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Transitioning Toward Nutrition-Sensitive Food Systems in Developing Countries

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Abstract

A nutrition-sensitive food system is one that goes beyond staple grain productivity and places emphasis on the consumption of micronutrient-rich nonstaples through a variety of market and nonmarket interventions. A nutrition-sensitive approach not only considers policies related to macrolevel availability and access to nutritious food, but it also focuses on household- and individual-level determinants of improved nutrition. In addition to agriculture, intrahousehold equity, behavior change, food safety, and access to clean water and sanitation are integral components of the food system. This article provides a detailed review, from an economic perspective, on the multisectoral pathways through which agriculture influences nutrition. A critical challenge is to identify and implement food and nutrition policies that are appropriate to the particular stage of structural transformation in the country of concern.

1. INTRODUCTION

Food systems are typically defined as all of the activities involved in the production, distribution, and consumption of food. This includes the processes related to growing crops, keeping livestock, harvesting the products, postproduction processing, packaging, transport, and consumption. In this review, we use this definition and extend it to include the intrahousehold distribution of food and the individual-level absorption and intake of micronutrients. A nutrition-sensitive approach not only considers policies related to macrolevel availability of and access to nutrient-dense food, but it also focuses on household- and individual-level determinants of improved nutrition. In addition to focusing on nutrition outcomes, this approach also addresses nutritional concerns throughout the food system in a holistic policy framework.

Making the whole food system more nutrition sensitive requires a deliberate policy-oriented approach, which includes a combination of nutrition-specific interventions, infrastructure investments, and producer incentives that complement each other. The overarching aim is to enhance the diversity, quality, and safety of the food system and make it more accessible and inclusive to all people at all times. This requires special policy attention toward vulnerable groups, especially in low-income developing countries.

Part of this holistic approach is the need to promote dietary diversity. More diverse diets are balanced in calorie, protein, and micronutrient intakes (Arimond et al. 2010, Arsenault et al. 2013, Kant 2004) and lead to better anthropometric outcomes for all age groups (Arimond & Ruel 2004, Busert et al. 2016, Rah et al. 2010) and better overall cognitive outcomes (Clausen et al. 2005, Wengreen et al. 2009). In less productive subsistence agricultural systems, farm production diversity plays a large role in the determination of household dietary diversity (Jones et al. 2014, Pellegrini & Tasciotti 2014, Powell et al. 2015). However, the reliance on one's own production for household diet diversity becomes less important as markets develop and agricultural systems become modernized. We address the issue of separability, or lack thereof, in the food production and consumption decisions in developing country food systems by stage of development.

Food systems and their contribution to nutrition outcomes change with economic growth and structural transformation of the agricultural sector. This means that food, nutrition, and health policies have had to evolve and adapt as economies grow and develop. In a number of countries, economic growth has been spurred by productivity growth in the agricultural sector owing to the Green Revolution (GR) (Pingali 2012, Timmer 1988, Timmer & Akkus 2008, Webb & Block 2012). That said, in a review of agriculture interventions aimed at improving nutritional outcomes, Turner et al. (2013, p. 369) find that "there is comparatively little current research on indirect effects of agriculture on nutrition, or the effect of policies or governance . . . ." Other studies (Berti et al. 2004, Girard et al. 2012, Leroy & Frongillo 2007, Masset et al. 2011) have also found a similarly limited impact of agriculture on nutrition. This is further borne out by the fact that, despite considerable agricultural growth, we see the persistence of malnutrition and undernutrition in a large number of low- and middle-income countries. Hence, a critical challenge is to identify and implement policies that are appropriate for the stage of economic development in the country of concern or, in other words, the particular stage of structural transformation there (Pingali et al. 2015).

In this article, we conduct an in-depth review of the literature on the linkages between agriculture and nutrition. We try to provide an economic perspective on the relationship between agriculture and nutrition. In Section 2, we discuss how countries are classified based on their relative position in the structural transformation process. We then introduce a conceptual framework of the multisectoral pathways through which agriculture influences nutrition. In Section 3, we focus on household-level factors that impact agriculture and nutrition. In Section 4, we describe various intrahousehold factors affecting individual food access and how the health environment

impacts individual level nutrition. We conclude with a brief review and some policy insights in Section 5.

2. AGRICULTURAL GROWTH, ECONOMIC DEVELOPMENT, AND NUTRITION OUTCOMES

As agriculture forms a major part of the food system, its role in enhancing nutrition always takes center stage (Fan & Pandya-Lorch 2012, IFPRI 2013, Levitt et al. 2011). Over the past four decades, the GR has played a key role in enhancing agricultural productivity as well as in raising incomes and kick-starting the structural transformation process.

Structural transformation has been a central tenet of the economic development literature (Chenery 1960, Clark 1957, Kuznets 1966). In a seminal paper, Johnston & Mellor (1961) provided the classic explanation of the role of agriculture over the course of development of an economy. Timmer (1988) and Timmer & Akkus (2008) emphasize the importance of agricultural productivity–led economic growth for a rapid and sustained transition out of poverty. Structural transformation based on agriculture growth leads to economy-wide income and wage growth. Increased income influences the demand for calories (Behrman & Deolalikar 1987, Pitt 1983, Sahn 1988, Strauss & Thomas 1995) and has the potential to raise the demand for diet diversity (Doan 2014, Du et al. 2004). The structural transformation process is also important for discussing the linkages of food systems and nutrition because of the role of productivity and income in determining the health status of the population and vice versa. Higher income and socioeconomic standards have a positive impact on a variety of health outcomes (Case et al. 2002, Deaton 2002, Frijters et al. 2005, Jones & Wildman 2008, Lindahl 2005, Parmar et al. 2016, Schmeiser 2009). Conversely, poor health, especially in low-income developing countries, has an adverse impact on agricultural productivity, which in turn affects short- and long-term income potential, especially for the rural poor (Bound 1991, Case & Paxson 2008, Haddad & Bouis 1991, Thomas & Strauss 1997, Vogl 2014). These relationships are especially strong in low-income developing countries (Backlund et al. 1996, Deaton 2002). Therefore, the relationship between income and health is bidirectional and is an important driver of economic and social change.

In the early stages of structural transformation, subsistence-oriented agricultural systems are the norm (Pingali 2012). Meeting the demand for staple grains is the primary challenge in these less productive systems. As economies develop and graduate to middle-income status, agricultural systems become increasingly modernized and commercialized. In many of these economies, the GR led to large increases in the productivity of staple grains, such as rice and wheat, and led to lower food prices (Pingali 2012). Increased demand for diet diversification led to the rising demand for nonstaple foods, such as vegetables, fruit, livestock, and dairy products (Pingali 2007). However, weak supply responsiveness for nonstaples and their high relative prices, due to the persistence of GR-era policies that favor staple grains, resulted in limited access for the poor to a more nutritious diet (Pingali 2015). Policy focus on enhancing the diversity of the food system, particularly for micronutrient-rich horticultural and livestock products, is extremely crucial in these contexts.

High-income developed economies have highly commercialized agricultural systems. Only a small proportion of the population is employed in agriculture, which is extremely mechanized. The contribution of agriculture to the gross domestic product is less than 10% (Pingali 2012), and agriculture accounts for a very small share in overall employment (Timmer & Akkus 2008). The challenges in terms of agriculture–nutrition policies are different in this category: They mostly have to deal with creating and upholding standards of food safety, as well as maintaining and overseeing the functioning of competitive markets and policies to prevent chronic and lifestyle conditions, such as diabetes and cardiovascular diseases.

2.1. A Framework for Linking Agriculture to Improved Nutrition

Agriculture shares a symbiotic relationship with nutrition (and health); in other words, nutrition affects agriculture, and in turn, agriculture has an impact on nutrition. Fogel (2004a,b) provides persuasive empirical evidence of the impact of nutrition on economic growth. Fogel (2004b, p. 33) claims that "the increase in the amount of calories available for work over the past 200 years . . . must have made a significant contribution to the growth rate of per capita income." There are multiple ways of conceptualizing the various pathways between agriculture and nutrition, and they all share many common features. It is now commonly accepted that the thinking around agriculture and nutrition is centered on the fact that food by itself is not enough. UNICEF (2013) has created one such theoretical framework that looks at the linkages between the food economy at the macrolevel, the household level, and the individual level. This framework creates linkages in how the food availability and access at the macrolevel feed into the household livelihood strategies, which in turn determines food consumption. Other organizations and researchers have proposed similar frameworks that are adapted versions of each other, differing in their unique focus on specific factors or the addition of some new causal pathways (Chung 2012, Gillespie & Harris 2015, Ruel et al. 2013, UNICEF 2013).

The framework we use is discussed in detail in Pingali & Ricketts (2014) and is presented here in **Figure 1**. This framework is consistent with the UNICEF framework but with the addition of an economic policy lens. This multidimensional framework for explaining the drivers of nutrition change is presented in terms of four quadrants (Pingali & Ricketts 2014, Pingali et al. 2015). The first pathway between agriculture and nutrition is through the income mechanism (quadrant 1), where gains in household income lead to increased access to food. In rural societies, smallholder agricultural productivity growth and off-farm employment play a critical role in income generation, especially in low-income developing countries. Additionally, production diversity at a macrolevel is vital for the availability of a diverse set of micronutrients for consumption. It is well established that nutrition outcomes are directly impacted by eating habits and other behaviors, including those that may be considered as non-nutrition related (e.g., those involving sanitation and hand-washing). The second pathway explores all of the behavioral traits that impact nutrition (quadrant 2).

Factors impacting intrahousehold food distribution are the next mechanism (quadrant 3). These factors are critical in determining individual-level food access within the household, especially with regard to women's and girls' access to food, both in terms of quantity and diversity. Women's empowerment enables them to ensure an equitable food distribution for themselves as well as their children. Empowered women are also more likely to be more productive and have higher income earning potential. Finally, quadrant 4 looks at improving the ability of the people to translate food intake into absorbed nutrients, and thereby positive nutrition outcomes, through enhanced environmental factors, such as access to clean drinking water and sanitation (Pingali & Rao 2017).

The framework divides these factors into two main pillars: household-level factors and individual-level factors. The various mediating factors among the four quadrants can be classified into these two broad categories. Quadrants 1 and 2 consist of the household-level factors that affect the quantity and quality of diets. Simultaneously, quadrants 3 and 4 comprise the factors that affect intrahousehold equity in food consumed and the nutritional impact at an individual level. Our framework brings together an integrated food systems approach that we had described earlier. This approach is in line with the approach taken in the Lancet Nutrition Series Framework (Bhutta et al. 2013), which extends the UNICEF framework and provides an operational guide on the determinants of nutrition outcomes. The UNICEF framework mainly focuses on nutrition as

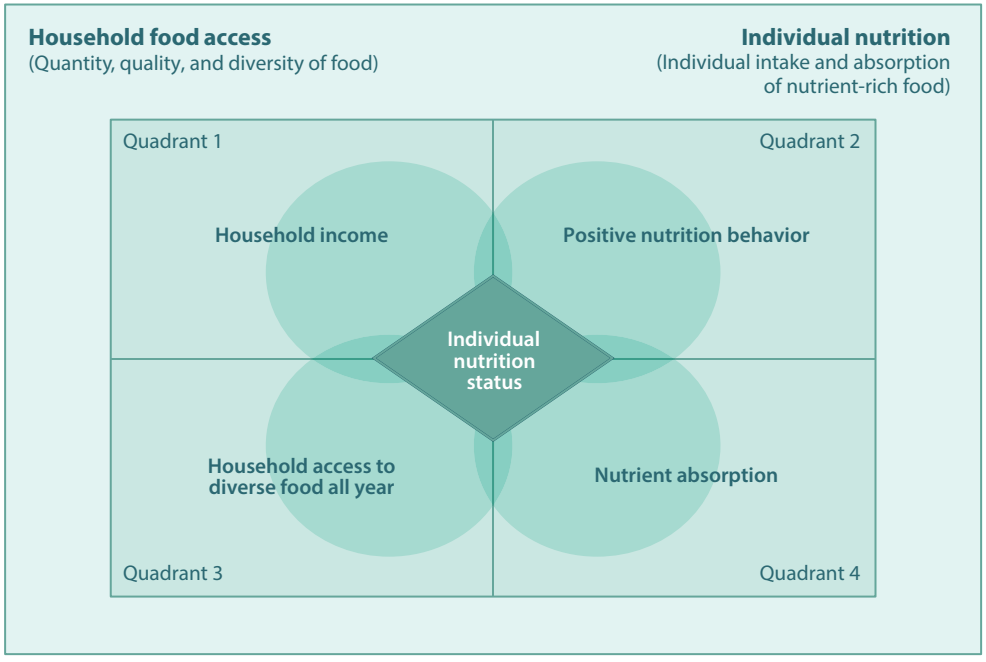

Figure 1

Multisectoral pathways toward improved individual nutrition. Adapted with permission from Pingali & Ricketts (2014). Copyright 2014, Wiley.

an objective, which is in contrast to our framework because we view it as an outcome of a larger set of multisectoral policies.

Our framework explicitly accounts for household-level and intrahousehold determinants of individual nutrition outcomes. It provides a clearer representation of the drivers of household access to food (in terms of quantity, quality, and diversity), as well as the factors that determine individual intake and absorption of nutrients.

3. HOUSEHOLD FOOD ACCESS: QUANTITY, QUALITY, AND DIVERSITY OF FOOD

First, we explore in detail the various household-level factors that affect diets. Income and agricultural productivity are main drivers of this link. Household income enters directly in the budget constraint of the household and hence determines the ability of the household to buy a nutritious diet. Even if income is not a concern, the household's location in relation to markets determines its access to food. In this section, we discuss issues related to income generation and food access as well as other related concerns.

3.1. Agricultural Productivity and Income Pathway to Improved Nutrition

Agriculture is the predominant employment sector in poor and underdeveloped countries (Ruel et al. 2013, Timmer 1988). This is especially the case in Africa where women compose nearly three-fourths of agricultural labor and food processing labor. In the early stages of structural

transformation, agricultural productivity growth is a primary driver of rural household income growth and overall economic growth. Consequently, this has a direct impact on household food consumption and the aggregate demand for food. The GR has played a pivotal role in the extraordinary rise of agricultural productivity during this period by generating large increases in the productivity of staple crops, particularly in Asia (Pingali 2012, Spielman & Pandya-Lorch 2010). It has also been established that the GR has had an unquestionably positive impact on the calorie and protein consumption of the population due to its direct (access to food) and indirect (through enhanced real incomes) effects (Alston et al. 1995, Fan & Brzeska 2010).

However, this rise in calorie consumption induced by the GR-led growth in staple grain productivity has not always been accompanied by an improvement in nutrition status as measured by micronutrient deficiencies and diet diversity, among other measures. Although agricultural productivity and crop yields increased dramatically, poverty and food insecurity persist in large parts of the developing world (Gómez & Ricketts 2013, Ravallion & Datt 1996, Spielman & Pandya-Lorch 2010, Thirtle et al. 2003). The reasons for the limited impact of the GR on consumption of micronutrient-rich food are discussed below.

Increased income as a result of the GR led to a rise in demand for nonstaple foods, such as vegetables, fruit, meat, and dairy products. This rising demand for diet diversity as countries move along the structural transformation pathway is consistent with Bennett's Law. However, the increased demand for nonstaples was not always matched by a corresponding increase in their supply. Hence, high relative prices of nonstaple food persisted. Joshi et al. (2004) provide empirical evidence of this phenomenon in the post-GR period in South Asia. A large number of crops (such as legumes, fruits, and vegetables), whose relative prices are high compared to staple grains, are especially rich in micronutrients. This limited the impacts of diet diversification on nutrition outcomes (Bouis 2000, Kataki 2002). This situation continued well into the post-GR period and, in some cases, worsened due to the persistence of GR policies of staple grain productivity enhancement, while ignoring nonstaple food supply. Prime examples of prostaple grain policies are subsidies, price support programs, and crop-specific input supply and credit programs. The situation was worsened by policy impediments to promoting food system diversity and a weak private sector, which meant limited supply responsiveness for nonstaples despite their high relative prices (Pingali 2015). To exacerbate the problem, in many parts of the developing world, traditional crops rich in certain micronutrients have been replaced by the big three staples of rice, wheat, and maize (Pingali 2015, Webb 2009).

A large improvement in nonstaples can be realized by improving their value chains. The markets for nonstaples are poorly developed in developing countries, especially when it comes to advanced transportation systems, cold storage, and relatively high-tech food processing. These are sectors where the government has lagged behind in terms of investment. The issue becomes more acute because the private sector has failed to pick up the slack. McCullough et al. (2008) provide an excellent in-depth review of this issue. Typically, smallholder farmers have high transaction costs in linking into modern value chains for high-value agricultural products. These costs can be daunting for small farmers and serve as obstacles to their integration into the new food system. Thus, pro-poor policies that connect smallholders to value chains for nonstaple crops could potentially increase income growth and enhance access to nutritious food (Pingali et al. 2015). In the process of modernizing the agricultural system, it is important to incentivize on-farm diversification through investment in rural market infrastructure and other policy support that helps lower nonstaple food prices and increase incomes. Producer cooperatives or other smallholder aggregation models could enhance their participation in value chains. McCullough et al. (2008) describe in detail a few successful aggregation models for smallholders that have worked in a variety of countries and socioeconomic conditions.

Another factor that further limits supply responsiveness of nonstaples is the limited amount of research and development (R&D) resources devoted to these crops. We find that, despite the many advances that GR techniques have accomplished (see Pingali 2012 for a summary), many R&D gaps remain in the agricultural sector, especially with respect to nutritionally important crops and livestock products. Therefore, there is an urgent need to increase investment in agricultural research on micronutrient-rich nonstaple crops. Agricultural research is often considered one of the best investments in terms of poverty reduction across a variety of contexts (Fan 2000, Fan & Pardey 1997, Fan et al. 2000). The exact mix of crops to be promoted depends on the geographic and socioeconomic context of the region. Though staple crop productivity continues to be important, the key is that policy should not be lopsided and must also place adequate focus on enhancing nonstaple food crop productivity. An important point is that the onus of this investment is not only on governmental agencies, but it must also be steered by donor agencies worldwide.

The skills needed for nonstaple crop production and sale are quite different from those for staple crops. Reardon et al. (2012) discuss the mismatch of skills needed and skills available as a potential constraint to the production of nonstaple crops. This implies that investments need to help people adapt, learn, and implement these new technologies and management practices. Furthermore, in most developing countries, food security policy has not yet evolved from its focus on calorie sufficiency to one that ensures access to a nutritionally balanced and diverse diet. To achieve and sustain a balanced food system, there is a need for a crop-neutral agricultural policy that reduces the bias toward particular staple commodities and lets farmers respond to market signals (Pingali 2015).

3.2. Access to Food Diversity

Merely producing diverse food does not ensure that food security and associated nutrition goals are achieved (Herforth et al. 2012). Diversification of food production systems constitutes a necessary but insufficient condition to achieve balanced diets. Household and individual access to food diversity may be constrained, even when macrolevel supplies are improved, due to poor rural market infrastructure. Remote rural societies may continue to face problems with access to balanced diets even as the better connected and urbanizing communities witness improvements in their diets and nutritional status. Industrial food fortification and supplementation programs are also constrained in reaching these societies, hence the recent focus on the biofortification of staple grains.

An important question in terms of food access is whether farm-level production diversity is a necessary condition to ensure household dietary diversity. Much of the development community seems to answer the question in the affirmative and considers the promotion of production diversity as essential for improving food access in developing countries. Therefore, the literature largely considers the production and consumption decisions as nonseparable; in other words, production diversity has a direct positive impact on dietary diversity (Jones et al. 2014, Snapp & Fisher 2015). This would imply that at a local level, there needs to be production diversity to provide a balanced diet. We suspect that the production–consumption relationship becomes increasingly separable as countries move along the structural transformation pathway. The nonseparability assumption possibly makes sense at the low end of the transformation process, where access to markets is low for remote rural communities. With economic growth, we should expect that access to markets improves, and the nonseparability assumption becomes weaker (Koppmair et al. 2017, Sibhatu et al. 2015). We would also expect that in areas with strong markets, both supply-side (ability to sell crops on the market) and demand-side (ability to buy crops with cash income) factors would

be considerably favorable. Therefore, an effective way to help farmers diversify their consumption in these environments would be to invest in developing rural market infrastructure, which would in turn facilitate the free movement of food across different regions.

To ensure the availability of a balanced set of micronutrients through the presence of a large variety of foods, rural markets are important. Nonstaple crops comprise a major portion of these micronutrient-dense foods. As discussed earlier, these nonstaple foods have relatively higher prices as compared to staples and are hence not affordable, especially for the vulnerable population. To reduce these relative price differences, there is a need for development of rural market infrastructure. This includes investments in connective infrastructure (paved roads, telecommunication networks, cold storage, quality and safety monitoring systems) as well as mediating infrastructure [credit providers, credit rating agencies, property titles, and other legal and regulatory institutions that can depersonalize exchange transactions and make assets fungible (De Soto 2000)]. Public efforts can also be geared toward providing market information that can be essential to harnessing demand and enabling smallholder integration into new markets. Public–private partnerships have been shown to increase information and investment flow as well as investment into supply chains capable of linking or integrating smallholder farmers. In some cases, evidence for improved efficiencies for smallholder farmers and traders has been identified through greater communication technologies, quality trainings, inputs, and services (Aker & Fafchamps 2014, de Silva & Ratnadiwakara 2008).

In the recent past, there has been a rapid growth in supermarkets across developing countries (Minten et al. 2010, Reardon et al. 2012). There have been some efforts at analyzing the effects of supermarket linkages on diets and nutrition in smallholder farm households (see Qaim 2016 for a detailed review and Chege et al. 2015 for an example from Kenya). In addition, sustainability standards have also been on the rise globally, and research shows that they have had a mixed impact on smallholder farmer welfare (Dragusanu et al. 2014). In a recent paper, Chiputwa & Qaim (2016) were one of the first teams to examine the impact of these changes on nutritional outcomes. They found that farmers in Uganda with sustainability certification have higher nutritional levels.

Where markets are not very developed, homestead gardens and backyard livestock systems are considered as viable solutions to the problem of access to food diversity (Berti et al. 2004, Girard et al. 2012, Leroy & Frongillo 2007, Masset et al. 2011, Meeker & Haddad 2013). Bangladesh is an example of a country where homestead gardens have added to household diet diversity (Ali et al. 2008). The suitability of the home production approach depends on certain factors. For example, the society's stage of both economic development and market integration is critical. Where rural market access is good, it is highly unlikely that homestead-based approaches would be an effective means of adding to diet diversity. This is particularly true where agricultural wages are high. It may not make economic sense for people to forego wage income in the pursuit of operating and maintaining homestead gardens for enhancing access to diet diversity. Seeking additional income through off-farm employment or crop specialization could be more effective strategies to improve diet diversity (Sibhatu et al. 2015). Moreover, projects involving homestead gardens that focused on income generation had limited impact on nutritional outcomes (Birdi & Shah 2016, Kumar & Quisumbing 2011). However, there have been contexts in which these strategies have proved successful in providing nutrients and a diverse diet. Bhutta et al. (2013) and Masset et al. (2011) discuss the potential of homestead gardens, animal husbandry, and aquaculture in improving nutrition and the policies required to make the most of these interventions. The bottom line is that the promotion of homestead production approaches for enhancing access to diet diversity ought to be carefully assessed relative to the stage of a country's development, the opportunity cost of labor, and the state of rural market infrastructure.

Biofortification is increasingly seen as an emerging tool for bridging micronutrient gaps in diet, especially for the poor in developing countries. Biofortification involves the breeding of crops so as to enhance their micronutrient content. The main micronutrients that biofortification interventions have targeted so far are iron, vitamin A, and zinc. Meenakshi et al. (2010) conducted a detailed ex ante cost benefit analysis of potential biofortification interventions in countries from across three continents and found that these interventions could be extremely effective in reducing malnutrition in a cost-effective manner. Biofortification can be an effective tool both for staple and nonstaple crops. Biofortified staples, such as zinc-fortified rice and wheat, can play an important role in environments where markets are not well developed and where rural populations largely consume what they produce. Biofortified nonstaples, such as pulses, could be an effective source of micronutrients in areas with poor or better market infrastructure conditions. Separability between production and consumption is an important factor in determining the effectiveness of biofortification investments.

As with any other solution, biofortification also has its pros and cons and hence should be approached with caution. It can be a cost-effective strategy for meeting the micronutrient needs of populations that cannot be reached through industrial fortification programs. Its initial focus on staple crops is important for targeting the micronutrient needs of poor rural populations in countries at the low end of the structural transformation process. The suitability and viability of particular biofortified crops depend on the food preferences and agroclimatic constraints of the geographies in which these crops are being targeted. For example, orange-fleshed sweet potato has worked in East African countries, such as Uganda, because it is a staple food there (Low et al. 2007). Introducing the same product to India would be more challenging because sweet potato is consumed sparsely and primarily as a vegetable. The focus on biofortification of staple grains could go against the trend toward diversification of diets as incomes rise and could shift the policy focus away from enhancing food system diversity. Finally, scaling biofortification solutions in developing countries' agriculture will face the same challenges as all other technology dissemination efforts for improving smallholder productivity.

3.3. Food Price Volatility and Safety Net Programs

In the previous section, we discussed the relative prices of staple and nonstaple foods and how they impact food security. Poor households in developing countries spend a majority of their income on food purchases, and hence the direct impact of food prices on their budget constraint is extremely critical. In this section, we explore this mechanism in greater detail and provide a discussion on how large price fluctuations impact nutrition. The literature suggests that large deviations in food prices have considerable nutritional and health impacts, which in turn affect productivity and income. This leads to a vicious cycle that subsequently impacts the access and affordability of food (Hawkes & Ruel 2012, Thompson & Amoroso 2010, Sahn 2015).

In some cases, price volatility is created by weather shocks in the form of irregular or inadequate rainfall, floods, or hurricanes, among other such natural phenomena. Sometimes the effect of these natural calamities is further accentuated by local economic conditions. Remote rural societies and poor landlocked countries could face higher price volatility because their ability to smoothen supply shocks through trade is limited (Vu & Glewwe 2011). In contrast, some large middle-income countries, such as China and India, have insulated themselves from global price changes using a strong domestic policy of trade restrictions and producer subsidies (Groom & Tak 2015).

Food-based safety nets are some of the most popular and widely used policy tools to dampen the effects of high and/or volatile food prices. They are an important part of the food distribution

network that ensures timely access and availability of food grains at subsidized prices for the poor. In developing countries where food markets are not always very well developed and the infrastructure is fairly primitive, the need for safety nets increases even further. The 2008 global food crisis brought this discussion to the fore, as food prices of essential staples skyrocketed in many countries, leaving the poor vulnerable to extreme food shocks (Pinstrup-Anderson 2015). By sheltering the poor against such adverse shocks, food safety net programs act as a conduit for maintaining and enhancing nutritional and health status.

The Indian food safety net program, the Public Distribution System, is one of the largest of its kind in the world and has been the object of much discussion and critique. Despite its many problems with inefficiencies and leakages, it has been an effective tool for hunger reduction (Dreze & Khera 2015, Khera 2011), although its predominant focus on staple grains means that, for now at least, it focuses mostly on maintaining calorie consumption, somewhat at the expense of nutrient adequacy. A similar program in the United States is the Supplemental Nutrition Assistance Program (SNAP). This has been the cornerstone program for reducing hunger and deprivation among low-income households in the United States. Census data reveal that SNAP benefits have lifted nearly 4.7 million people out of poverty and 1.3 million people out of deep poverty (White House 2015). This program has reduced food insecurity, especially among vulnerable populations, decreased child poverty, and improved in-utero growth, among other development outcomes.[1] These two examples together show the capability and effectiveness of large-scale food safety nets in reducing hunger and malnutrition across economies at different stages of the structural transformation process.

Cash transfer programs have recently been considered a panacea for a wide range of development problems (including malnutrition) for poor and vulnerable groups (women and children). These financial instruments have been used to incentivize and affect behaviors surrounding health and nutrition. The nature of most of these programs is that they target the poorest and are considered politically feasible. These programs have become extremely popular because of their cash component and have been hailed to have a big impact. Leroy et al. (2009) used a program impact model to review the evidence of the impact of such programs on health and nutrition. They found that these programs have a significant impact on child anthropometry across different contexts.[2] Bassani et al. (2013) also conduct a systematic review of the impact of these programs on health-related behaviors. After examining evidence from more than 1,600 studies, they found that cash transfer programs have a limited impact on breastfeeding, immunization, and health care use by children. But in the same review, these authors find that the programs have limited impact on micronutrient deficiencies. More importantly, they find a lack of evidence related to the mechanisms through which nutrition impacts take place.

Therefore, it seems that cash transfer programs could potentially be powerful tools that could be used in most contexts to achieve nutritional goals. Cash transfers alone are not a panacea to malnutrition. But like any other policy measure, there needs to be a careful and deliberate approach of other complementary policy measures to realize this potential. Because the mechanisms through which these programs influence nutrition remain unclear, there needs to be a well-defined set of policy goals that should be grounded in program theory and evaluated rigorously.

[1] Here, we do not go into great detail about the SNAP program. Davis & Huang (2015) provide an excellent review of this literature.

[2] For a comprehensive discussion of the impact of cash transfer programs on various other outcomes, we refer readers to Manley et al. (2013).

4. FROM HOUSEHOLD FOOD SECURITY TO INDIVIDUAL NUTRITIONAL INTAKE AND ABSORPTION

In the previous sections, we evaluated household factors, including agricultural productivity and incomes, that affect nutrition and health. However, there are some critical individual-level factors that would eventually determine the health and nutrition status of specific members within a household. The success of a diversified food system in ensuring positive nutrition outcomes depends on intrahousehold equity in food access and an individual body's ability to convert food to nutrients. One concern with respect to individual-level factors is the relatively marginalized position of women and girls within households across various parts of the world. In the analysis using our framework, this falls in quadrant 3 (**Figure 1**) and is explored in greater detail in this section. Additionally, in quadrant 4 of the framework, we include other environmental factors that affect the ability of the body to absorb the nutrients consumed. The most important among them are disease prevalence, water/sanitation facilities, and food safety. This section explores these mechanisms in greater detail.

4.1. Intrahousehold Inequity in Food Access

Policies focused on household food security sometimes neglect the importance of the intrahousehold distribution of food. Traditionally, the distribution of food within the household has been lopsided in favor of men and older boys (Engle & Nieves 1993). This has meant that even if the household as a whole is food secure, there might be individuals (mostly women and girls) who might be food insecure (Ivers & Cullen 2011). In addition, they may not have equal access to more nutritious food. Therefore, enhanced emphasis on equitable distribution of food within the household, both in terms of quantity and quality, is extremely vital in determining individual-level nutrition.

Women's status in the household is an important determinant of intrahousehold equity in access to nutritious food and improved nutrition outcomes. There is a growing literature that examines the impact of women's household status on improved nutritional outcomes and uses different measures of empowerment. A woman's years of education are a popular measure of women's empowerment (Berti et al. 2004, Smith & Haddad 2000). Other similar measures include self-reported power over earned income (Arimond et al. 2010, Berti et al. 2004, Pinstrup-Andersen & Watson 2011), the household head's gender (Kennedy & Peters 1992), and assets at the time of marriage (Quisumbing & Maluccio 2003). More recently, multidimensional measures of women's empowerment have been developed that incorporate a more comprehensive view of women's bargaining power in the household (Malapit & Quisumbing 2015, Sraboni et al. 2014). Women also face a lack of access to collateral, education, and contracting power in the market, which further worsens their bargaining and decision-making power in the household (see Quisumbing & Pandolfelli 2010 for a detailed review).

Enhancing the status of women within the household by raising their decision-making and bargaining power is of paramount importance. This not only has lasting impacts on their own nutritional outcomes, but it also has positive externalities on the nutritional outcomes of children (Bisgrove & Popkin 1996, Haddad & Hoddinott 1994, Negin et al. 2009). Smith et al. (2003) discuss a framework that explores the channels through which women's empowerment could impact various household and individual health and nutrition outcomes. Using this framework, they find that the status of women in South Asia is worse than that of sub-Saharan African women in terms of their decision-making power at home.

Coffey et al. (2014) take a closer look at this phenomenon in the Indian context and posit that the low decision-making power of women could be due to their relative position in the

family hierarchy. They find that women who are low-rank daughter-in-laws (i.e., those who are married to younger sons within the household) have children with worse health. They explain these differences using the relatively low bargaining power of lower-ranked daughters-in-law within the household. Furthermore, Pingali & Rao (2017) find that low-ranked daughters-in-law tend to have below normal body mass index. This is clearly in line with the extensive anthropological, demographic, and economic literature that supports the measurement of women's autonomy through her position in the family hierarchy after marriage (Dyson & Moore 1983, Singh & Singh 2005).

Although women's role in agriculture is growing, their involvement in household chores is not waning. In fact, women's household activities are mostly energy intensive and pose significant demand on women's time and health (Barrett & Browne 1994, Hyder et al. 2005). Women also face a trade-off between the time they spend in agriculture and the amount of time they have for childcare and child-rearing. The amount and quality of antenatal and postnatal care provided in the first 1,000 days of life have a considerable impact on the health of children (Currie 2011, Gluckman et al. 2007). Therefore, women's involvement in agriculture might reduce this by curtailing the amount of time spent on childcare. Theoretically, this could be mitigated by the provision of childcare facilities. However, these facilities are widely absent in developing countries. Labor-saving technologies that can reduce women's drudgery in agriculture could also help reduce the trade-off between women's participation in agriculture and the adverse nutrition and child health consequences. There is a need for agricultural policy to address these gender-specific needs in terms of labor, bargaining power, and health/nutrition through concerted policy action.

Additionally, economic and climatic shocks might have a differential impact on females (as compared to males). For example, Quisumbing et al. (2008, p. 1) explore the gender dimension of global food price shocks and note that "women are less able to cope with and overcome crises than men are because they have less access to and control over resources than men." This point is further illustrated by Neumayer & Plümper (2007) who show data from 141 countries demonstrating that catastrophic events have a larger impact on the life expectancy of women. They also show that this gender gap is mostly explained by the social status of women in these countries and has little to do with biological or physiological mechanisms. It has also been shown that climatic and other economic shocks have a lopsided impact on women, even though women are better at managing resources in noncrisis environments (Beaumier & Ford 2010, Levin et al. 1999). Therefore, there is a need for well-designed communication about behavior change that highlights the importance of the gender dimension in nutrition outcomes (Arimond et al. 2010).

4.2. Health Environment and Nutrition Outcomes

In the context of low-income countries, the health environment in terms of safe food, safe drinking water, sanitation, and other related factors has a large impact on individual nutrition. A growing literature links stunting and cognitive underachievement to poor sanitation in early life, including the practice of open defecation (Almond & Currie 2011, Almond & Mazumder 2011, Case & Paxson 2008). Sanitation conditions worldwide have a significant impact on the disease incidence and health status of children (Spears 2012, 2013). Additionally, factors related to environmental entropathy have been linked to lower levels of overall health. These papers measure health in many different ways, but predominant among them is the use of the height-for-age z-score, which is a stock measure that includes health inputs from the point of conception (Kosek et al. 2013, Matsumoto et al. 2008). All of these factors together show that proper sanitation and water play critical roles in determining the efficiency of labor engaged in agriculture and thus affect its productivity directly.

In addition, the aforementioned literature also suggests that water, sanitation, and hygiene (WASH) policies have a critical role in determining the health status of children, especially in developing countries. Through these mechanisms, it is clear that WASH contribute to health and nutrition status through their direct and indirect impact on agriculture. Although agriculture has a large and significant impact on nutrition, these health environment determinants play an enabling (or disabling) role in the process of nutrition determination.

Spears (2012) evaluates the problem of open defecation from a global perspective by examining evidence from 65 developing countries based on data from demographic and health surveys. He finds a strong association between improved sanitation and child height that does not vanish even after controlling for income and a variety of other household and individual covariates. He also finds that open defecation can explain much of the puzzling India-Africa height difference.[3] In explaining the same dissimilarity, Jayachandran & Pande (2015) contend that most of these differences can be explained by a combination of birth order and the prevalence of son preference in India.

In a similar fashion, the availability of clean drinking water also plays a large role in household health dynamics, especially among children. The causal measurement of the impact of improved water on health outcomes is challenging because the placement of water projects is seldom random, and there are many concerns with trying to implement them randomly (Molyneaux & Gertler 2000, Pitt et al. 1999). Nonetheless, researchers using novel econometric techniques and innovative research designs have shown rigorous empirical evidence of the impact of access to clean water provision on a variety of health outcomes including child health and mortality (Jalan & Ravallion 2003, Lee et al. 1997, Mangyo 2008).

Apart from drinking water, contaminants can enter our body through the food we eat. Therefore, food safety is an integral part of ensuring food security worldwide. First and foremost, any food that is contaminated must be thrown away. In developing countries where food shortages are rampant, food waste exacerbates the hunger and malnutrition problem. Additionally, consumption of such unsafe food can be doubly dangerous, as it can cause illnesses that inhibit the absorption of nutrients and thus make the body vulnerable to other negative conditions (Chan 2014).

The key issue is that careful intervention is required at each step "from farm to table" because contaminants can enter the system at any step of the production process (Unnevehr 2015, p. 24). Although the fixed cost of identifying, implementing, and regulating a food safety system may be high, there are substantial benefits to doing so (Hoffmann & Anekwe 2013). Thus, there is an urgent need for significant public and private investment to ensure that an improved and coordinated supply chain is maintained (Antle 2001, Unnevehr & Jensen 2005). The good news is that growing attention is paid to food safety standards across different developing countries. Part of this focus is due to increased trade between developing and developed countries, which leads to developing countries' adherence to improved safety standards.

5. CONCLUSIONS

There exists a strong connection between the stage of economic transition—the process of structural transformation—and population-level nutrition patterns, particularly the decline in child stunting and wasting (low weight for height). Positive nutrition effects are, however, conditional on a country's support for agricultural development through targeted policies aimed at smallholder farmers. Agriculture and food systems evolve as countries go through the structural

[3] Children from sub-Saharan Africa have higher height-for-age z-scores than Indian children.

transformation process. Therefore, these policies need to be calibrated to match the changing economic climate. A one-size-fits-all characterization would imply that we will not be able to leverage the economic growth achieved through structural transformation for ensuring higher nutritional and health standards.

In addition to lowering food prices and expanding the available supply of staple cereal food, GR-era productivity-focused policies drove the process of structural transformation and stimulated growth in the nonagricultural sectors. Today, rising incomes and declining per capita consumption of staple cereals in much of the developing world, with the exception of the least-developed countries, imply that policy emphasis must shift from a focus on cereal intensification to one that encourages broader food supply diversification. Diversification of diets toward protein- and micronutrient-rich food provides new opportunities for agriculture-led growth for smallholder farmers while simultaneously raising the quality and diversity of their diets. That said, it is important to realize the role that growth in staple crop productivity has played in ensuring food security in the past and its continued future role in meeting the rising demand of a growing population. There is need to focus on an agricultural policy that ensures a food system that is balanced between staple grains and other nutrient-dense foods.

Given the connection between market linkages, economic growth, and dietary diversity, investments that can equip a diverse socioeconomic group of farmers to participate are essential. Public policies aimed at developing new market opportunities mean working with private companies to access and identify market opportunities. It also implies creating an enabling environment that focuses on developing necessary institutions to ensure broad-based participation. The latter includes investments in connective infrastructure (paved roads, telecommunication networks, known and widespread networks for distribution) as well as mediating infrastructure (credit providers, credit rating agencies, property titles, and other legal and regulatory institutions that can depersonalize exchange transactions and make assets fungible).

Developing rural markets would additionally imply a break between the production and consumption of smallholders. A thriving market infrastructure would not only guarantee the continuous supply of a balanced and nutritious diet, but it would also provide the means to purchase it by providing a market for people to sell their produce. This would imply a shift in policy focus from raising diversity on individual farms to concentrating on creating and maintaining an overall balanced food supply system.

Although supply-side policies and institutional investments can expand the availability of diverse foods and enable smallholder income gains, agricultural policies for improved nutrition can also aim to strengthen consumer demand for foods rich in micronutrients and protein. This alignment is essential. Broadly, policy investments in market information technologies, product standardization, and food safety regulations can build consumer trust, identify new market demands, and provide meaningful opportunities for farmer response.

Policies promoting food safety should be a priority for upgrading traditional markets and ensuring that human health is safeguarded. In addition to reducing instances of foodborne illness and disease, food safety policies can make traditional markets a viable place for procurement by modern retailers. This can further improve smallholder incomes. Improvements can include infrastructure investments, such as providing cement slabs for establishment of stalls, zoning of animal/livestock products away from produce, and establishing sanitation stations in wet markets where equipment and products can be washed and waste can be discarded safely.

Along with policies to enable productivity growth and linkages to markets, complementary policies that support changes in nutrition behavior as well as women's empowerment and education are crucial to ensure a more nutrition-sensitive food system. Access to improved sanitation and

hygiene are also important to safeguard public health and positive nutrition outcomes. A healthy environment determines the ability of the body to absorb essential micronutrients and plays an important role in improving individual health in developing countries. Investments in improved household access to clean drinking water and toilets are crucial in this regard. Increased sanitation awareness along with the construction of toilets are required to inform and nudge behavioral change.

Targeting the barriers faced by women in agricultural production and nutritional access would result in rapid improvements in their productivity, income generation, and nutritional outcomes. Mechanisms such as the promotion of women-centered extension services or investment in peer-to-peer networks for accessing inputs, credit, and information can connect women to new high-value markets and support adequate intensification of their land. Women generally have greater difficulties in accessing information and extension services, and when access is made available, households see significant gains in income and productivity.

Asymmetric intrahousehold access to food has a profound impact on the nutritional status of women and children. Cultural norms, beliefs, and socioeconomic behavior condition this status, and they vary greatly across geographies and cultures. Institutions that improve social networks, education and awareness, ownership of assets, and control of household finances can influence these conditioning factors and play an important role in improving nutritional outcomes. Drives to promote mechanization also greatly influence the reduction of women's drudgery in agriculture, especially for their own labor use in small-farm households, and may have positive outcomes on nutrition through labor savings.

Therefore, along with policy change to improve food system diversity and access to markets, behavioral and environmental changes are important components that need attention to influence nutritional outcomes. Policy must focus on (*a*) building infrastructure to improve access to clean drinking water and toilets, (*b*) providing institutional support to promote self-help groups to enable peer-to-peer networks, and (*c*) improving the control of household-level finances and support and outreach programs to inform behavior change.

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