The impact of Universal Salt Iodization

One of the greatest public health success stories is also one of the least known. It started with a beautifully simple innovation: putting iodine into table salt. Salt is regularly consumed around the world by rich and poor alike, and so by fortifying salt with iodine, most people’s daily iodine needs could be met at a negligible cost with no change in behavior. In the 1990s, 113 countries were classified as iodine-deficient; that number is now 20. The impact of Universal Salt Iodization (USI) on human capital development is staggering when one considers that iodine deficiency is the most common cause of preventable mental retardation worldwide and that it can reduce IQ scores by an average of 13.5 points. The global scale-up of USI inspired the establishment of new institutions in the early 2000s to extend the success of USI into the fortification of edible oils and cereals such as wheat, maize, and rice to address other micronutrient deficiencies in low- and middle-income countries.

With that amplification, the global infrastructure for reaching nutritionally vulnerable groups in developing countries with fortified foods was born. In the past 15 years, mandatory fortification of various staples and condiments has been scaled across sub-Saharan Africa and many countries in Asia. However, in the context of a dynamic and rapidly evolving food system, fortification cannot realize its full potential for impact as a static public health intervention based upon delivering what is known and accepted today. Even an intervention as successful as salt iodization has had to respond to a changing context, including increased consumption of salt through processed foods, growing rates of diet-related chronic disease in lower- and middle-income countries, and technological advances that enable the addition of multiple micronutrients to salt. These present both challenges and opportunities for innovation.

Breakthroughs in fortification

Historically, there has been a tendency to emphasize innovations in products and technology. However, the types of
breakthroughs needed to improve global nutrition will not stem from product or technological innovations alone but will also require innovation in the underlying systems and structures. Viewed through this lens, three types of innovation can be defined:

- **Technology innovations** enable formulation of the appropriate food vehicles with the appropriate levels of micronutrients to reach consumers with fortified products that can withstand real-world transport, storage, and food preparation conditions.

- **Systems innovations** are necessary to galvanize and incentivize industry to manufacture, package, and distribute fortified foods within the constraints of their businesses.

- **Structural innovations** have enabled complex yet accountable public-private partnership structures between ministries of health, regulators, food processors, and international and non-governmental organizations to pursue public health objectives through both commercial food markets and public-sector channels.

**Technology innovations**

Technology innovations in food fortification have addressed the combinability, stability, bioavailability, and sensory challenges posed by certain micronutrient compounds, with iron being a critical focus given its public health importance and the persistent challenges faced with its delivery. For instance, sodium iron EDTA (NaFeEDTA), which has been on the market for over 20 years, has over time been introduced into a number of fortification programs to enhance iron bioavailability in foods with strong absorption inhibitors, such as phytates in high-extraction wheat flour. Newer solutions also exist to address technical challenges associated with specific food vehicles, such as new, encapsulated iron forms that can be blended with salt, and chelating ferric pyrophosphate (FePP) with citric acid and trisodium citrate to improve bioavailability while minimizing sensory challenges in rice. Additionally, a range of encapsulation technologies, from fungi to polymers, are in development to protect iron and other micronutrients from sensory interaction with the food matrix, improve their combinability with other micronutrients, and in some cases, improve the bioavailability of iron. Technologies are also in development that address the safety risks associated with iron intake. These technologies take different approaches to more slowly releasing iron into the bloodstream, better mimicking the

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pathway of iron from natural sources, and avoiding the inadvertent feeding of pathogens in high-infection populations.

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Looking ahead, we believe there is a need to widen the range of ingredient solutions to better capture evolving consumer needs and reflect emerging evidence on the determinants of poor growth. For instance, we need to think more creatively about potential codelivery of solutions to improve gut health, as simply adding micronutrients into the diets of children with chronic infection or environmental enteric dysfunction will not solve micronutrient malnutrition in these subgroups. The range of emerging solutions from bioactive peptides to polyphenols with prebiotic properties to oligosaccharides that have demonstrated impact on non-communicable diseases in developed-world markets may also play a significant role in improving micronutrient utilization. In fact, early research on the effect of prebiotics on iron absorption, particularly in complementary foods, has shown promise.

Additionally, with the renewed interest in the role of proteins in growth and development, the pendulum seems to be swing-ing back, this time recognizing that deficiencies in both macro- and micronutrients contribute to poor linear growth and weight gain and therefore that both need to be considered part of the solution. This coincides with a strong resurgence in protein research by the private sector, driven mainly by developed-world interests in satiety for weight control, glycemic management for diabetes, and the impact of specific amino acids on cell growth and digestibility for better differentiation. Newer plant-based and alternative protein sources, with lower costs and lighter environmental profiles, are becoming widely available and show promise to be adapted to a range of applications.

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Consideration should be given to expanding the use of nutrient-dense, natural ingredients grown in the developing world, such as spirulina, to help reach fortification goals. These types of ingredients have the potential to deliver proteins and micronutrients simultaneously; they have components, such as provitamin A, that are less vulnerable to degradation from heat and humidity compared to the retinyl palmitate that is added to foods, and they pose fewer safety issues when it comes to increasing fortification levels. While an ingredient such as spirulina does confer a change in color, specific varieties are flavorless, and therefore hold strong potential for integration into ready-to-use therapeutic foods and lipid-based nutrient supplements, for which both proteins and micronutrients are needed. Moreover, demand is growing among consumers in middle- and lower-middle-income countries for “natural” ingredients and products, which are perceived to be healthier. Innovations to improve manufacturability at scale are critically needed to drive down costs and expand sources of raw materials for fortification programs.

Ultimately, innovations to improve nutrition should be driven by a deep understanding of the unmet nutritional needs, aspirations, behaviors, and preferences of consumers who remain underserved by markets and face limited access to affordable, nutritious foods. For an increasing proportion of lower-income consumers in Africa and Asia, processed foods represent a significant percentage of the daily calories consumed. There is a considerable opportunity to enhance the nutritional profile of widely consumed packaged foods through innovations that improve nutrient density, while simultaneously reducing saturated fat, salt, and sugar intake from these foods. These types of products can complement the more traditional approaches of fortifi-
fying staples and basic condiments, and can increase nutrient intakes across the food basket.

**Systems innovations**
A more consumer-driven approach to innovation should put greater focus on systems innovations. Consumers — and the food system in which they are immersed — are, by definition, dynamic. Therefore, a data-driven feedback loop needs to be established that regularly assesses consumption patterns and resulting nutrient intake, and then optimizes the impact achievable through fortification by calibrating combinations of nutrients and levels, the mix of products that are fortified, and the economic cost and benefit to society. New ways to source and analyze data, whether through big-data approaches or innovative means such as crowdsourcing product information through mobile platforms, provide potential alternatives to relying on stand-alone data collection efforts that are time- and resource-intensive.

“The next generation of systems innovations has tremendous potential to leverage the data revolution and artificial intelligence to enable data-driven decision-making”

In the past, systems innovations that integrated certification and procurement schemes enabled access to high-quality micronutrient premix supply at lower prices and favorable credit terms. The next generation of innovation in quality systems has tremendous potential to leverage the data revolution and artificial intelligence in order to enable data-driven decision-making. Smart dosifiers are already being implemented in small-scale commercial maize mills in Tanzania to largely automate fortification. This type of equipment transmits data to a cloud-based system to remotely monitor fortification levels. Paired with the technology innovation is a business model innovation that subsidizes the cost of the micronutrient premix through cost-savings generated by other value-added services. Such models could offer insights into new ways to approach monitoring in larger-scale systems for specific value chains. Another promising opportunity area is the application of blockchain technology to ensure traceability and accountability throughout the value chain so that the appropriate micronutrient levels are maintained within food products from factory to fork. Finally, building upon the growing global trend toward personalized health and nutrition, IT-enabled *in vitro* diagnostics could lead to better targeting to ensure the right nutrients are reaching the right people for the greatest impact.

**Structural innovations**
As food fortification programs shift from a focus on the beneficiary to the consumer, structural innovations will be required to enable a new level of coordination and accountability to transform food systems so that they provide greater access to affordable nutrition. This means including partners within the fortification ecosystem with the greatest ability to influence and reach consumers, namely consumer-facing food manufacturers and retailers as well as consumer advocacy groups, to increase their accountability. The evolution in many humanitarian and safety-net programs from food-based to cash- or voucher-based schemes that involve food retailers is a good example of innovation to date that has structural implications for how disparate actors can work together in new ways to meet the needs of underserved consumers and empower them with choice and greater convenience. Bringing these actors together could also be an opportunity to connect those working to address undernutrition,
on the one hand, and obesity and chronic disease, on the other, through a common platform for better-quality food.

The existing food fortification infrastructure has evolved from single-vehicle initiatives to platforms that promote micronutrient fortification across a range of food vehicles. This infrastructure includes multisectoral alliances of public- and private-sector stakeholders to oversee implementation of national food fortification programs, industry associations, technical partners supporting policies and programs, and the scientific research community. In the future, this infrastructure could be leveraged and broadened to include, for example, entities involved in protein research, manufacturing, and sales. This also creates an opportunity for convergence with the new ecosystems that are now emerging for food innovation, including start-ups and social enterprises, food- and agriculture-focused venture capital funds, and a host of accelerators and incubators.

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Conclusion

In conclusion, current thinking about food fortification must evolve to incorporate macrotrends, emerging research, the convergence of certain health needs across rich and poor countries alike, and innovation from other sectors. A radical transformation of existing food systems is required to better serve lower-income consumers at risk of malnutrition, involving layers of innovation to reshape underlying systems and structures. No single entity in isolation can bring about this type of transformation. But collectively, we all bear responsibility for making food systems work more effectively for nutritionally vulnerable consumers.

In the end, is fortification a silver bullet? No. Can more be done through fortification to close the gap in nutrient intakes among vulnerable populations? Yes. And is this reason to invest in new ways of thinking about innovation in fortification? Absolutely. This calls for both optimism and urgency.

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