Chapter Eleven

The Power of Innovation

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"Discovery consists of seeing what everybody has seen and thinking what nobody has thought."

Albert von Szent-Gyorgy

Key messages

- For centuries, innovations across the entire span of human nutrition, from plant to population, have targeted aspects of the farm-to-table continuum. Through these innovations, humans have sought ways to improve mechanisms to assess, understand and meet nutritional requirements, both locally and globally.
- Recent transformative innovations targeting distribution systems, leveraging public-private partnerships, and utilizing technological advances have the potential to catalyze research and improve nutrition in both the developed and developing world.

Introduction

In a world of over 7 billion people today, access to sufficient nutrition plays a crucial role in the well-being of the population. Currently, nearly 45 percent of deaths in children under age 5 can be attributed to nutrition-related factors. Others, who are undernourished but survive, face health concerns such as stunted growth and limited neurodevelopment, which impact livelihoods in adulthood. Sir Gordon Conway, one of the world's foremost experts on global food needs, has stated: "Hunger is a daily reality for nearly a billion people. More than six decades after the technological discoveries that led to the Green Revolution aimed at ending world hunger, regular food shortages, malnutrition, and poverty still plague vast parts of the world."

Innovation is essential to alleviate this enormous burden, as it seeks to improve the mechanisms necessary to meet the demands associated with the growth of the world's population and to thwart the morbidity and mortality associated with malnutrition in children and adults.

Innovation in nutrition has occurred since the planting of the first seeds intended to grow food for consumption. In early agricultural societies, the selection of crops directly affected the well-being of local populations, and local solutions were developed for local problems. In the 21st century we live in an interconnected society faced with climate change and an ever-growing population. Increasing yield, enhancing nutritional quality, ensuring diversity of crops and improving access to nutritional interventions have become global priorities. At the same time, we are challenged to define specific nutritional needs and deficiencies at a population level so that programs and policies are responsive to local and regional needs.

This chapter presents examples of innovations that target aspects of the farm-to-table continuum, from plant to population. Recent potentially game-changing innovations are discussed that target distribution systems, leverage public-private partnerships, and utilize technological advances. We first present innovations in production and distribution mechanisms. We then discuss collaborations in the food industry as a mechanism to create an enabling environment for enhanced nutrition. We also review technological innovations that have improved the areas of diagnostics, delivery, and communication. We close with a discussion of new frontiers and directions that further address sustainable nutrition in the world today.

Farm-to-table continuum

The five steps in the farm-to-table continuum provide several access points for nutritional innovations (see Figure 1). Throughout the chapter, we refer to this continuum, in terms of both existing and potential innovations. Many innovations couple one aspect of the continuum with another, illustrating that the innovations along the continuum are most effective when not directed at one aspect in isolation. For ease of reference, each case study title contains the stages along the continuum most relevant to the given innovation.

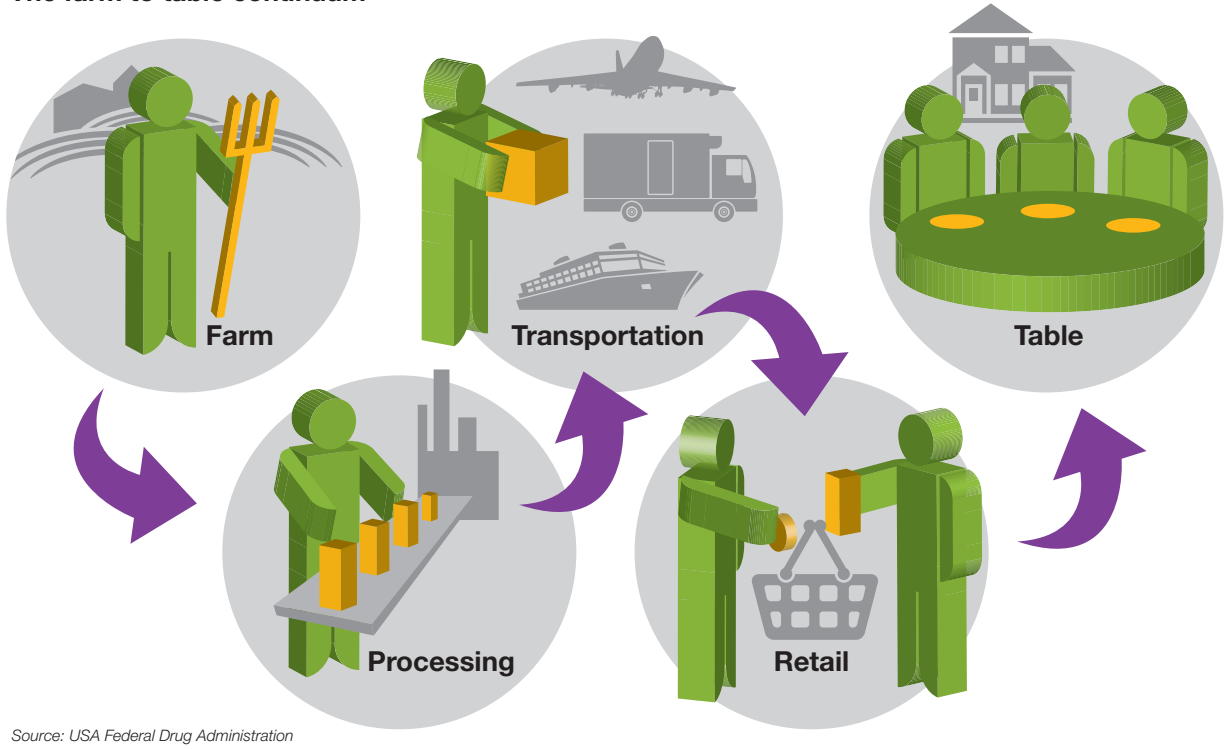
Production

Farm production is the first stage in the continuum. In the past when facing food deficits, the focus of innovation was on simply producing an increased yield of staple crops such as wheat and rice. However, surpassing the growth of demand with greater production is a necessary but not sufficient response for modern societies. The focus has turned to highlight the nutritional benefits provided with a greater variety and diversity of food as well as the economic enhancement this diversity can bring to individuals, corporations, and governments. In 2011, Rachel Nugent noted that if farm and food systems are to meet human needs and contribute to human health and longevity, they must produce affordable, diverse, and healthy food. Decision-makers at all levels, both public and private, must participate in steering the food environment in such a direction*. As a consequence, the priority agenda of donors and governments has become one that increases not only the quantity but also the quality and diversity of food production.

As a mechanism for altering food production in a sustainable manner with more nutritional options, some innovations have been developed to combat malnutrition and related health concerns that are specific to certain geographic localities. The first example is the development of β-Carotene-rich orange-flesh sweet potatoes, which have been biofortified through conventional breeding rather than through transgenic approaches. These biofortified potatoes have been introduced in regions with populations suffering from vitamin A deficiency and have been found to be an effective way of reducing deficiencies in women and children (see Case Study 1).
A second case study presents an innovation in the fortification of rice (see Case Study 2).

*Souce: *Bringing agriculture to the table, Rachel Nugent, The Chicago Council on Global Affairs, USA, 2011*

The farm to table continuum



Source: USA Federal Drug Administration

Case study 1

Continuum: Production and Table

β-Carotene rich orange sweet potatoes

Vitamin A deficiency (VAD) is a global problem, estimated to affect over 200 million women and children and to account for over 600,000 deaths globally each year among children under 5 years of age. Deficiency in vitamin A increases the risk of mortality, xerophthalmia and night blindness. Even subclinical deficiency can lead to increased risk for infections, severe diarrhea, and anemia. African regions account for the greatest number of preschoolchildren with night blindness and for more than one quarter of all children with subclinical VAD.

Sweet potato remains a major staple food in several African countries. A preponderance of the varieties grown are white or pale yellow and contain no or relatively little provitamin A carotenoids.In contrast, orange-fleshed varieties of sweet potato (OSP) can contain large amounts of β-Carotene, which is a precursor for vitamin A. Recently several large-scale intervention programs were implemented in Mozambique and Uganda to evaluate the impact of introducing orange sweet potato rich in β-Carotene to rural communities.

Mozambique is a country with modest use of sweet potato as a staple food. A 3-year-long, large-scale intervention in rural communities of Zambezia Province integrated three major components. An agricultural component supported the distribution of vines as planting material for OSP and provided training. A demand creation/behavior change component included education on maternal and child health and nutrition topics targeted to women in participating households and a campaign for the general public to raise awareness of the benefits of OSP as a source of vitamin A through community drama, field-day events and radio spots and programs. A marketing and product development component included training for OSP traders and the establishment of distinct market stalls selling and providing information on OSP. The intervention successfully integrated OSP into the diet of women and children and significantly increased the adequacy of vitamin A intake. No significant differences existed between more or less intensive intervention designs, indicating that future interventions can use less intensive models with the same success.

The large-scale intervention in Uganda resulted in a significant increase in the dietary intake of OSP among children and women in farmer group member households. This resulted in a substantial increase in total vitamin A intake from β-Carotene in all three age groups. It also resulted in a significant decrease in the prevalence of inadequate vitamin A intake among non-breastfed 12-35-month-old children. These children are at elevated risk of VAD, as breast milk is the primary source of vitamin A and the vitamin A requirements for this group are still relatively high; therefore this finding was particularly important. Increased vitamin A intake from OSP led to improved vitamin A status in children and women and reduced the prevalence of marginal vitamin A status in children by nearly 10%.

Because sweet potato is a seasonal crop, this type of intervention will not provide the same amount of additional vitamin A throughout the entire year. However, in these communities, sweet potato is harvested 2 to 3 times per year, and OSP would be available for around 9 to 10 months of the year.

*(**Sources:** 'A large-scale intervention to introduce orange sweet potato in rural Mozambique increases vitamin A intakes among children and women' Christine Hotz, Cornelia Loechl et al. Published in the British Journal of Nutrition, 2011.*

'Introduction of β-Carotene-Rich Orange Sweet Potato in Rural Uganda Resulted in Increased Vitamin A Intakes among Children and Women and Improved Vitamin A Status among Children' Christine Hotz, Cornelia Loechle et al. Published in the Journal of Nutrition, 2012.

Low JW, Arimond M, Osman N, Cunguara B, Zano F, Tschirley D. A Food-Based Approach Introducing Orange-Fleshed Sweet Potatoes Increased Vitamin A Intake and Serum Retinol Concentrations in Young Children in Rural Mozambique. Journal of Nutrition. 2007. 137(5):1320-7.)

The β-Carotene-rich sweet potato has a characteristic orange-colored flesh

Case study 2

Continuum: Production, Transportation, Retail and Table

Ultra Rice® Technology

PATH is an international nonprofit organization whose work focuses on transforming global health through innovation. The organization's Ultra Rice® technology is designed to be an effective micronutrient delivery system that is culturally appropriate and cost-effective. It uses a warm extrusion process to make rice grains from rice flour fortified with vitamins and minerals, including iron, zinc, thiamin, and folic acid. The extruded grains called Ultra Rice® resemble normal rice in size, shape, and color. When mixed with milled rice, usually at a 1:100 ratio, the fortified rice is nearly identical to traditional rice in smell, taste, and texture. Because the added micronutrients are inside the grains, they are less vulnerable to nutrient loss during preparation and cooking.

In India, a large local miller, Usher Agro, now has the capabilities to produce Ultra Rice®. At the same time, PATH is working within the state systems to widen the distribution of fortified rice within India's public-sector food programs. This work encompasses the Public Distribution System, which provides subsidized commodities to families below the poverty line.

In Brazil, Urbano Agroindustrial is one of the country's largest rice millers. PATH has transferred the Ultra Rice® technology to this miller. In conjunction with the Global Alliance for Improved Nutrition (GAIN), an organization dedicated to fostering private sector investment in adaptation to climate change, PATH and Urbano will be introducing fortified rice through commercial retailers, accompanied by a social marketing campaign to enhance demand for the product.

In Burundi, PATH has partnered with World Vision to distribute fortified rice to children through a school meal program. Supplementing the program, supported by the World Food Program (WFP), with fortified rice aims to improve nutritional status of children who participate. The impact in this country can provide data to support inclusion of Ultra Rice® as an approved commodity for the WFP.

Source: PATH, www.path.org, (June 2012. Ultra Rice® is a registered US trademark of Bon Dente International, Inc.).

NutriRice™ Technology

A similar technology, created by DSM, uses hot extrusion to create fortified rice kernels with encapsulated micronutrients. As compared to some other fortified rice, these grains look, taste and behave exactly like normal rice, and the embedded nutrients are well protected during washing and cooking. The recomposed, vitamin-and mineral-enriched rice kernels have shown demonstrated success in being incorporated into the usual diet. Those ingesting the fortified rice have also seen improvement in health. In Beijing, the Chinese Center for Disease Control and Prevention implemented a pilot project wherein they introduced NutriRice™ into a school's meal plan. The students ate NutriRice™ and vitamin-A-enriched oil and iron-enriched soy sauce for eight months. The students' nutritional condition was improved, and micronutrient deficiencies were reduced by 50%.

Similarly, in Bangalore, India, schoolchildren aged 6-12 participated in a trial of NutriRice™. After six months, the children who were eating NutriRice™ had improved vitamin B levels, and they experienced improvements in physical performance, particularly pertaining to endurance.

Source: A breakthrough in rice fortification http://www.dsm.com/en_US/nip/public/home/pages/productsservices-nutririce.jsp

These case studies illustrate how innovations implemented at the production level can be coupled with enhancements to subsequent steps in the continuum, including processing, transportation, retail and table, to directly address malnutrition. Fortified rice and orange-flesh sweet potato are both good examples of how improved production, in conjunction with robust, targeted population supplementation strategies, stands to increase the pace of progress against malnutrition and its consequences. To bolster the uptake of OSP, production was combined with a marketing strategy for OSP traders, dedicated market stalls for OSP sellers, and community education efforts for consumers. Partnering UltraRice™ with school meal programs (in Burundi) and government and non-government distribution channels (India and Brazil) coupled production with other components of the continuum. Aiming to establish an agriculture system that is highly productive, stable, resilient and equitable with explicit recognition of the critical role of smallholder agriculture is essential. Small-scale agriculture is once again playing an important role in production that supports diverse food choices and improved nutrition. Women are becoming more prominent players in successful agricultural initiatives. Empowering women in successful farming at local levels improves both their health and their children's health (see Case Study 3).

Case study 3

Continuum: Production and Table

Women in small-scale agriculture

Helen Keller International (HKI) is well known in Bangladesh for its homestead food production (HFP) program. The program seeks to improve nutritional outcomes for women and children through promoting small-scale agriculture among women. Nutritional outcomes of interest include dietary diversity and knowledge of maternal self-care and infant/young child feeding practices.

The program was introduced in Bangladesh two decades ago, targeting women with limited land and promoting an integrated package of home gardening, small livestock production, and nutrition education. The program's design specifically seeks to combat micronutrient deficiencies, including vitamin A, brought on by food insecurity and dietary monotony over time.

Project monitoring and evaluation data show that this work has directly benefited more than five million people in rural Bangladesh. Among HFP farmers, vegetable yields have improved greatly. At the "table" stage of the farm-to-table continuum, HFP monitoring has shown a marked increase in the household-level consumption of micronutrient-dense foods, particularly of iron- and vitamin-A-rich dark green leafy vegetables and eggs.

Source: Hillenbrand, Emily (2010). Transforming gender in homestead food production. Gender & Development, 18(3), p411-425.

A woman farmer at work in Bangladesh
Source: CIAT

Distribution

Innovations to bridge the gap between production, market availability, and household consumption can improve the diversity of choices available to consumers in remote, rural populations. Yet, distribution is often seen as merely a means to an end rather than a means to grow, develop and innovate in the domain of nutritional access. Yet it is in the phases of the continuum that involve distribution (**processing, transportation, and retail**) where innovation has yielded potentially life-saving initiatives in the field of nutrition.

One of the best illustrations of innovation in the area of distribution also highlights how partnerships can yield untold health and nutritional benefits. In this example, pre-existing private-sector supply chain systems were utilized to deliver health promotion commodities, keeping the costs low but the coverage extensive. The ColaLife project leveraged Coca-Cola's existing distribution systems to piggy-back the distribution of AidPods in a simple, smart manner that ensured oral rehydration kit coverage in the most remote communities in Zambia (see Case Study 4). While oral rehydration could be considered more of a health intervention, similar partnerships could be leveraged to include nutritional products such as micronutrient supplements.

Aidpods utilizing the Coca-Cola distribution system
Source: A Refreshing Development by Andrew Marshall, Development Asia www.development.asia, January–March 2012.

Case study 4

Continuum: Transportation

Medicine via Coca-Cola

"In remote, impoverished places where clean water and medicine are hard to find, people can still buy a Coke. In 1988, when Simon Berry was a British aid worker in Africa, he made two observations that would change his life.

"Fact 1: In remote parts of Zambia, where families scratched out a subsistence living by farming, many young children died of preventable diseases, such as dehydration from diarrhea.

"Fact 2: In these same rural areas, you could almost always buy Coca-Cola."

Berry, then a technical cooperation officer for the British aid program, posed a question of possible connections: "Could Coca-Cola's unrivaled local distribution networks be harnessed to deliver simple but potentially life-saving medicines to hard-to-reach places?"

"Twenty years later, in a concerted attempt to answer that question, Berry and his wife Jane launched an independent non-profit organization called ColaLife. The organization's goal was to leverage Coca-Cola's distribution channels to carry so-called social products – oral rehydration solution (ORS), zinc supplements, water purification tablets – that last mile in an effort to save lives."

They developed the AidPod: a crush resistant, wedge-shaped canister that fits snugly between the necks of the Coca-Cola bottles when in their crates. By using the unused space, the products can reach the same places that Coca-Cola does. Rather than reinventing the process, they found a pre-existing, efficient mechanism to distribute the kits to the most remote of locations.

Source: A Refreshing Development by Andrew Marshall, Development Asia www.development.asia, January–March 2012.

Collaboration

Collaboration between public and private sectors has had an unprecedented global impact on health in areas such as vaccine delivery and medication access, but this synergy has just begun to grow in the field of nutrition. At this point, the potential opportunity for harnessing public-private collaboration exists in several forms, including developing food products and systems, scaling up effective nutrition solutions, providing sustainable cost-effective solutions for information sharing, and conveying much-needed educational messages to consumers. Inroads to improve health and nutrition outcomes could be made on a global scale and can be enacted at all stages of the continuum.

However, these partnerships have been slow to grow. At the Building Effective Partnerships for Improved Nutrition meeting in 2012, companies, donors, researchers, and funders assessed the barriers and explored the potential for innovative partnerships. Several barriers were identified but were not insurmountable, provided buy-in from both sides could be garnered. Partnerships would need to develop shared objectives and mutually meaningful targets. In order to accomplish scalability, the food industry would need to consider corporate social responsibility (CSR) projects as core rather than supplemental strategies. For the partnerships and initiatives to be sustainable, firms need to see a valuable return on investment (ROI) through sustained demand while the public partners would need to see improved health and capacity strengthening at the local level.

Private sector innovations in product development, manufacturing, financial sustainability, message delivery, behavior change and distribution can be applied to public health nutrition strategies. In Case Study 4, a public-private partnership between Coca-Cola and ColaLife has resulted in improved distribution of essential oral rehydration and diarrhea prevention kits. Such a partnership could also be used to distribute interventions more directly relevant to nutrition such as micronutrient supplements.

Successful innovations identify opportunities of value to both the private sector and the public health community. Collaborations between corporations and initiatives for public nutrition expand the value of the corporations' brands and potentially expand the consumer base for the other products manufactured by the company. An important caveat in this realm, however, is the potential for conflict of interest, where public health programs are concerned about exposing already vulnerable populations to commercial exploitation. In an effort to find a more equitable and agreeable bottom-line, an innovative financial model in the private sector is the long-term investment known as 'patient capital', where investors do not expect a quick return on their initial investment (see Case Study 5).

Case study 5

Continuum: Farm

Acumen Fund

Acumen Fund is a venture capital fund that invests in enterprises dedicated to serving poor people in developing countries. Patience regarding the speed in which the ROI is felt has shown to pay off in the long run. Founder and chief executive Jacqueline Novogratz believes that such patience pays, giving the example of an investment Acumen Fund made into an international development project in India.

"In 2002, after nearly ten years of running a nonprofit to help poor farmers in India get the most out of their land, Amitabha Sadangi was frustrated. Government aid to alleviate poverty had largely bypassed individuals earning less than $1 day. Instead, it was subsidizing large farms and being invested in technology he said his farmers didn't want. Sadangi sought to treat the poor as customers, not passive recipients of charity. He decided he would adapt a water-saving drip irrigation system to the specific needs of Indian smallholders and sell it at an affordable price.

"Acumen Fund gave Sadangi's nonprofit International Development Enterprises India a US$100,000 grant and loans to experiment. In 2006, we invested $1 million in equity in Global Easy Water Products (GEWP), a for-profit spinoff Sadangi created in western India to further increase the technology's reach among the poor and sell other products to them.

To date, GEWP and its parent nonprofit have sold irrigation systems to some 350,000 farmers. Including the farmers' family members, roughly 2 million people are now benefiting from higher income levels- for some, $5 to $6 a day instead of $1 to $2. With 101 employees and sales that have tripled since 2008, GEWP is now one of Acumen's most profitable enterprises. It has even begun to pay dividends to its shareholders. By all measures, that is the kind of return on investment we need to see in a world with more than 2 billion people living in poverty."

Source: *(Bloomberg Businessweek, The Case for Patient Capital, May 2011, http://www.businessweek.com/smallbiz/content/may2011/sb20110524_877194.htm*

With private-public partnerships, some debate exists over whether patents should be allowed on life-saving food supplements or other innovations. A balance may be able to be achieved if the ROI is sufficient for firms, but not being able to patent an innovation may reduce the incentive to develop such supplements in the private sector.

Technology

In our efforts to satisfy the nutritional needs of the world's growing population, we put significant pressure on the resources of our planet as well as on agricultural systems and distribution networks. At the same time, if nutritional needs of populations are not addressed, the healthcare systems and budgets of nations will come under intense stress as the complications of malnutrition are addressed in acute and chronic care. The systems are interconnected and interdependent. For instance, agricultural systems may be affected by climate extremes (droughts and floods), a deficit of manual labor, a lack of technical resources, or a lack of expertise. Healthcare systems, meanwhile, might be impacted by lack of trained staff and equipment and an influx of patients with nutrition-related illnesses as well as communicable and non-communicable diseases. While technology is not the universal panacea, technological solutions have been developed that have potential to bring about positive and much needed change in several of these systems and at many stages of the farm-to-table continuum.

This section examines technological innovation in terms of diagnostics, treatment and delivery (food fortification, supplementation and increasing dietary diversity), and communications.

Diagnostics

Anticipating complex nutritional emergencies and intervening appropriately depends on accurate and efficient analysis of a population's nutritional status and knowledge of the nutrient content of foods. Understanding potential health consequences of nutritional deficits and how to address them early is crucial in all settings. Preventive treatment can be provided and resources properly allocated when reliable data are available.

Deficiencies of key nutrients such as iron and vitamin A can have dramatic health consequences, severely influencing morbidity and mortality rates of populations. Anemia affects more than 1.6 billion people globally and contributes to at least 100,000 maternal deaths and 157,000 child deaths annually. Vitamin A deficiency affects over 200 million women and children and accounts for over 600,000 deaths globally each year among children under 5 years of age.

At the beginning of the 20th century with the discovery of vitamins, research began on the nutritional composition of foods. Since then, multiple technological innovations in diagnostics have enhanced our ability to analyze the nutrient content of foods, and current methods allow the assessment of several micronutrients rapidly and accurately (see Case Study 6)

Case study 6

Continuum: Farm, Processing, Retail

iCheck and vitamin A

BioAnalyt is a manufacturer of equipment used for analyzing micronutrients in food. It has just created a portable device, the iCheck FLUORO, which determines levels of vitamin A in food. Its use has already been incorporated by non-governmental organizations, the food and food processing industry, laboratories, universities and monitoring agencies. It extracts a sample from any fortified food, such as flour, sugar, or premix, as well as biological fluids, into a disposable extraction vial containing necessary reagents for efficient extraction of vitamin A. Using fluorescence measurement through LED technology accurately determines the vitamin A concentration in food.

The device is said to be as reliable as the gold-standard laboratory-based methods that require significant and costly laboratory equipment and a substantial amount of time. Its portability means that the iCheck FLUORO can be used in multiple sites from the factory production lines to markets in remote areas. The process is user-friendly and the three steps of injection, reaction, and measurement take only a few minutes to complete.

Source: http://www.bioanalyt.com/products/icheck-fluoro-and-iex-mila

Assessing the nutrient content in food is important for the prevention of dietary deficiency, but technological innovations are also required to assess the current nutritional status of populations. Technological advances have been rapid in this area, and include screening diagnostics for both iron and vitamin A status (see Case Study 7a and 7b).

Case study 7a

Continuum: Table

Screening for anemia

A rapid, cost-effective, and culturally acceptable screening mechanism was essential to identify individuals in need of iron supplementation. In recent years, advances in technology have brought about a number of non-invasive screening devices that do not require the traditional blood-draw. For instance, a portable transcutaneous hemoglobin (Hb) meter uses a probe applied to a clean fingertip or arm. The probe emits infra-red light and uses photo-plethysmography and reflectance spectroscopy to establish the Hb absorption pattern in the individual. Crowley and colleagues (2012) tested two similar methods of non-invasive Hb screening and found that both classes of non-invasive Hb recording devices performed acceptably in field conditions.

In keeping with the common phrase, "There's an app for that," a team of biomedical engineering undergraduates at Johns Hopkins University in Baltimore, Maryland, USA, have developed a mobile phone application for screening for anemia. Their 'prick-free' device, the HemoGlobe, converts mobile phones of healthcare workers into 'hemoglobinometers' at a cost of $10-20 per phone. The phone can then read the Hb levels, which are displayed on the cellphone screen. Concurrently, an automated text message sends the data to a central server. The students received seed funding from global health organizations and are currently testing this innovative "app" in the field.

Case study 7b

Continuum: Table

Screening for vitamin A deficiency

Night blindness is a common manifestation of moderate to severe vitamin A deficiency and is also associated with a host of poor health indicators.

In 2008, Congdon and colleagues demonstrated a correlation between serum retinol and pupillary response, advancing work in Dark Adaptometry pioneered by Wald and others in the 1930s. Basically, this earlier work established that individuals with low circulating levels of vitamin A (retinol) frequently suffered from night blindness attributable to associated low levels of rhodopsin, the molecule necessary for vision under low-light conditions. In the 1930s through 1950s a battery of tests were developed to assess, subjectively, the lowest level of light at which dark-adapted individuals could recognize shapes or words. In the 1990s field devices were used in a number of settings to evaluate the threshold of light intensity required for a 'major' pupillary response to be observed; these tests were not practical due to the requirement for dark-room conditions in difficult field settings, but also unpopular due to the subjective nature of the data. In the late 2000s Labrique et al. of the Johns Hopkins Bloomberg School of Public Health developed the Portable Field Dark Adaptometer (PFDA), harnessing digital technology to revitalize these principles.

This new method uses lightweight, head-mounted 'light stimulus and pupillary response' goggles run by a laptop computer to expose participants to a series of calibrated light stimuli and digitally measuring pupillary diameter changes. The device requires no dark room environment and is both novel and time saving, a potential alternative to existing invasive biochemical assessments of vitamin A status which require drawing blood and laboratory analytics. This device is in the process of being validated as a proxy for vitamin A status in a number of South Asian and African populations.

The Portable Field Dark Adaptometer (Labrique, West & Sommer), being validated in Kenyan schoolchildren as a proxy for serum-based assessments of VAD.
2010 Alain B. Labrique

Sources: Validity and correspondence of non-invasively determined hemoglobin concentrations by two trans-cutaneous digital measuring devices. By Caitlin Crowley, Gabriela Montenegro-Buthaneart, Noel W. Solomons and Klaus Schuman.
Article on HemoGlobe innovation, NewsMedical, July 25 2012
An advanced, Portable Field Dark Adaptometer for assessing functional vitamin A deficiency. By Alain B. Labrique, Keith P West Jr, Parul Christian and Alfred Sommer.

While low-cost and accurate screening for key nutrients is a crucial innovation to enhance our ability to respond to the global burden of malnutrition, nutritional status is now widely recognized as the outcome of a highly complex and dynamic body system. The field of nutrition now fully recognizes this complexity and incorporates the fields of proteomics (study of proteins expressed by a person's genes), metabolomics (measurement of metabolites at a cellular level), and nutrigenomics (effects of food on gene expression).

These emerging fields enable us to identify biomarkers, or biological specimens, that can be used as proxy indicators of nutritional status, revealing the intake of food energy, fat, protein, minerals, vitamins, and other components not classed as nutrients. For instance, in the area of anemia prevention, an antimicrobial-like peptide hormone called hepcidin has emerged as the master regulator of iron metabolism, controlling the absorption of dietary iron and the distribution of iron among cell types in the body. Its synthesis is regulated by both iron and innate immunity.

Once low-cost and accurate screening tools for these new biomarkers are developed, major advances in health and nutrition programs may result.

In the field of proteomics, analysis of the entire complement of proteins in cells, tissues, or organisms, has led to the development of diagnostic tests that will not diagnose just one major nutrient deficiency, but have the capacity to assess multiple micronutrient deficiencies in populations. Significant further development is required in this area but such innovations could provide another vital tool with which to tackle nutrient deficiencies.

Everyone should have access to the health benefits of fruit and vegetables
Source: Gates Foundation

Case study 8

Continuum: Table

Proteomics in research and food science

A new proteomics approach utilizing mass-spectrometry technologies is revolutionizing our understanding of diagnostics in food science. The proteome is the complement of proteins expressed at a cellular level and is dynamic and highly positional in character.

Stephen Barnes and Helen Kim pointed out in their 2004 review paper that the study of proteomes and their interaction networks is crucial in understanding biological systems, and tissue and fluid proteomes provide novel biomarkers for the detection and progression of disease. In their conclusion they state:

"Clearly, proteomics and protein mass spectrometry technologies can provide rich resources to investigators in nutrition and related areas of biomedical research. Those who are able to include their technologies in their experiments will make the meaningful contributions over the next decade."

Nutritional scientists recognize the problem of the 'hidden' aspect of micronutrient deficiencies. The new field of proteomics could hold the key. Groups are currently working on establishing the validity of a 'plasma nutriproteome,' which could be the basis for developing tests that assess multiple micronutrient deficiencies in populations on a single methodological platform. Senechal and Kussmann (2011) state the possibilities when they wrote,

"Nutritional proteomics holds great promise to (a) profile and characterize body and dietary proteins, including digestion and absorption of the latter; (b) identify biomarkers of nutritional status and health/disease conditions; and (c) understand functions of nutrients and other dietary factors in growth, reproduction and health."

Sources: Nutriproteomics: Identifying the Molecular Targets of Nutritive and Non-nutritive Components of the Diet 2004. Stephen Barnes and Helen Kim Assessing Multiple Micronutrient Deficiences In Undernourished Populations Through The Plasma Nutriproteome2010. Ingo Ruczinski, West, Cole et al Nutriproteomics: technologies and applications for identification and quantification of biomarkets and ingredients. 2011. Sandra Senechal and Martin Kussmann

Delivery

Technological advances discussed in this section have more to do with delivery of micronutrients through mechanisms such as biofortification than the enhancement of delivery/distribution systems discussed previously. Current understanding of the complexity of nutritional processes has led to a significant change in nutritional interventions aiming to improve nutritional status. Improving nutrient intake in this area can occur through nutrient supplementation and food biofortification.

A shift has occurred away from interventions that provide single nutrient supplements and toward those innovations that provide multiple nutrients simultaneously. Industrial food fortification is a convenient method of delivery for multiple nutrient interventions at the population level. Foods such as breakfast cereals, rice, margarine and cooking oils have been targeted for the delivery of multiple micronutrients, with favorable results so far. For instance, Nestle's 'Maggi' cube, fortified with iron and iodine, can be found on the shelves of shops and market stalls throughout West and Central Africa.

Nutrient-dense and safe foods in the form of ready-to-use therapeutic foods (RUTF) are now also being delivered to children suffering from malnutrition. These high-energy nutrientdense foods are typically delivered in small sealed packages and fed directly into the mouths of children. The foods are often made from groundnuts or other locally available staple foods, and mixed with oils and nutrients. One of the first RUTFs to be developed, called Plumpy'nut®, resulted from a public-private partnership (see Case Study 9).

Rice fields in Uruguay
Source: CIAT

Case study 9

Continuum: Retail and Table

Ready-to-use Plumpy'nut®

Plumpy'nut®, a ready-to-use therapeutic food (RUTF), was conceived in 1999. It was developed by a public-private partnership between Nutriset, a French private firm specializing in therapeutic food, and the Institute of Research for Development, a French public research institute. A groundnut-based protein-packed, nutrient-dense paste, Plumpy'nut® needs neither refrigeration nor preparation. The ongoing use of Plumpy'nut® to fight child malnutrition is regarded as a success story in Ethiopia, based on 2008 field research.

A key to its success was the community-based management of its provision, using some existing and some new community networks. Another key was Nutriset's willingness to share knowledge and to allow manufacture through franchises.

However, while Plumpy'nut® was successful in Ethiopia, a 2010 study in a slum area in Dhaka found that eight out of ten women did not like it as a food supplement. This shows the importance of adapting RUTF to the local context for acceptability.

Sources: Management of Moderate Acute Malnutrition with RUTF in Niger. Innovation to Fight Hunger: The case of the Plumpy'nut®. Jose Guimon, University of Madrid. Engy Ali et al, Kamrangirchar Slum

Farmer with his mobile phone in Buhar, India
Source: CIMMYT - TBC

Information & Communications

The global proliferation and widespread reach of mobile phones over the past decade has led to several innovations in information and communication strategies and nutrition. New mobile technologies can be applied in a variety of innovative ways to impact the farm-to-table continuum and beyond, through supporting farming (mAgriculture) and healthcare systems (mHealth).

Applied to mAgriculture, mobile technologies can be used to share important information among farmers. Much like modern agricultural extension which began during the 19th century Irish potato famine when agricultural instructors traveled out to teach farmers about alternate crops, mobile technology has become a 21st century extension worker. It is a mechanism by which essential information can be disseminated in a time-efficient and effective manner.

New technologies have made information more accessible to all, including the smallest scale of farmers. "Plantwise" (www.plantwise.org) is an initiative focused on benefitting small-scale farmers through improving food security for the rural poor by helping them to reduce crop losses. As a modern twist on the 19th and 20th century agriculture extension work, community-based plant clinics share the latest information and research and offer practical advice. The clinics also store feedback information from the farmers in a central knowledge bank. Farmers can access the knowledge bank, which includes information such as the local pest distribution, at the clinic or via a community computer.

Additionally, mobile technology can facilitate the initial steps of getting food from farm-to-table. An illustration in action is the *purjee* system in Bangladesh (see Case Study 10).

Case study 10

Continuum: Farm and Processing

e-Purjee system and sugarcane farmers

Communication is key to successful small-scale agriculture, and in Bangladesh the lives of sugarcane farmers have benefitted from the use of SMS technology. Traditionally, a 'purjee' is a legal permit given to the sugarcane farmers by the sugar mill, informing them that they wish to buy their crops. On receiving it, the farmers then have three days to gather their sugarcane and deliver it to the mill. It is a system that has been in place for over 200 years, since Bangladesh was a British colony.

However, the process has always had flaws. In many cases, the purjees would take more than two days to reach the farmers, who then would not have sufficient time to prepare their crops and bring them to the mills. The purjee system was also fraught with corruption: in the delivery process and in price manipulation.

A system set up as a joint initiative between the Access to Information (A2I) Program at the Bangladesh Prime Minister's Office and the Bangladesh Sugar and Food Industries Corporation (BSFI), known as e-Purjee, intends to resolve some of the issues. Using SMS, the purjee is sent direct to the farmer's mobile phone, along with information on when/where to deliver, how much, and such. The intention with this mobile system is to bypass the myriad problems of the past system.

Source: http://manthanaward.org/section_full_story.asp?id=986

In addition, mobile networks can be mobilized to assist in efficient delivery and distribution of food in crisis situations. Whether helping to organize the multiple actors who are mobilized in times of natural disasters and humanitarian emergencies or simplifying the distribution of emergency foodstuffs, mobile technologies have shown to impact nutrition of those impacted by these situations (see Case Study 11).

Drying maize in Himachal Pradesh
Source: CIAT

Harvesting cauliflowers in Himachal Pradesh
Source: CIAT

A farmer in Nicaragua
Source: CIAT

Case study 11

Continuum: Transportation, "Retail", and Table

Texts and Food Aid

About two million Iraqis have fled their country since 2003, and an additional 60,000 are leaving each month. Prior to the Syrian civil war following the Arab Spring, Syria received the majority of these refugees. At last estimate, there were 1.4 million Iraqis in Syria, many of whom needed food aid, according to the World Food Program (WFP) To meet this need, as part of the WFP program in conjunction with the Syrian Red Crescent, eligible refugee families could receive monthly rations. Each family would receive basic food commodities, such as rice, lentils, and oil, and other items such as sugar, tea, pasta, tomato paste, and bulgur.

As the organization responsible for distribution, WFP alerted eligible families about food rations and directed them to the appropriate distribution centers. Ordinarily, the WFP uses local non-governmental organizations (NGOs) working with the refugees to notify groups when aid became available. However, in this instance, because not all eligible families had regular contact with local NGOs, the strategy needed updating.

In 2007, the UN agency developed and implemented a text messaging program to notify refugees when and where food aid became available. WFP bought text messages in bulk, thereby securing a volume discount, and accessed a list of phone numbers held by the UN High Commissioner for Refugees (UNHCR) to target its text-based food distribution alerts. Initially, text messages to 800 families were piloted. Proving successful in reaching the desired participants, the program expanded dramatically. By the end of the first six months of operation in 2007, 35,000 text messages had reached 140,000 eligible people, the equivalent of one message per WFP-registered family.

Source: Humanitarian Assistance, Wireless Technology for Social Change: Trends in Mobile Use by NGOs.

In the arena of mHealth, mobile systems have also been developed to enhance the capacity of field workers to monitor the growth and nutritional status of children, an outcome of the farm-to-table continuum. The mobile phones have a place in diagnostics and the reporting of screening results (as illustrated in Case Studies 7a and 7b). Information collected can be analyzed immediately to trigger a response, and accumulated data can be aggregated to produce reports for policy decision-makers and program managers.

Another mHealth application is the use of Rapid-SMS, a text-message-based data platform developed by UNICEF and partners, for nutrition surveillance in sub-Saharan Africa. Increasingly used in field settings to support the delivery of interventions, Rapid-SMS allows for monitoring, data collection and information-sharing on a large scale, using mobile telephones. SMS messages have the advantage that they can be sent to multiple recipients, so are ideal for informing a large group very quickly. For data collection, the speed of SMS response means reporting can happen in real time, with no delay while the monitors return from the field. SMS messaging helps information sharing, and the speed means that gaps, for example, in medical supplies or food aid in one area can be identified quickly and also remedied. It is hoped that Rapid-SMS will help to reduce child mortality by shortening the lag time between identifying nutritional emergencies and scaling up treatment in affected areas.

New frontiers

One of the biggest challenges facing the agriculture system currently and looking into the future is how it will respond to climate change. 'Climate-smart agriculture' that increases productivity and resilience to environmental pressures while reducing greenhouse gas emissions requires urgent innovations. The former Director General of the United Nations Food and Agriculture Organization, Jacques Diouf, has given examples of the changes needed to make agriculture climate-smart such as crop diversification, seaweed farming and urban farming, and many of these innovations could be increased in scale in years to come.

The breeding of plant cultivars more able to respond to changing climates may prove a critical innovation for the future. A variety of maize with significantly increased resilience to drought, and a variety of rice able to withstand long periods of flooding (Scuba-rice) are excellent examples of such innovative breeding that are already being used. Some innovations, such as the use of algorithms to provide tailored insurance policies for farmers (see Case Study 12), have yet to be instituted in developing countries, but their potential can already be seen.

Case study 12

CASE STUDY 12 (Continuum: Farm)

Agriculture and algorithms

In India, where delayed onset of monsoons can bring about crop failure, farmers often struggle to repay the debts they incurred to purchase seeds. More than 15,000 commit suicide every year in desperation. Farming has always been a gamble, but the growing number of unusual weather events, as experts call these changes attributed to global warming, makes seeding, farming, and harvesting an even riskier business.

The Climate Corporation, based in Silicon Valley, wants to reverse the trend and reduce farmers' financial risks by crossing agriculture with information technology's trend of big data. The firm collects all kinds of information, including on weather patterns, climate trends and soil characteristics, and analyses the data down to an individual field. These insights are then used to offer farmers tailored insurance policies against the damage from extreme weather events.

So far, the Climate Corporation offers its policies only in the United States. If its combination of agriculture and algorithms succeeds there, however, it has potential to apply these methods on a global scale. Australia, Canada and Brazil are next on its list of countries to apply the assessments. Perhaps insurance policies based on these kind of analytics will one day also protect Indian farmers against the changing weather patterns.

Source: http://www.economist.com/blogs/schumpeter/2012/11/weather-insurance

Conclusions

Innovations across the entire span of human nutrition, from plant to population, have impacted and improved aspects of the farm-to-table continuum. In doing so, humans have sought ways to improve mechanisms to meet growing nutritional requirements, on local and, more recently, global scales. The game-changing innovations discussed in this chapter target farming and distribution systems, develop collaborations, leverage public-private partnerships and utilize technological advances. They have the potential to improve nutrition in both the developed and developing world. Transformative innovations are often born of interdisciplinary collaboration and increasingly, a 'systems' approach is necessary to address intractable problems in global nutrition. The interdependencies from production to consumption present important challenges for the future, requiring continued innovations to develop, produce and deliver optimal nutrition to the continuously expanding human population.

Cattle raised within a silvopastoral system, in which trees are planted at wide spacings into grazed pastures
Source: CIAT

Biofortified beans
Source: CIAT

Our personal view

The process of innovation has been most successful when driven by public health need. Whether in reference to new technologies, transformative methods of cultivation, or simple system processes, innovations that are grounded firmly in the contextual realities of the populations which they aim to serve stand the greatest chance of successful scale. Some have recently criticized the development space as suffering from "technologic solutionism", referring to the tendency of technologies, developed in relatively isolated settings, to search for entrenched problems to solve.

Another often neglected perspective is that of the end-users or beneficiaries of the innovations we seek to develop. Increasingly, researchers are identifying the value of substantial inclusion of these stakeholders in the process of priority-setting, identifying barriers and constraints to optimal outcomes and in the design and implementation of innovations themselves. Not only is the likelihood of achieving better "fit" with the target populations increased, but a local ownership of the strategy is fostered through such methods.

Finally, the importance of continued prioritization and investment in high-quality research cannot be understated. Donors and implementing agencies must focus considerable energy not only on "implementation science", that is exploring how best to deliver what we know is efficacious, but also on developing and testing the efficacy of new solutions. To quote Dean Emeritus Alfred Sommer of the Johns Hopkins Bloomberg School of Public Health, "Today's research forms the basis for tomorrow's programs." Investment is necessary into research that is rigorous, problem-driven, collaborative, interdisciplinary and which seeks to build and engage local capacity.

Further reading

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