

# When Biological Systems Meet Food Systems

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“A good means to discovery is to take away certain parts of a system to find out how the rest behaves”

*Georg Christoph Lichtenberg (1742–99)*  
*German scientist, satirist and philosopher*

Despite substantial global and national mitigation strategies, malnutrition in all its forms, from undernourishment and micronutrient deficiencies to overweight and obesity and related noncommunicable diseases (NCDs), is still on the increase. In a recent workshop on food safety and healthy diets organized by the Academy of Sciences of the Vatican, FAO Director-General José Graziano da Silva highlighted the fact that by now a frightening 2.6 billion people are overweight and obese. Moreover, the United Nations General Assembly in September 2018 dedicated a full day to a high-level meeting on the prevention and control of NCDs. Da Silva sees unhealthy diets – composed of foods that are dense in energy, fat, sugar and salt – as the most important factors behind the “global pandemic of obesity.” The Sustainable Development Goals (SDGs) aim to eliminate malnutrition, including overweight, by 2030. Without a miracle, the achievement of this objective is highly unlikely in the dozen years before that date.

“Without a miracle, the elimination of malnutrition by 2030 is unlikely”

## The risk of neglecting human biology

Without any doubt, the situation is dire, unsustainable, and requires action by all actors in the food system. Traditional food systems are characterized predominantly by stunting, wasting and micronutrient deficiencies and less by the prevalence of overweight. Modern food systems are dominated by overweight, obesity and NCDs. But can food systems and food environments be changed simply by

educating consumers, persuading the food & beverage industry to reformulate products, imposing sugar taxes, and regulating front-of-the pack labeling and product marketing? These efforts crowd the current discourse in national and international nutrition circles, but don't we run the risk of neglecting human biology in our quest to eradicate the double – or even triple – burden of malnutrition?

## Nutritional and psychological well-being

Nutritional and psychological well-being go hand in hand. Poverty and household food insecurity lead to stress, anxiety and depression. Recognizing this, the charity GiveDirectly provides ‘basic income’ to those in need without any restriction. Between 2011 and 2013, GiveDirectly provided unconditional cash transfers to extremely poor households in western Kenya. The average transfer corresponded to almost two years of per capita expenditure.

Researchers from Princeton University evaluated the program. The cash transfers had positive effects on happiness, life satisfaction, stress levels and depression. The glucocorticoid cortisol (a stress hormone) was found to be lower when transfers were made to the wife rather than the husband, when a lump sum was given rather than monthly installments, and when the payment was large rather than small. Most cells in the body have cortisol receptors. Cushing syndrome – a disease involving chronically elevated cortisol levels caused by a tumor of the pituitary or adrenal glands – is characterized by weight gain (predominantly in the face and abdomen), diabetes, hypertension and suppressed immune function.

Harvard University behavioral biologist Katie Hinde and colleagues studied 108 nursing rhesus macaque mothers. Some macaque mothers delivered significant levels of cortisol to their babies through their milk. Milk high in cortisol made babies put on weight faster, become nervous and develop a less confident temperament. Interestingly, lower parity correlated with higher milk cortisol levels. Shaping the phenotype of the offspring via the transmission of biologically active compounds (including glucocorticoids) into breastmilk has been designated as ‘lactational programming.’ Other factors in lactational programming are, for instance, leptin, ghrelin and adiponectin, which are also known to affect satiety, metabolism and adiposity.

## Early-life programming of overweight and NCD risk

Early-life programming of overweight and NCD risk does not start

with breastfeeding. Fetal exposure to maternal glucocorticoid cortisol also increases risk of adiposity in early life after birth. Glucocorticoids could even be an underlying mechanism – or, indeed, *the* underlying mechanism – of early-life programming, leading to fetal growth retardation (small-for-gestational age [SGA], stunting), adiposity and increased NCD risk in adulthood. Epigenetic modifications, especially methylation, which can change gene expression, have also been implicated in fetal programming. Developmental Origins of Health and Disease (DOHaD) is now a field of intense research that links undesirable early-life exposures (pre- and post-natal) – and poor nutrition and micronutrient deficiencies in particular – to a higher risk of NCDs, which is further compounded by rapid weight gain after birth. There is an urgent need to better understand the role of DOHaD in adiposity and NCD risk for low- and middle-income countries and how this relates to the respective food systems and environments.

The gut microbiota has also been implicated in the development of overweight and obesity. Overweight people have a lower diversity of gut microorganisms than people of normal weight. This lower diversity causes a microbial imbalance (dysbiosis) in the intestine. It appears that microbiota dysbiosis enhances diet-induced obesity and metabolic complications by a number of mechanisms including immune function, energy metabolism, changes in gut hormones and inflammation. Dietary factors such as fiber, carbohydrates, protein and fats affect the abundance of different microorganisms in the gut. With this in mind, isn't the gut microbiota another important target for addressing the global malnutrition burden? It should be observed that we will need to better understand how dietary factors interact with the good and bad bugs in our intestines in order to effectively explore this relationship.

## “Isn't the gut microbiota another important target for addressing the global malnutrition burden?”

Elsewhere in this edition of *Sight and Life* magazine, we report about the Asian phenotype with relatively low body mass index (BMI), increased body fat and a high risk of central adiposity and metabolic syndrome (see Time to Recalibrate Nutrition Improvement Strategy? on [page 64](#) of this issue). I was intrigued by a study from rural Bangladesh in which women had excess adipose tissue at substantially lower BMI compared with non-South Asian populations. A BMI of 21 kg/m<sup>2</sup> identified subjects of >30% body fat. This calls into question the validity, at least for the Asian context, of higher cut-off points established by the WHO.

### Discovery science

In *Sight and Life* 29(1), 2015, Dr Andrew Prentice states, “I

strongly believe that discovery science will lead us more quickly to effective interventions than continuing to feel our way in the dark with trial after trial.” Prentice goes on: “We are seduced by the possibility of a silver bullet that will provide a quick fix.”

## “Our biological and metabolic knowledge of malnutrition is still too sketchy”

I can only concur with Dr Prentice: our biological and metabolic knowledge of malnutrition in all its forms is still too sketchy. We now possess the technologies (e.g., omics) to amplify discovery research. We must explore how the human genome and epigenome interact with the food system and environment to shape the phenotype. Only a better understanding of these interactions will fast-track our efforts to overcome malnutrition in all its forms. This is where the biological systems meet the food systems, as well as the related cultural and socioeconomic systems. Given the importance of the biology of the first 1,000 days for establishing physical, mental, health, economic and socioemotional well-being for the whole life course, I wonder why we don't focus more closely on these interactions.

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### References

- > FAO. Trade and consumption of cheap junk food are an obstacle for healthy diets. Rome: FAO; 2018.
- > Haushofer J, Shapiro J. The short-term impact of unconditional cash transfers to the poor: experimental evidence. *Q J Econ.* 2016 Nov;131(4):1973–2042.
- > Mandy M, Nyirenda M. Developmental Origins of Health and Disease: the relevance to developing nations. *J Clin Endocrinol Metab.* 2017;102(4):1366–74.
- > Shaikh S, Jones-Smith J, Schulze K, Ali H, Christian P, Shamim AA, et al. Excessive adiposity at low BMI levels among women in rural Bangladesh. *Nutritional Sci.* 2016;5(e11):1–9.
- > Karakochuk CD, Whitfield KC, Green TJ, Kraemer K. The biology of the first 1,000 days. Boca Raton, FL: CRC Press; 2018.
- > Hinde K, Skibiell AL, Foster AB, Del Rosso L, Mendoza SP, Capitanio JP. Cortisol in mother's milk across lactation reflects maternal life history and predicts infant temperament. *Behav Ecol.* 2015 Jan–Feb; 26(1): 269–281. Published online 31 October 2014. doi: [10.1093/beheco/aru186].