experimental and observational studies of how nutrients, foods, and dietary patterns relate to human health outcomes. All kinds of nutritional research also draw heavily on *food science*, meaning laboratory and field studies of the nutrients and biological or chemical contaminants found in foods before and after processing, and a wide variety of *agricultural and environmental sciences* about how foods are produced and interact with other things, as well as nutritional anthropology and studies of societal influences on health behavior collectively known as the *social determinants of health*.

Research in each field advances not only by gathering new data, but also interpreting existing data in new ways. Different researchers bring different causal frameworks to their understanding of potential mechanisms behind the data, and the hypotheses to be tested in any new study.  The mechanistic models used in nutrition science involve physiology, and the biochemical and metabolic pathways through which foods are transformed within the body.  When described in textbooks or lecture slides, underlying mechanisms may be illustrated with photographs or diagrams, and drawn using symbols and arrows that show cause and effect over time such the citric acid cycle in biochemistry. For research on social determinants of health*,* as in Mayen et al. (2014), the underlying mechanisms may be drawn using left-to-right arrows illustrating the passage of time, or the concentric circles approach of Bronfenbrenner (1979), vertical arrows from underlying to proximate causes of malnutrition as in UNICEF (1990), or circular feedback loops in system dynamic models following Forrester (2007).

One example of a causal framework diagram that might be used in public health nutrition is presented below in Figure 2 for the determinants of stunting, a condition in which a child is too short for his or her age and which is associated with reduced earnings capacity, reduced educational attainment, reduced cognitive development (Sudfeld et al. 2015; Black et al. 2015; Alderman and Fernald 2017), and poorer physical health throughout life.

Figure 2. Example of a causal framework showing possible pathways to prevent child stunting




The illustration shown above uses a combination of features commonly found in causal framework diagrams. In this case, a set of potentially observable variables such as education are linked by potentially causal arrows to a set of other potentially observable variables such as child care practices, with visual cues such as darker colors and different shapes to show the hypothesized structure of the relationship.  Given this framework, specific relationships can then be tested using randomized trials, observational studies, or simulation models of various kinds, with vibrant debate about the appropriate standards of evidence for clinical or policy implications.

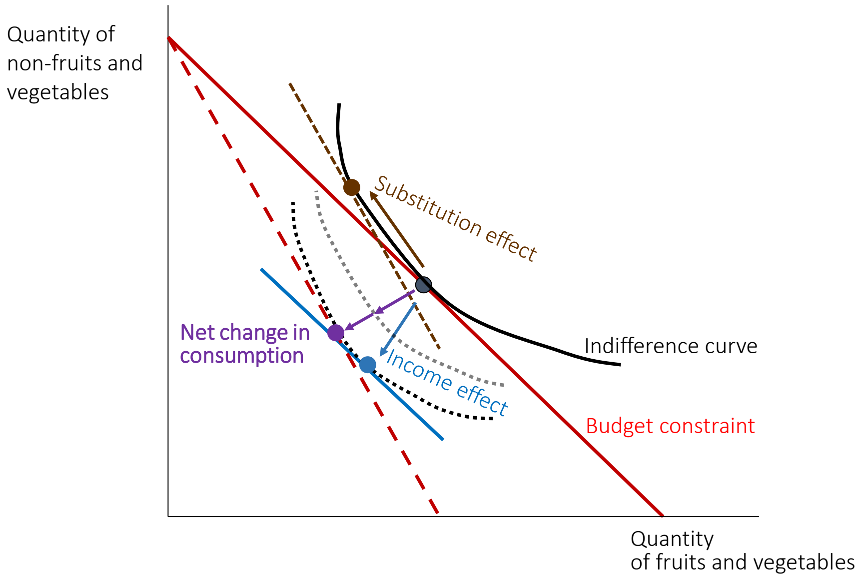
Economic analysis of the processes shown in Figure 2 generally starts with a frictionless benchmark model of individual choice and social interactions, and then adds specific features tailored to particular circumstances. These models aim to explain and predict average behaviors as the result of individuals pursuing their goals under specific constraints, reaching societal outcomes that depend on institutional arrangements, cultural traditions, or government policies. The mathematical structure of economic models vary but typically use optimization to represent each individual person's choices, maximizing benefits or minimizing costs subject to their constraints, with societal outcomes modeled as any equilibrium in which each person has made their preferred choice among limited options. Using that common framework, economists can then specify structural features of a model to capture aspects of individual choice or societal equilibria to explain and predict particular kinds of data. When expressed mathematically, these models are systems of equations that aim to capture specific causal mechanisms in society, just as biochemical models aim to capture causal mechanisms inside the body, with specialized models to explain particular kinds of data.

The economics of nutrition begins with recognition that observed food choices may not reveal peoples' underlying preferences for their own well-being, if only because the long-term consequences of eating one food instead of another are unknown. Our food preferences formed over millennia based on trial and error, leading to a wide variety of dietary patterns and culinary traditions around the world. Existing dietary patterns enable survival and reproduction under historical circumstances but do not necessarily select for longevity and well-being today. What is inside each food, and how food composition affects health, remains unknown in part because many important components cannot be seen or tasted, and many careful observations over time would be necessary to detect a link between food intake and health. Data on food composition and its effects on health are improving rapidly, with great variation in the degree to which the healthfulness of foods is known to nutritionists and to consumers.

Differences in nutrition knowledge can help explain some of the wide variation in food consumption seen around the world and over time, but many other factors are likely to intervene. People may systematically choose foods which they know to be unhealthy, perhaps because they are pursuing other objectives such as taste (Binkley and Golub 2011) and convenience (Capps et al. 1985), or because of psychological constraints on decision-making such as impatience and inattention that are studied in the field of behavioral economics. Food choices are heavily influenced by interpersonal relationships within families and households or other groups that cook and eat together, as well as the relative costs of different foods in terms of money and time, and peoples' full income or other ability to acquire food and other things.

The simplest possible model used in economics to explain and predict individuals' food choices can be illustrated in a two-dimensional diagram such as Figure 3 below. This model distinguishes between two kinds of influences on food choice: a person's *preferences* illustrated by the bowed indifference curves, and their *purchasing power* illustrated by the diagonal budget lines. The slope of each budget line is the price of what's on the horizontal axis relative to what's on the vertical axis, and the intercepts show the person's overall income or other entitlement in terms of the goods on the axes. The indifference curves show combinations that provide an equally high level of well-being, and are bowed-in towards the origin because the benefits of consuming each additional unit diminish as more is consumed. The budget lines show combinations that are equally affordable, and are linear because the cost of acquiring each additional unit is a constant determined by the price and time required to consume it.

Figure 3. Example of an economic model using indifference curves and budget constraints to explain food choice




In the causal framework illustrated by Figure 3, observed quantities are explained as having been chosen by people to reach the highest level of well-being they can afford. This approach allows economists to make testable predictions, estimate model parameters and infer changes in well-being associated with changes in peoples' circumstances. The example here shows intake of fruits and vegetables along the horizontal axis, and consumption of all other goods and services along the vertical axis, to illustrate the consequences of an increase in the cost of fruit and vegetables. When the consumer's income and cost of other things remains unchanged, the vertical intercept of the dashed budget line remains unchanged, but its slope becomes steeper as they can afford less of fruits and vegetables. The predicted outcome is that consumers might choose to consume less fruit and vegetables, but also less of other things as the price rise reduces their level of well-being as shown by the dashed indifference curve.

The purpose of this causal framework is to disentangle observed changes in consumption into distinct causal mechanisms, shown here in two dimensions: a hypothetical pure substitution effect along each indifference curve if well-being were unchanged, and a hypothetical pure income effect from one indifference curve to another if prices were unchanged. More math would increase the dimensionality of the model, and estimating the parameters of the model would require randomized trials or statistical inference from observational data, but the theory itself provides rich insight into food choices.

Even the simplest possible economic model of food choice illustrated in Figure 3 allows for many useful thought experiments yielding testable predictions. A change in nutrition knowledge might shift preferences towards fruits and vegetables, drawn as a change in the indifference curves to be steeper at each point, leading consumers to move along their budget line towards higher intake of these healthier foods. Vouchers to buy more fruits and vegetables would be drawn as a rightward shift in the budget line, with a horizontal segment starting from the vertical intercept that might result in the same predicted choice as a cash transfer. Each of these predictions can be tested using observable data, and model parameters can be estimated to make out-of-sample predictions and analyze the cost-effectiveness of alternative policies.

### 3. Biomedical influences on nutritional status

The field of nutrition economics described above investigates several outcomes of interest, including food security, dietary diversity, food expenditure, food consumption, food acquisition, price and income elasticities, dietary quality, heights, and weights. Modern nutrition science, which began in 1926 with the isolation of vitamin B1 (Mozaffarian et al. 2018), often delves deeper into health outcomes that require more physically invasive measurement, such as vitamin and mineral status, bone density, blood glucose, and blood lipids, as well as to the diseases of malnutrition such as cardiovascular disease, diabetes, cancer, marasmus, kwashiorkor, and various types of anemia. In this section, we will describe the biomedical determinants of nutritional status and describe the placement of these factors within the economics of nutrition.

In nutrition science, randomized controlled trials are considered the gold standard of evidence as they are in medical research, but the generalizability of these studies may be poor because of different constraints and habits across a diverse population. Randomized controlled trials focused on single nutrients or foods may minimize confounders as much as possible, but many nutrients are found in many foods and individual cravings and desires for foods depends on gut health, genetics, and baseline nutrient status, which ensures that individual nutrient intakes will be highly correlated (Ioannidis 2018; Mozaffarian et al. 2018). These complications make statistical inference difficult in nutrition. Ensuring rigorous empirics, scientific validity and replicability of results are growing challenges in the field of nutrition science, and these challenges mirror those in the other health sciences such as medicine and its sub-fields.

#### *3.1 Macronutrients*

Macronutrients – fats, proteins, and carbohydrates – are essential nutrients that have specific roles within the body, and can also be metabolized for energy (calories). Carbohydrates are the body's main source of fuel, but if there are insufficient carbohydrates in the diet, fats and proteins will be used for energy instead. Fats or lipids improve the satiety of meals, are essential for the absorption of fat-soluble vitamins and play other roles in metabolism. Proteins are necessary for maintaining fluid balance, for building body structures and for synthesizing compounds such as hormones and enzymes. Excess energy from all macronutrients cause weight gain and eventually an increased prevalence of overweight and obesity, including among children (FAO 2017), while inadequate nutrition can limit child growth and cognitive development, affecting an estimated 155 million children in 2016 (FAO 2017; Black et al. 2013; Sudfeld et al. 2015; Black et al. 2015; Alderman and Fernald 2017). Even within energy balance, the quality of energy sources is increasingly understood as influential on health outcomes (Mozaffarian et al. 2018). For example, complex carbohydrates have different effects on diabetes risk than simple carbohydrates, and omega-3 fatty acids pose different cardiovascular risks than saturated fats.

The share of dietary energy provided by each macronutrient changes gradually, with Bennett's law for starchy staples generally leading people at higher incomes to derive a smaller share of total energy from carbohydrates and a higher share from fats, but there is significant variation over time and space (Gerbens-Leenes et al. 2010). Over time in the United States, for example, the USDA (2015) estimate of total carbohydrates in the food supply declined gradually from 58 to 46 percent of calories during most of the $20^{th}$ century, with a corresponding rise in the share of total fats as protein's share remained around 12 percent. The longstanding decline in carbohydrates' share ended abruptly in 1975 and was followed by a sharp reversal from 1985 to 1997, back up to above half of all dietary energy after which it fell again to 46 percent of total energy in the 2000s. The unexpected reversal of Bennett's law in the U.S. during the 1980s and 1990s, when carbohydrates rose as a share of dietary energy, is also visible in NHANES survey data (CDC 2004). In both USDA and CDC data, some of the change in total carbohydrates is from fluctuation in various kinds of sugar, but most is due to processed starchy staples.

Changes in macronutrient consumption and energy balance have many influences on nutritional status, and are a key feature of nutrition transition. There has been a particularly rapid rise in overweight and obesity in Latin America such as Brazil where 1 of 7 adults was obese in the year 2009 (Conde and Monteiro 2014), and Colombia where obesity coexists with stunting (Sarmiento et al. 2014), as well as lower income countries such as India, where increasing obesity coexists with widespread undernutrition (Siddiqui et al. 2017). Many communities experience malnutrition in multiple ways, most notably the triple burden of high child stunting, adult overweight, and persistent micronutrient deficiencies (Meenakshi 2016). These multiple burdens of malnutrition in all its forms account for a high and rising fraction of all development risks, especially in locations experiencing prolonged civil conflict and insecurity (Finaret 2016, FAO 2017).

*3.2 Micronutrients*

Micronutrients – vitamins and minerals – are essential compounds that are needed in small amounts in the diet, and do not contain calories for energy. While early nutrition researchers focused on the links from individual micronutrients to specific diseases (Mozaffarian et al. 2018), more recent efforts have turned to combinations of foods and dietary patterns that provide adequate nutrients and help maintain energy balance and long-term health. For most people, getting enough vitamins and minerals in a balanced diet is possible by eating a wide variety of plant- and animal-based foods including vegetables, fruits, nuts, whole grains, dairy, and meat, with certain vitamin and mineral supplements generally recommended only for specific life-stage and growth needs such as pregnancy and lactation. While a balanced diet could provide adequate nutrients, about two billion people around the world are deficient in one or more micronutrients (Brugh et al. 2018; Miller and Welch 2013), and the key nutrients of concern are vitamin A, zinc, iodine, and iron, all of which are found in high quantities in animal sourced foods (Black et al. 2013; Hasler et al. 2018). High prices in low-income countries are a significant barrier limiting access to these perishable and hard-to-transport foods (Headey et al. 2018), whose consumption is associated with helping children achieve their growth potential (Sari et al. 2009).

*3.3 Non-nutrient compounds*

Beyond the essential nutrients, diet quality measurement concerns a variety of other compounds found in foods, such as contaminants and additives, due to their relationship with nutrition indicators of interest and other health outcomes. Protection from stunting, for example, is dependent on a safe food supply, because frequent gastrointestinal infections can pull children off their growth curves (Headey et al. 2018), and diarrheal disease caused about 500,000 deaths of children under age 5 in 2015 (Kotloff et al. 2017). Foodborne illness data is limited in low- and middle-income countries (Grace 2015), but exposure to mycotoxins such as aflatoxin are known to be associated with poor nutritional outcomes (Etzel 2014). In conjunction with nutrition science as it turns towards gut-health interactions, applied economists are investigating causal pathways for environmental enteric dysfunction caused by continual exposure to fecal-oral contamination (Geruso and Spears 2018). Several current explorations are integrative and address whole food systems, including the risks from having livestock near living spaces (Hasler et al. 2017). Even without threats of contaminants on the farm or at home, soil health contributes to food safety through mineral balances, especially phosphorus (Mylona et al. 2018). While food systems mature to be able to cope with increased demand for new, healthier, and diverse diets, it is important that food safety is not neglected for other priorities.

## 4. Economic influences on individual and household dietary patterns

### *4.1 Incomes*

For most of human history and for many people today, poor diets are primarily a symptom of poverty, as malnourished people lack the means to produce and consume things that others have available to them (Sen 1981). Metabolic constraints ensure calorie balance over time (Smith et al. 2017), with sustained changes in dietary energy per person as in Figure 1 due primarily to shifts in age, height and weight, with some additional effect of changing health and physical activity, food waste and other factors. These biological constraints drive empirical regularities in food consumption associated with income, notably the 19th century observation known as Engel's Law that total food consumption changes less with income than demand for other things, and the 20th century finding known as Bennett's Law shown in Figure 1 as diversification away from starchy staples (Norton et al. 2014). Response to rising incomes include greater food security, meaning less experience of hunger and more consistent ability to obtain desired foods, as well as shifts in diet composition towards more animal sourced foods (ASF), more processed foods (Drewnowski and Popkin 1997; Zhou et al. 2015), and more food away from home (FAFH) (Jabs and Devine 2006, Smith et al. 2013, Popkin 2017). These choices form patterns that persist over the life cycle (Liu et al. 2015), so income changes have both short- and long-term impacts on food choice.

Incomes affect nutrition not only through an individual's own purchasing power, but also through their food environment in the sense of others' activity around them (Turner et al. 2018), and indirectly through time constraints (Rose 2007; Monsivais et al. 2013; Smith et al. 2013). The availability of nutritious foods is a determinant of dietary patterns, and a rich body of research on this topic has emerged, particularly in the public health literature regarding 'food deserts.' In the public health field, these studies typically examine the associations between distance from grocery stores and obesity, as in Rummo et al. (2014) in the context of critical perspectives such as Otero et al. (2015). In developing country contexts, investigations of food availability typically incorporate the role of local agricultural production as well, as in Herforth and Ahmed (2015) and Rosenberg et al. (2018). The role of food availability is important to examine, and this work has shifted from national-level food availability studies to the more useful but less frequently conducted household-level studies, as outlined carefully in Burchi and De Muro (2016).

New food processing, packaging and marketing techniques have responded to and shaped consumer preferences, bringing a sharp rise in the levels of added salt and other flavorings as well as sugar and other refined carbohydrates, including sugar in caloric beverages consumed as packaged foods or FAFH (Popkin 2017; Piperata et al. 2011). Increased use of these foods, as opposed to meals prepared at home in traditional ways, is linked to weight gain and rising body-mass index (BMI) among children and adolescents as well as adults, and larger fractions of each population classified as overweight or obese (Drewnowski and Popkin 1997; Abarca-Gómez et al. 2017; Ng et al. 2014; Ford and Dietz 2013; Ezzati et al. 2017). In low-income countries, it is usually richer people who can afford more of these foods and are more likely to become obese, while that wealth gradient reverses as national income rises so in high-income countries it is poorer people who consume less healthy foods and are more likely to become obese (Monteiro et al. 2004, Ford et al. 2017).

The per-capita average diet in higher-income countries generally includes more healthy items than in low-income countries, but also includes more unhealthy items (Imamura et al. 2015; Clements and Si

2015). Similar shifts in diet composition have been observed in Africa (Worku et al. 2017). Looking within countries, indices of overall diet quality such as the Healthy Eating Index (HEI) suggest some convergence between higher- and lower-income individuals in the U.S. (Beatty et al. 2014), as incomes and dietary preferences shift over time. Salois et al. (2012), Ogundari and Abdulai (2013), Ali et al. (2018), and Colen et al. (2018) find substantial variation in income elasticities across different contexts, and other settings where diet quality is not associated with income but linked instead with age and education (Gao et al. 2013).

As incomes grow, people typically improve food quality rather than quantity (e.g. Loos and Zeller 2014), with changes in total calorie intake tied primarily to changes in body size (Worku et al. 2017). In countries where a large proportion of the population receives income in the form of remittances from abroad, consumption volatility may be reduced but chronic undernutrition was not improved with these remittances (Thow et al. 2016), indicating that households may be increasing the quality rather than quantity of calories when incomes rise. Whether short-term changes in national average income reduces the prevalence of child undernutrition has been subject to some debate (Vollmer et al. 2014, Alderman et al. 2014, O'Connell and Smith 2016; Cummins and Aiyar 2018). This debate is related to the literature on dietary response to macroeconomic shocks such as the recession that began in 2007 (Smith et al. 2014), although there is some evidence that local unemployment rates are negatively associated with diet quality (Dave and Kelly 2012), and that economic insecurity is positively associated with obesity (Smith 2011).

Safety nets and transfers play a key role in mediating the link between household income and diet quality (Barrett 2002, Brugh et al. 2018). As in low-income countries, high-income places such as the United States often provide safety nets for food consumption, such as school meals or the U.S. program for Women, Infants and Children (WIC), or vouchers and electronic benefit cards with a fixed cash value to buy eligible products such as the U.S. Supplemental Nutrition Assistance Program (SNAP), sometimes with discounts and encouragement to buy healthier foods (Wilde et al. 2016). However, another example using Mexico data found that the effects of cash transfers on household nutritional status is very small due to substitution effects within staple food groups (Skoufias et al. 2011). Policies can also strategically invest in certain types of food outlets than others, depending on the specific socioeconomic characteristics of the communities at-risk for food insecurity (Taylor and Villas-Boas 2016). Large aggregate price shocks in the context of economic shocks such as recessions may induce large changes in estimated price and income elasticities (Dimova et al. 2014), necessitating careful attention paid to elasticities when designing policy.

*4.2 Prices*

Along with incomes, relative food prices are a major determinant of dietary patterns. In the U.S., healthier dietary patterns have been estimated to cost about $1.50 per day more than less healthy dietary patterns (Rao et al. 2013). In the model above (Figure 3), changing relative prices are reflected by rotations of the budget constraint. Own- and cross-price elasticities of food demand are complicated by variation in the time cost of preparing different foods, and covariance in the costs of similar foods that could substitute for each other and drive differences in diet quality, leading to the development of new food price indexes that reflect the overall cost of healthy diets (Masters et al. 2018). Food prices and consumption may be heavily influenced by changes in food away from home which is often poorly measured, which could help explain paradoxes in measured consumption (Smith 2015).

Shocks to the prices of individual foods or food price indices can affect welfare in different ways, depending on whether people are net food sellers or buyers (Ivanic and Martin 2008; Lederman and

Porto 2015). The most recent and pervasive shocks to global food prices have been in 2007-2009 and 2010-2011. During these periods, the prices of staple foods such as corn, wheat, rice, and soybeans rose significantly, increasing by between 50 percent and 300 percent over the baseline (Pinstrup-Andersen 2015; Headey and Fan 2008). The negative effects of food price volatility were higher in rural areas than urban areas in six African countries, and were higher in countries with only one major staple crop compared to several staple crops (Yu and Shimokawa 2016). Households in Latin America and in Africa spend a substantial proportion of their budgets on commodities, but these households also often produce commodities as part of their livelihood (Lederman and Porto 2015).

The relationship between food prices and dietary patterns depends on the nature of food price changes and the livelihoods of people affected by the price changes. People living in poverty are affected most (Headey and Fan 2008), but baseline conditions also matter. The impacts of a price increase of a local food basket on diets during the food price crisis in Nepal did not vary based on income level because households that were poorest also had rising incomes over the same period, and all households had poor dietary quality at baseline regardless of the crisis (Akhter et al. 2016). Examining the welfare impact patterns in uncertain political and environmental contexts is essential. Worldwide, aggregate food prices are expected to increase on average in the future, as well as be more volatile (von Braun and Tadesse 2012; Webb 2009), and higher food prices are associated with food insecurity and lower dietary quality (Brinkman et al. 2009; Chang et al. 2016). Since 1950, fruit and vegetable prices have increased in real terms (Christian and Rashad 2009). In India, relative prices for nutrient-dense vegetables have risen faster than relative prices for less nutrient-dense cereal crops (Meenakshi 2016).

A large body of literature in applied economics estimates own- and cross-price elasticities of foods using systems of demand equations such as the foundational Almost Ideal Demand System (AIDS) (Deaton and Muellbauer 1980). Extensions of this demand system including the Quadratic-AIDS model have demonstrated that cash transfers would be a better policy response to local price increases compared with price subsidies (Attanasio et al. 2013). In another example, the Linear-Approximate AIDS estimated that the demand for sugar sweetened beverages in Mexico was relatively elastic at >1 (Colchero et al. 2015). Using Monte Carlo Markov chain methods to extend the AIDS to foods that are purchased infrequently, Tiffin and Arnoult (2010) find that households with children have much lower demand for fruits and vegetables in the United Kingdom.

In an analysis of a consumer expenditure survey in India, own-price price elasticities within the group of pulses were high and there was high substitutions between types of pulses (Umanath et al. 2016). Using theoretically consistent whole demand models can also demonstrate the differential welfare effects of government policies on key demographic groups, such as for dairy regulation in the U.S. (Chouinard et al. 2008). These models can also be used to predict food demand in the future, although substantial uncertainty remains (Gouel and Guimbard 2017). Deriving compensated demand elasticities across food groups shows that different foods have different roles in the diet: some foods are necessities and others are luxuries, and this classification depends on income (Clements and Si 2016).

In economic models, the demand for nutrition can be separated from the demand for taste to examine the effects of changing circumstances (Silberberg 1985). Integrated models of demand which take disaggregated food groups into account are useful for understanding how dietary patterns change with the prices of individual foods, allowing for estimates of compensated and uncompensated own- and cross-price elasticities (Attanasio et al. 2013). However, the specific method and type of data used makes a difference when estimating price elasticities (Gibson and

Rozelle 2011; Teklu 1996), and meta-analyses of elasticity estimates may in fact be the most informative for guiding policies (Cornelsen et al. 2016, Ogundari and Abdulai 2013). Modern modeling of food demand using full demand systems in the U.S. and elsewhere could benefit from incorporating household production theory (Huffman 2011). Some empirical studies address household production theory indirectly, such as in Loos and Zeller (2014). The role of household production theory is especially important when studying the linkages between agricultural production and health status, which is a growing area of research (Pingali and Sunder 2017; Huffman 2011).

In the U.S., lower-income consumers have coping strategies when grocery shopping such as using store loyalty cards, but other strategies such as coupon use, shopping with a list, and reading nutrition facts labels are less accessible (Chang et al. 2016). Using an agent-based modeling simulation, nutrition scientists have examined food choice behaviors and found that the price of a food per calorie is the main metric that people with low incomes use in deciding what to purchase (Beheshti et al. 2016). Price increases for fast food, as measured by the Fast Food Price Index (FFPI), were associated with improved dietary quality. However, contrary to what would be expected, increased prices for fruits and vegetables as measured by the Fruit and Vegetable Price Index (FVPI) were associated with reductions in BMI and improvements in dietary quality (Beydoun et al. 2008). In the U.S., the richest adults are less likely to consume fast food compared to the poorest adults, but the differences between the richest and poorest cohorts is not large (Zagorsky and Smith 2017).

People living in countries with lower average incomes also have coping strategies when prices spike. In Senegal and the Republic of Congo, currency devaluation may support export markets, but also makes imported food more expensive, which negatively affects urban food purchasers who may resort to coping strategies like meal-skipping, and reducing consumption of fruits, vegetables, and fats (Fouere et al. 2000). In Vietnam, price increases induce changes in the composition of the diet, including a larger expenditure on rice as a starchy staple (Hoang 2018). There is typically an inverse relationship between the income and the price elasticities of foods (Beydoun et al. 2008; Green et al. 2013).

Governments may use prices as a lever for influencing consumer dietary choices. Economic analyses can help identify the most cost-effective ways for those taxes to be levied. Due to the regressiveness of sales taxes on foods (Muller et al. 2016), food security advocates have cautioned against the use of Pigouvian taxes for foods deemed unhealthy, and other experts find that excise taxes would be preferable to ad valorem taxes (Etile and Sharma 2015). In the context of a new hypothetical tax on added sugar, for example, equity across consumers may be ameliorated by subsidies on healthier foods and by taxing and subsidizing nutrients instead of foods (Bishai 2015). But under this system, disproportionate benefits would still be gained by those with higher incomes (Muller et al. 2016), and disproportionate losses would be felt by those with lower incomes. Estimating specific nutrient elasticities across many situations and contexts may be necessary in order to design an appropriate Pigouvian tax for foods, added sugars or saturated fats. Similarly, depending on the type of food-away-from-home and its elasticity, consumers will respond differently to food taxes. Using an instrumental variables approach, Richards and Mancino (2013) find that food consumed away from home is price elastic, and that fine dining is much more price elastic than fast-food, indicating that taxing fast food is unlikely to improve dietary quality or improve nutritional status in low-income populations (Richards and Mancino 2013).

*4.3 Preferences*

Through early interactions with food and family at home, children learn habits and make associations between eating and emotions, which affects relationships with food in later life (Benton 2004). In the model above (Figure 3), the indifference curves are a mapping of preferences. That indifference curves are convex to the origin, negatively sloped, and never intersect reflect consistent preferences, but these assumptions may be violated if cognitive biases interfere. Individuals and households try to reach the highest possible indifference curve with respect to their budget constraints, which involves making trade-offs between different types of goods. Indifference curves provide important insight into understanding nutrition interventions. Given the interconnectedness of factors which determine diets and of the diets themselves, focusing on improving nutritional status through providing single goods such as fortified vegetable oil or multivitamins may be misguided (Basu et al. 2016). Individuals and households attempt to reach the highest possible indifference curve with respect to their budget constraint, but they are also negotiating trade-offs within a consumer bundle between different types of goods at the same time. The indifference curve-budget line model in Figure 3 allows analysis of the trade-offs that households face, instead of assuming that the determinants of nutritional status are independent of other things as in Figure 2.

Preferences play an important role in what people decide to eat, and these preferences can be approximated using data on actual food choices. Individuals have their own food likes and dislikes, which develop over time as functions of tastes and experiences and in the contexts of diverse family, cultural, and community traditions. This complication makes it difficult to design universally effective policies; indeed, dietary change is highly context-specific. Even within countries, differences in food demand cannot be fully explained by differences in prices and incomes (Dubois et al. 2014). Brand names, invisible attributes, and perceived health attributes are important drivers of consumer food choices (Ahmand and Anders 2012; Bonroy and Costantatos 2014; Irz et al. 2016), as is food safety (Grunert 2005). As incomes grow, consumers in LMICs become more concerned with food safety issues, but there is little data on food safety in low-income contexts (Ortega and Tschirley 2017). For example, in comparing food prices between Madagascar and India which are both unregulated food markets, Vandeplas and Minten (2015) find that foods in India are of better quality in terms of food safety, and have higher premiums, which reflects different average income levels between the two countries.

Habits and choices within food groups play an important role in people's dietary patterns, demonstrated by Atkin (2013) in India, where households could have increased calorie consumption through reallocating food purchases, but did not do so. Recent work looks to examine consumer choices across different types of the same food, such as rice in Tanzania, where domestic and imported rice varieties are only weakly substitutable (Lazaro et al. 2017). Preferences within food groups also matter for more highly processed items like breakfast cereals, for which demand is inelastic for lower-nutrition and higher-nutrition items (Lin et al. 2017). Improvements in the measurement of disaggregated food demand in low- and middle-income countries have allowed for detailed investigations such as Lazaro et al. (2017), with details on intra-household allocation such as Finaret et al. (2018).

Poor quality assurance and market failure due to asymmetric information in is not limited to food safety, and also affects nutrient composition of packaged foods in many low- and middle-income countries (Masters et al. 2017), as well as consumer interest in non-nutrition related attributes of foods such as 'organic' or 'cage-free'. Despite demand for higher quality, market shares for premium foods remain limited, suggesting that a better understanding of the economics of information related to dietary choices is needed (Lusk 2018). Reducing information asymmetries about credence attributes through food labels may increase consumer well-being, but product differentiation through labeling could also increase market fragmentation (Bonroy and Costantatos 2014). In a natural experiment application using data on ready-to-eat breakfast cereals, the convenience of labeling for healthy foods increased the likelihood of that the healthier item would be chosen, through a decrease in search costs for healthy foods (Liu et al. 2015). However, a recent application of machine learning found that even if consumers understand the health benefits of dietary change and have incentives to make healthier dietary choices, it is difficult for them to actually change their diets (Hut and Oster 2018).

Methods from behavioral economics and psychology can examine the role of cognitive biases in dietary choices, such as reference dependence (Hu 2007). Choice experiments have demonstrated that consumers are interested in the carbon footprint of their foods, but specific food types and prices are still the primary influencers on food purchases (Apostolidid and McLeay 2016). Other choice experiments find evidence that generic information on nutrition labels is of less interest than specific, customizable information about foods related to their own health (Balcombe et al. 2016), even though the evidence base is weak for linking specific foods to specific diseases. Due to several social movements including those that promote local food, organic food, and food sovereignty, people can now purchase foods that have different environmental impacts than conventionally grown foods, and 'sustainable diets' are gaining traction among consumers (Blackstone et al. 2018; Johnston et al. 2014; Tilman and Clark 2014).

The role of government in consumer food choices arises mainly through efforts to increase information about nutrition and food attributes to the public through regulation, labeling, and dietary guidelines, which shift the relationships between food intake and nutritional status through the intensive margin (Beatty et al. 2014, Barrett 2002). However, messages about nutrition may be difficult to tailor across diverse populations. In examining the demand for whole-grain bread before and after the release of the Dietary Guidelines for Americans (DGA) in 2010, which urged people to consume at least 50% of their grains from whole-grain (WG) sources, Mancino and Kuchler (2012) find that effects differ depending on incomes. Higher income consumers increased their consumption of WG after the 2010 DGA, and lower income consumers did not (Mancino and Kuchler 2012). Government policies will also have different consequences depending on consumer expectations about future food availability, as demonstrated for China by Shimokawa (2013). The author finds that improvements in dietary knowledge will reduce calorie intake when expected food availability is increasing, such as within the context of an in-kind transfer or a reduction in prices. In contrast, when expectations of future food availability are decreasing, such as in the face of increasing prices, dietary knowledge will affect the quality of the diet but not the quantity of calories consumed (Shimokawa 2013).

Nutritional recommendations from government agencies have different effects depending on how foods are intertwined in the diet (Irz et al. 2015). Some models attempt to combine economic and epidemiological methods to simulate how food choices change with respect to different policy options. Accounting for consumer preferences as well as the nutritive value of foods, Irz et al. (2015) found that recommendations to reduce salt and increase fruit and vegetable consumption were more cost-effective than recommendations to increase fiber intake or reduce cholesterol. Policies should attempt to balance health benefits against the costs of giving up tastes that people like (Irz et al. 2016). This concept is consistent with economic thinking about balancing the marginal costs with the marginal benefits of consuming a particular food (Figure 3), but is not necessarily consistent with dietary advice from nutrition science, which is focused on maximizing physical health (Figure 2).

**5. New areas of focus for nutrition economics**

Economics research about nutrition has followed changes in other kinds of research on agriculture, food and health, with rapid adoption of new statistical methods and data sources for environmental as well as socioeconomic and biological variables. With each passing year, more observations from an increasingly diverse range of circumstances become available, improving generalizability and contextualization of findings (Masters et al. 2018). One key trend is the use of data over longer time spans to detect the later impacts of early-life shocks, relying on randomness in exposure for natural experiments in observational data. The literature on the developmental origins of disease spans several other disciplines including economics, and is based on the work of David J. Barker who posited that adverse conditions during pregnancy could affect child development and adult health outcomes (Barker 1990).

The effects of an adverse shock during gestation, infancy, or young childhood depend on the exact nature and timing of the shock, and thus the biological etiology of disease is especially important to incorporate in analyses. A current focus of the nutrition field is on mothers, infants, and young children due to the possibilities for this cohort of preventing malnutrition and its comorbidities, achieving higher benefit-to-cost ratios for programming activities, and addressing the immense impact of malnutrition on child mortality (Black et al. 2013). A recognition that malnutrition and its associated morbidities is rooted in inequalities of many kinds is emerging (Perez-Escamilla et al. 2018), which invites the expertise of applied economists for the measurement of social and economic variables, causal inference, and understanding the mechanisms behind food choices and dietary change, including randomized trials of incentives for individuals (Wilde et al. 2015) and caregivers (Singh and Masters 2017, 2018).

Incorporating data on agriculture, environment, and climate variables enhances the use of early-life shocks for identification in nutrition economics. This understanding has led to several important strands of literature in the area of linkages between agriculture and health (Pingali and Sunder 2017), although some studies in the public health literature do not incorporate economic thinking and instead focus on nearby food supplies as a static risk factor, such as in Krebs-Smith et al. (2010). Methods from behavioral economics such as choice experiments have the potential to increase internal and external validity especially when using 'big data' such as in Lusk (2017), with the accumulation of diverse datasets allowing identification of previously hidden forms of bias and measurement error such as Larsen et al. (2018) or Finaret and Hutchinson (2018). More and even better data on the agriculture-nutrition-health nexus, especially from low- and middle-income country contexts, would advance the field, as would better inclusion of scholars from those regions.

The measurement of agriculture, climate, and environmental variables using remotely sensed data and improved climate simulation models increases the potential for understanding the causal mechanisms behind nutrition outcomes, as does the disaggregation of food demand models into varieties of key commodities. Measurements are also improving for other key variables, such as prices (Masters et al. 2018), healthy eating (Guenther et al. 2013), food acquisition, dietary diversity (Martin-Prevel et al. 2017), and malnutrition (Webb et al. 2015). Using geocoded data has improved the ability to merge observations spatially and temporally (Ricketts 2003), allowing for analyses of the nutritional implications of food systems from field to fork to fettle.

Perhaps the most significant contribution of economics to the field of nutrition is improved causal inference, especially for questions that cannot be answered with ideally-designed randomized control trials. Faced with substantial criticism about evidence in nutrition science (Ioannidis 2018), those interested in studying nutrition outcomes can use empirical strategies from applied economics, to improve research and communicate results more effectively. Ioannidis (2018) calls for more large-scale randomized controlled trials in nutrition science to build a rigorous evidence base on the etiology of disease. Funding for those trials would be desirable but may not be forthcoming, and even when randomized trials are done nutrition researchers could benefit from using economic methods such as falsification tests with placebo outcomes, bounds on possible bias from selective attrition, and randomization inference to the limitations of any finite sample. Applied economics can help with understanding mechanisms for changes seen in nutritional outcomes, potential confounders in observational data, as well as developing empirical strategies to address confounding and bias.

## 6. Conclusion

Food consumption and health outcomes involve a complex web of simultaneous changes. Economists interested in nutrition aim to disentangle the effects of specific interventions and other changes one at a time, in relation to the system as a whole. Until the late 20th century, the primary concern in agriculture and the food system was to meet energy needs associated with population growth, economic development and consumer demand. More recently, concerns about other aspects of food have led to a new economics of nutrition that focuses on diet quality and its implications for health and human development, including the rapid spread of obesity and diet-related diseases alongside continued micronutrient deficiencies, food safety concerns and other interrelated challenges.

The new economics of nutrition reveals how individual and community-level differences in income, prices, and preferences drive food choice and health outcomes, mediated by differences in biological and agroecological conditions as well as culture, habits, traditions, and social norms. Going forward, more critical analyses of the structures that influence dietary choices will help complement work in economics and nutritional epidemiology. Given that dietary change towards disease-preventing dietary patterns is highly context-specific, research should aim to inform and influence policies for nutrition improvement that take account of heterogeneity and change over time among individuals and communities. Extending research beyond calories reflects past achievements in raising food supplies to meet energy needs, leading to a focus on diet quality and other aspects of nutrition economics described in this review.

## References

Abarca-Gómez, L., Abdeen, Z. A., Hamid, Z. A., Abu-Rmeileh, N. M., Acosta-Cazares, B., Acuin, C., . . . Aguilar-Salinas, C. A. (2017a). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128· 9 million children, adolescents, and adults. *The Lancet, 390*(10113), 2627-2642.

Ahmad, W., & Anders, S. (2012). The value of brand and convenience attributes in highly processed food products. *Canadian Journal of Agricultural Economics, 60*(1), 113-133.

Akhter, N., Saville, N., Shrestha, B., Manandhar, D. S., Osrin, D., Costello, A., & Seal, A. (2018). Change in cost and affordability of a typical and nutritionally adequate diet among socio-economic groups in rural nepal after the 2008 food price crisis. *Food Security, 10*(3), 615-629.

Alderman, H. and Fernald, L., 2017. The nexus between nutrition and early childhood development. *Annual review of nutrition*, *37*, pp.447-476.

Alderman, H., Haddad, L., Headey, D. D., & Smith, L. (2014). Association between economic growth and early childhood nutrition. *The Lancet Global Health, 2*(9), e500.

Alderman, H., Hoddinott, J., & Kinsey, B. (2006). Long term consequences of early childhood malnutrition. *Oxford Economic Papers, 58*(3), 450-474.

Ali, M., Villa, K.M. and Joshi, J., 2018. Health and hunger: nutrient response to income depending on caloric availability in Nepal. *Agricultural Economics*, *49*(5), pp.611-621.

Apostolidis, C., & McLeay, F. (2016). Should we stop meating like this? reducing meat consumption through substitution. *Food Policy, 65*, 74-89.

Atkin, D. (2013). Trade, tastes, and nutrition in India. *American Economic Review, 103*(5), 1629-1663.

Attanasio, O., Di Maro, V., Lechene, V., & Phillips, D. (2013). Welfare consequences of food prices increases: Evidence from rural mexico. *Journal of Development Economics, 104*, 136-151.

Balcombe, K., Fraser, I., Lowe, B., & Souza Monteiro, D. (2015). Information customization and food choice. *American Journal of Agricultural Economics, 98*(1), 54-73.

Barker, D. J. (1990). The fetal and infant origins of adult disease. *BMJ: British Medical Journal, 301*(6761), 1111.

Babu, S., Gajanan, S.N. and Hallam, J.A., 2016. *Nutrition economics: Principles and policy applications*. Academic Press.

Beatty, T. K., Lin, B., & Smith, T. A. (2014). Is diet quality improving? distributional changes in the united states, 1989–2008. *American Journal of Agricultural Economics, 96*(3), 769-789.

Beheshti, R., Igusa, T., & Jones-Smith, J. (2016). Simulated models suggest that price per calorie is the dominant price metric that low-income individuals use for food decision Making–3. *The Journal of Nutrition, 146*(11), 2304-2311.

Benton, D. (2004). Role of parents in the determination of the food preferences of children and the development of obesity. *International Journal of Obesity, 28*(7), 858.

Beydoun, M. A., Powell, L. M., & Wang, Y. (2008). The association of fast food, fruit and vegetable prices with dietary intakes among US adults: Is there modification by family income? *Social Science & Medicine, 66*(11), 2218-2229.

Bishai, D. (2015). Generalized nutrient taxes can increase consumer welfare. *Health Economics, 24*(11), 1517-1522.

Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., De Onis, M., . . . Martorell, R. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet, 382*(9890), 427-451.

Black, M.M., Pérez-Escamilla, R. and Fernandez Rao, S., 2015. Integrating Nutrition and Child Development Interventions: Scientific Basis, Evidence of Impact, and Implementation Considerations–. *Advances in Nutrition*, *6*(6), pp.852-859.

Blackstone, N. T., El-Abbadi, N. H., McCabe, M. S., Griffin, T. S., & Nelson, M. E. (2018). Linking sustainability to the healthy eating patterns of the dietary guidelines for americans: A modelling study. *The Lancet Planetary Health, 2*(8), e352.

Bonroy, O., & Constantatos, C. (2014). On the economics of labels: How their introduction affects the functioning of markets and the welfare of all participants. *American Journal of Agricultural Economics, 97*(1), 239-259.

Brinkman, H., de Pee, S., Sanogo, I., Subran, L., & Bloem, M. W. (2009). High food prices and the global financial crisis have reduced access to nutritious food and worsened nutritional status and health. *The Journal of Nutrition, 140*(1), 161S.

Bronfenbrenner, U. (1979). *The ecology of human development*. Cambridge: Harvard University Press.

Brugh, K., Angeles, G., Mvula, P., Tsoka, M., & Handa, S. (2018). Impacts of the Malawi social cash transfer program on household food and nutrition security. *Food Policy, 76*, 19-32.

Bureau of Labor Statistics (2018), *Occupational Outlook Handbook: Dieticians and Nutritionists.* Washington, DC: BLS. https://www.bls.gov/ooh/healthcare/dietitians-and-nutritionists.htm

Burchi, F. and De Muro, P., 2016. From food availability to nutritional capabilities: Advancing food security analysis. *Food Policy*, *60*, pp.10-19.

Chang, Y., Kim, J., & Chatterjee, S. (2016). The effect of food price on food insecurity and diet quality: Exploring potential moderating roles of SNAP and consumer competency.

Chouinard, H. H., Davis, D. E., LaFrance, J. T., & Perloff, J. M. (2010). Milk marketing order winners and losers. *Applied Economic Perspectives and Policy, 32*(1), 59-76.

Clements, K. W., & Si, J. (2016). Price elasticities of food demand: Compensated vs uncompensated. *Health Economics, 25*(11), 1403-1408.

Clements, K. W., & Si, J. (2017). Engel's law, diet diversity, and the quality of food consumption. *American Journal of Agricultural Economics, 100*(1), 1-22.

Colchero, M. A., Salgado, J. C., Unar-Munguia, M., Hernandez-Avila, M., & Rivera-Dommarco, J. A. (2015). Price elasticity of the demand for sugar sweetened beverages and soft drinks in mexico. *Economics & Human Biology, 19*, 129-137.

Colen, L., Melo, P. C., Abdul-Salam, Y., Roberts, D., Mary, S., & Paloma, S. G. Y. (2018). Income elasticities for food, calories and nutrients across africa: A meta-analysis. *Food Policy, 77*, 116-132.

Conde, W. L., & Monteiro, C. A. (2014). Nutrition transition and double burden of undernutrition and excess of weight in brazil–. *The American Journal of Clinical Nutrition, 100*(6), 1622S.

Cornelsen, L., Mazzocchi, M., Green, R., Dangour, A. D., & Smith, R. D. (2016). Estimating the relationship between food prices and food consumption—methods matter. *Applied Economic Perspectives and Policy, 38*(3), 546-561.

Cummins, J., & Aiyar, A. (2018). Age-profile estimates of the relationship between economic growth and child health. *Age-Profile Estimates of the Relationship between Economic Growth and Child Health,*

Dave, D. M., & Kelly, I. R. (2012). How does the business cycle affect eating habits? *Social Science & Medicine, 74*(2), 254-262.

Deaton, A., & Muellbauer, J. (1980a). An almost ideal demand system. *The American Economic Review, 70*(3), 312-326.

Deaton, A., & Muellbauer, J. (1980b). An almost ideal demand system. *The American Economic Review, 70*(3), 312-326.

Del Gobbo, L.C., Khatibzadeh, S., Imamura, F., Micha, R., Shi, P., Smith, M., Myers, S.S. and Mozaffarian, D., 2015. Assessing global dietary habits: a comparison of national estimates from the FAO and the Global Dietary Database. *American Journal of Clinical Nutrition*, 101(5), pp.1038-1046.

Dimova, R., Gang, I. N., Gbakou, M. B., & Hoffman, D. (2014). The impact of food and economic crises on diet and nutrition. *The Journal of Development Studies, 50*(12), 1687-1699.

Dubois, P., Griffith, R., & Nevo, A. (2014). Do prices and attributes explain international differences in food purchases? *American Economic Review, 104*(3), 832-867.

Etilé, F., & Sharma, A. (2015). Do high consumers of Sugar-Sweetened beverages respond differently to price changes? A finite mixture IV-Tobit approach. *Health Economics, 24*(9), 1147-1163.

Etzel, R. A. (2014). Reducing malnutrition: Time to consider potential links between stunting and mycotoxin exposure? *Pediatrics, 134*(1), 4-6.

Finaret, A.B. (2016). Nonviolent civil insecurity is negatively associated with subsequent height-for-age in children aged< 5 y born between 1998 and 2014 in rural areas of Africa, 2. The *American Journal of Clinical Nutrition*, 105(2), 485-493.

Finaret, A.B. and Hutchinson, M. (2018). Missingness of Height Data from the Demographic and Health Surveys in Africa between 1991 and 2016 Was Not Random but Is Unlikely to Have Major Implications for Biases in Estimating Stunting Prevalence or the Determinants of Child Height. *Journal of Nutrition*, 148(5), pp.781-789.

Finaret, A. B., Miller, L. C., Joshi, N., Mahato, S., Lohani, M., Drozdowsky, J., & Rogers, B. L. (2018). Longitudinal analysis of the intrahousehold distribution of foods in rural Nepal: Relative variability of child dietary quality across age and sex cohorts. *Food Policy*, 79, 101-110.

Ford, E. S., & Dietz, W. H. (2013). Trends in energy intake among adults in the united states: Findings from NHANES. *The American Journal of Clinical Nutrition, 97*(4), 848.

Ford, N.D., Patel, S.A. and Narayan, K.V., 2017. Obesity in low-and middle-income countries: burden, drivers, and emerging challenges. *Annual Review of Public Health*, 38, pp.145-164.

Forrester, J.W., 2007. System dynamics—a personal view of the first fifty years. *System Dynamics Review*, 23(2-3), 345-358.

Fouere, T., Maire, B., Delpeuch, F., Martin-Prevel, Y., Tchibindat, F., & Adoua-Oyila, G. (2000). Dietary changes in african urban households in response to currency devaluation: Foreseeable risks for health and nutrition. *Public Health Nutrition, 3*(3), 293-301.

Gao, Z., Yu, X., & Lee, J. (2013). Consumer demand for diet quality: Evidence from the healthy eating index. *Australian Journal of Agricultural and Resource Economics, 57*(3), 301-319.

Gerbens-Leenes, P. W., Nonhebel, S., & Krol, M. S. (2010). Food consumption patterns and economic growth. increasing affluence and the use of natural resources. *Appetite, 55*(3), 597-608.

Gibson, J., & Rozelle, S. (2011). The effects of price on household demand for food and calories in poor countries: Are our databases giving reliable estimates? *Applied Economics, 43*(27), 4021-4031.

Gouel, C., & Guimbard, H. (2017). Nutrition transition and the structure of global food demand. *American Journal of Agricultural Economics,*

Grace, D. (2015). Food safety in low and middle income countries. *International Journal of Environmental Research and Public Health, 12*(9), 10490-10507.

Green, R., Cornelsen, L., Dangour, A. D., Turner, R., Shankar, B., Mazzocchi, M., & Smith, R. D. (2013). The effect of rising food prices on food consumption: Systematic review with meta-regression. *Bmj, 346*, f3703.

Grunert, K. G. (2005). Food quality and safety: Consumer perception and demand. *European Review of Agricultural Economics, 32*(3), 369-391.

Guenther, P. M., Casavale, K. O., Reedy, J., Kirkpatrick, S. I., Hiza, H. A., Kuczynski, K. J., . . . Krebs-Smith, S. M. (2013). Update of the healthy eating index: HEI-2010. *Journal of the Academy of Nutrition and Dietetics, 113*(4), 569-580.

Häsler, B., Dominguez-Salas, P., Fornace, K., Garza, M., Grace, D., & Rushton, J. (2017). Where food safety meets nutrition outcomes in livestock and fish value chains: A conceptual approach. *Food Security, 9*(5), 1001-1017.

Häsler, B., Msalya, G., Garza, M., Fornace, K., Eltholth, M., Kurwijila, L., . . . Grace, D. (2018). Integrated food safety and nutrition assessments in the dairy cattle value chain in tanzania. *Global Food Security,*

Headey, D., & Fan, S. (2008). Anatomy of a crisis: The causes and consequences of surging food prices. *Agricultural Economics, 39*, 375-391.

Herforth, A. and Ahmed, S., 2015. The food environment, its effects on dietary consumption, and potential for measurement within agriculture-nutrition interventions. *Food Security*, *7*(3), pp.505-520.

Hic̦, C., Pradhan, P., Rybski, D. and Kropp, J.P., 2016. Food surplus and its climate burdens. *Environmental Science & Technology*, 50(8), pp.4269-4277.

Hoang, H. K. (2018). Analysis of food demand in vietnam and short‐term impacts of market shocks on quantity and calorie consumption. *Agricultural Economics, 49*(1), 83-95.

Hu, F.B. (2002). Dietary pattern analysis: a new direction in nutritional epidemiology. *Current Opinion in Lipidology*, 13(1), pp.3-9.

Hu, W. (2007). Bargains or rip-offs? reference price effects in conjoint stated demand. *Journal of Agricultural and Resource Economics,* , 256-272.

Huffman, W. E. (2011). Household production and the demand for food and other inputs: US evidence. *Journal of Agricultural and Resource Economics,* , 465-487.

Hut, S., & Oster, E. (2018). Changes in household diet: Determinants and predictability.

Imamura, F., Micha, R., Khatibzadeh, S., Fahimi, S., Shi, P., Powles, J., . . . Global Burden of Diseases Nutrition and Chronic Diseases Expert Group (NutriCoDE. (2015). Dietary quality among men and women in 187 countries in 1990 and 2010: A systematic assessment. *The Lancet Global Health, 3*(3), e142.

Irz, X., Leroy, P., Réquillart, V., & Soler, L. (2015). Economic assessment of nutritional recommendations. *Journal of Health Economics, 39*, 188-210.

Irz, X., Leroy, P., Réquillart, V., & Soler, L. (2016). Beyond wishful thinking: Integrating consumer preferences in the assessment of dietary recommendations. *PloS One, 11*(6), e0158453.

Ivanic, M., & Martin, W. (2008). *Implications of higher global food prices for poverty in low-income countries* The World Bank.

Jabs, J., & Devine, C. M. (2006). Time scarcity and food choices: An overview. *Appetite, 47*(2), 196-204.

Johnston, J. L., Fanzo, J. C., & Cogill, B. (2014). Understanding sustainable diets: A descriptive analysis of the determinants and processes that influence diets and their impact on health, food security, and environmental sustainability–. *Advances in Nutrition, 5*(4), 418-429.

Kotloff, K. L., Platts-Mills, J. A., Nasrin, D., Roose, A., Blackwelder, W. C., & Levine, M. M. (2017). Global burden of diarrheal diseases among children in developing countries: Incidence, etiology, and insights from new molecular diagnostic techniques. *Vaccine, 35*(49), 6783-6789.

Krebs-Smith, S. M., Reedy, J., & Bosire, C. (2010). Healthfulness of the US food supply: Little improvement despite decades of dietary guidance. *American Journal of Preventive Medicine, 38*(5), 472-477.

Larsen, A., Headey, D., & Masters, W. A. (2018). Misreporting Month of Birth: Implications for Research on Nutrition and Early Childhood in Developing Countries. *Demography,* in press (Prepring online at https://ssrn.com/abstract=2907726)

Lazaro, E., Sam, A. G., & Thompson, S. R. (2017). Rice demand in tanzania: An empirical analysis. *Agricultural Economics, 48*(2), 187-196.

Lederman, D., & Porto, G. (2015). The price is not always right: On the impacts of commodity prices on households (and countries). *The World Bank Research Observer, 31*(1), 168-197.

Lin, B., Dong, D., Carlson, A., & Rahkovsky, I. (2017). Potential dietary outcomes of changing relative prices of healthy and less healthy foods: The case of ready-to-eat breakfast cereals. *Food Policy, 68*, 77-88.

Liu, H., Wahl, T. I., Seale, J. L., & Bai, J. (2015). Household composition, income, and food-away-from-home expenditure in urban china. *Food Policy, 51*, 97-103.

Loos, T. K., & Zeller, M. (2014). Milk sales and dietary diversity among the maasai. *Agricultural Economics, 45*(S1), 77-90.

Lusk, J. L. (2017). Consumer research with big data: Applications from the food demand survey (FooDS). *American Journal of Agricultural Economics, 99*(2), 303-320.

Lusk, J. L. (2018). Separating myth from reality: An analysis of socially acceptable credence attributes. *Annual Review of Resource Economics,* (0)

Mancino, L., & Kuchler, F. (2011). Demand for whole-grain bread before and after the release of dietary guidelines. *Applied Economic Perspectives and Policy, 34*(1), 76-101.

Masters, W. A., Nene, M. D., & Bell, W. (2017). Nutrient composition of premixed and packaged complementary foods for sale in low-and middle-income countries: Lack of standards threatens infant growth. *Maternal & Child Nutrition*, 13(4), e12421.

Masters, W. A., Bai, Y., Herforth, A., Sarpong, D. B., Mishili, F., Kinabo, J., & Coates, J. C. (2018). Measuring the affordability of nutritious diets in Africa: Price indexes for diet diversity and the cost of nutrient adequacy. *American Journal of Agricultural Economics, 100(5), 1285-1301*.

Masters, W. A., Rosenblum, N. Z. & Alemu, R. G. (2018). Agricultural transformation, nutrition transition and food policy in Africa: Preston curves reveal new stylized facts. *Journal of Development Studies, 54*(5), 788-802.

Mayen, A., Marques-Vidal, P., Paccaud, F., Bovet, P., & Stringhini, S. (2014). Socioeconomic determinants of dietary patterns in low-and middle-income countries: A systematic review. *American Journal of Clinical Nutrition, 100*(6), 1520-1531.

Meenakshi, J. V. (2016). Trends and patterns in the triple burden of malnutrition in India. *Agricultural Economics, 47*(S1), 115-134.

Meyer, B. D., & Sullivan, J. X. (2013). Consumption and income inequality and the great recession. *American Economic Review, 103*(3), 178-183.

Micha, R., Coates, J., Leclercq, C., Charrondiere, U.R. and Mozaffarian, D., 2018. Global Dietary Surveillance: Data Gaps and Challenges. *Food and Nutrition Bulletin*, 39(2), pp.175-205.

Miller, D. D., & Welch, R. M. (2013). Food system strategies for preventing micronutrient malnutrition. *Food Policy, 42*, 115-128.

Monsivais, P., Aggarwal, A. and Drewnowski, A., 2014. Time spent on home food preparation and indicators of healthy eating. *American journal of preventive medicine*, *47*(6), pp.796-802.

Monteiro, C.A., Conde, W.L., Lu, B. and Popkin, B.M., 2004. Obesity and inequities in health in the developing world. *International Journal of Obesity*, 28(9), p.1181.

Mozaffarian, D., Rosenberg, I., & Uauy, R. (2018). History of modern nutrition science—implications for current research, dietary guidelines, and food policy. *Bmj, 361*, k2392.

Muller, L., Lacroix, A., Lusk, J. L., & Ruffieux, B. (2017). Distributional impacts of fat taxes and thin subsidies. *The Economic Journal, 127*(604), 2066-2092.

Ng, S. W., Slining, M. M., & Popkin, B. M. (2014). Turning point for US diets? recessionary effects or behavioral shifts in foods purchased and consumed–. *The American Journal of Clinical Nutrition, 99*(3), 609-616.

Norton, G.W., Alwang, J. and Masters, W.A., 2014. *The economics of agricultural development: world food systems and resource use*. New York: Routledge.

O'Connell, S. A., & Smith, C. (2016). Economic growth and child undernutrition. *The Lancet Global Health, 4*(12), e902.

Ogundari, K., & Abdulai, A. (2013). Examining the heterogeneity in calorie–income elasticities: A meta-analysis. *Food Policy, 40*, 119-128.

Ortega, D. L., & Tschirley, D. L. (2017). Demand for food safety in emerging and developing countries: A research agenda for asia and sub-saharan africa. *Journal of Agribusiness in Developing and Emerging Economies, 7*(1), 21-34.

Otero, G., Pechlaner, G., Liberman, G., & Gürcan, E. (2015). The neoliberal diet and inequality in the United States. *Social Science & Medicine, 142*, 47-55.

Oxford Dictionaries (2018), *Oxford English Dictionary*.  Online at www.oxforddictionaries.com.

Perez-Escamilla, R., Bermudez, O., Buccini, G. S., Kumanyika, S., Lutter, C. K., Monsivais, P., & Victora, C. (2018). Nutrition disparities and the global burden of malnutrition. *Bmj, 361*, k2252.

Pinstrup-Andersen, P. (2015). *Food price policy in an era of market instability: A political economy analysis* Wider Studies in Development E.

Piperata, B. A., Ivanova, S. A., Da-gloria, P., Veiga, G., Polsky, A., Spence, J. E., & Murrieta, R. S. (2011). Nutrition in transition: Dietary patterns of rural amazonian women during a period of economic change. *American Journal of Human Biology, 23*(4), 458-469.

Popkin, B. M. (2017). Relationship between shifts in food system dynamics and acceleration of the global nutrition transition. *Nutrition Reviews, 75*(2), 73-82.

Popkin, B.M. and Gordon-Larsen, P., 2004. The nutrition transition: worldwide obesity dynamics and their determinants. *International journal of obesity*, *28*(S3), p.S2.

Prasad, V., & Jena, A. B. (2013). Prespecified falsification end points: Can they validate true observational associations? *Jama, 309*(3), 241-242.

Rao, M., Afshin, A., Singh, G., & Mozaffarian, D. (2013). Do healthier foods and diet patterns cost more than less healthy options? A systematic review and meta-analysis. *BMJ Open, 3*(12), e004277.

Richards, T. J., & Mancino, L. (2013). Demand for food-away-from-home: A multiple-discrete–continuous extreme value model. *European Review of Agricultural Economics, 41*(1), 111-133.

Ricketts, T. C. (2003a). Geographic information systems and public health. *Annual Review of Public Health, 24*(1), 1-6.

Ricketts, T. C. (2003b). Geographic information systems and public health. *Annual Review of Public Health, 24*(1), 1-6.

Rose, D., 2007. Food stamps, the Thrifty Food Plan, and meal preparation: the importance of the time dimension for US nutrition policy. *Journal of Nutrition Education and Behavior*, *39*(4), pp.226-232.

Rosenberg, A.M., Maluccio, J.A., Harris, J., Mwanamwenge, M., Nguyen, P.H., Tembo, G. and Rawat, R., 2018. Nutrition-sensitive agricultural interventions, agricultural diversity, food access and child dietary diversity: Evidence from rural Zambia. *Food Policy*, *80*, pp.10-23.

Rummo, P.E., Meyer, K.A., Boone-Heinonen, J., Jacobs Jr, D.R., Kiefe, C.I., Lewis, C.E., Steffen, L.M. and Gordon-Larsen, P., 2015. Neighborhood availability of convenience stores and diet quality: findings from 20 years of follow-up in the coronary artery risk development in young adults study. *American journal of public health*, *105*(5), pp.e65-e73.

Salois, M. J., Tiffin, R., & Balcombe, K. G. (2012). Impact of income on nutrient intakes: Implications for undernourishment and obesity. *The Journal of Development Studies, 48*(12), 1716-1730.

Sari, M., de Pee, S., Bloem, M. W., Sun, K., Thorne-Lyman, A. L., Moench-Pfanner, R., . . . Semba, R. D. (2009). Higher household expenditure on animal-source and nongrain foods lowers the risk of stunting among children 0–59 months old in indonesia: Implications of rising food prices–. *The Journal of Nutrition, 140*(1), 200S.

Sarmiento, O. L., Parra, D. C., González, S. A., González-Casanova, I., Forero, A. Y., & Garcia, J. (2014). The dual burden of malnutrition in colombia–. *The American Journal of Clinical Nutrition, 100*(6), 1635S.

Sen, A. (1982). *Poverty and famines: An essay on entitlement and deprivation* Oxford university press.

Shimokawa, S. (2013). When does dietary knowledge matter to obesity and overweight prevention? *Food Policy, 38*, 35-46.

Siddiqui, M. Z., Donato, R., & Jumrani, J. (2017). Looking past the indian calorie debate: What is happening to nutrition transition in india. *The Journal of Development Studies,* , 1-20.

Silberberg, E. (1985). Nutrition and the demand for tastes. *Journal of Political Economy, 93*(5), 881-900.

Singh, P., & Masters, W. A. (2017). Impact of caregiver incentives on child health: Evidence from an experiment with Anganwadi workers in India. *Journal of Health Economics*, 55, 219-231.

Singh, P. & Masters, W. A. (2018). Performance bonuses in the public sector: Winner-take-all prizes versus proportional payments to reduce child malnutrition in India. *Journal of Development Economics*, in press (Online at doi.org/10.1016/j.jdeveco.2018.10.003).

Skoufias, E., Di Maro, V., González-Cossío, T., & Ramirez, S. R. (2011). Food quality, calories and household income. *Applied Economics, 43*(28), 4331-4342.

Smith, A., A. Collene and C. Spees (2017). *Wardlaw's Contemporary Nutrition: A Functional Approach*, 5th ed. New York: McGraw-Hill.

Smith, L. P., Ng, S. W., & Popkin, B. M. (2013). Trends in US home food preparation and consumption: Analysis of national nutrition surveys and time use studies from 1965–1966 to 2007–2008. *Nutrition Journal, 12*(1), 45.

Smith, L. P., Ng, S. W., & Popkin, B. M. (2014). Resistant to the recession: Low-income adults' maintenance of cooking and away-from-home eating behaviors during times of economic turbulence. *American Journal of Public Health, 104*(5), 840-846.

Smith, L. C. (2015). The great indian calorie debate: Explaining rising undernourishment during india's rapid economic growth. *Food Policy, 50*, 53-67.

Smith, T. G. (2011). Economic stressors and the demand for "fattening" foods. *American Journal of Agricultural Economics, 94*(2), 324-330.

Sudfeld, C.R., McCoy, D.C., Danaei, G., Fink, G., Ezzati, M., Andrews, K.G. and Fawzi, W.W., 2015. Linear growth and child development in low-and middle-income countries: a meta-analysis. *Pediatrics*, *135*(5), pp.e1266-e1275.

Taylor, R., & Villas-Boas, S. B. (2016). Food store choices of poor households: A discrete choice analysis of the national household food acquisition and purchase survey (FoodAPS). *American Journal of Agricultural Economics, 98*(2), 513-532.

Teklu, T. (1996). Food demand studies in sub-saharan africa: A survey of empirical evidence. *Food Policy, 21*(6), 479-496.

Thorne-Lyman, A. L., Valpiani, N., Sun, K., Semba, R. D., Klotz, C. L., Kraemer, K., . . . Sari, M. (2009). Household dietary diversity and food expenditures are closely linked in rural bangladesh, increasing the risk of malnutrition due to the financial Crisis–3. *The Journal of Nutrition, 140*(1), 188S.

Thow, A. M., Fanzo, J., & Negin, J. (2016). A systematic review of the effect of remittances on diet and nutrition. *Food and Nutrition Bulletin, 37*(1), 42-64.

Tiffin, R., & Arnoult, M. (2010). The demand for a healthy diet: Estimating the almost ideal demand system with infrequency of purchase. *European Review of Agricultural Economics, 37*(4), 501-521.

Tilman, D., & Clark, M. (2014). Global diets link environmental sustainability and human health. *Nature, 515*(7528), 518.

Todd, J. E., & Scharadin, B. (2016). Where households get food in a typical week: Findings from USDA's FoodAPS. *Where Households Get Food in a Typical Week: Findings from USDA's FoodAPS,*

Turner, C., Aggarwal, A., Walls, H., Herforth, A., Drewnowski, A., Coates, J., Kalamatianou, S. and Kadiyala, S., 2018. Concepts and critical perspectives for food environment research: A global framework with implications for action in low-and middle-income countries. *Global Food Security*, 18, 93-101.

Umanath, M., Chengappa, P. G., & Vijayasarathy, K. (2016). Consumption pattern and nutritional intake of pulses by segregated income groups in India. *Agricultural Economics Research Review, 29*(Conference Number), 53-64.

UNICEF (1990). Strategy for Improved Nutrition of Children and Women in Developing Countries. New York: UNICEF.

Vandeplas, A., & Minten, B. (2015). Food quality in domestic markets of developing economies: A comparative study of two countries. *Agricultural Economics, 46*(5), 617-628.

Vollmer, S., Harttgen, K., Subramanyam, M. A., Finlay, J., Klasen, S., & Subramanian, S. V. (2014). Association between economic growth and early childhood undernutrition: Evidence from 121 demographic and health surveys from 36 low-income and middle-income countries. *The Lancet Global Health, 2*(4), e234.

von Braun, J., & Tadesse, G. (2012). Global food price volatility and spikes: An overview of costs, causes, and solutions.

Waehrer, G., Deb, P., & Decker, S. L. (2015). Did the 2009 american recovery and reinvestment act affect dietary intake of low-income individuals? *Economics & Human Biology, 19*, 170-183.

Webb, P. (2009). Medium-to long-run implications of high food prices for global nutrition. *The Journal of Nutrition, 140*(1), 147S.

Webb, P., Luo, H., & Gentilini, U. (2015). Measuring multiple facets of malnutrition simultaneously: The missing link in setting nutrition targets and policymaking. *Food Security, 7*(3), 479-492.

Wilde, P., Klerman, J.A., Olsho, L.E. and Bartlett, S., 2015. Explaining the Impact of USDA's Healthy Incentives Pilot on Different Spending Outcomes. *Applied Economic Perspectives and Policy*, 38(4), 655-672.

Worku, I. H., Dereje, M., Minten, B., & Hirvonen, K. (2017). Diet transformation in africa: The case of ethiopia. *Agricultural Economics, 48*(S1), 73-86.

Yu, X., & Shimokawa, S. (2016). Nutritional impacts of rising food prices in african countries: A review. *Food Security, 8*(5), 985-997.

Zagorsky, J. L., & Smith, P. K. (2017). The association between socioeconomic status and adult fast-food consumption in the US. *Economics & Human Biology, 27*, 12-25.

Zhou, Y., Du, S., Su, C., Zhang, B., Wang, H., & Popkin, B. M. (2015). The food retail revolution in china and its association with diet and health. *Food Policy, 55*, 92-100.

Zhu, C., Lopez, R. A., & Liu, X. (2015). Information cost and consumer choices of healthy foods. *American Journal of Agricultural Economics*, 98(1), 41-53.