## Mini Review

# Benefit risk and cost ratios in sustainable food and health policy: Changing and challenging trajectories

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There is benefit, risk and cost in all that we do, but when it comes to food, we expect that it will benefit our health, be available, safe to eat and affordable. But as climate change and demographic shifts through displacement and ageing gather momentum, the emphases on each of benefit, risk and cost will alter. That we are *ecological beings* whose health and wellbeing are ecosystem-dependent, must now be the underpinning framework for risk management. Loss of natural environment and biodiversity represents reduced nutritional and health resilience, which will need to be factored in to risk assessment and management with climate change. This is proving a problematic risk communication challenge. Previously desirable food and food pattern recommendations will be tempered by substantial sustainability, availability, safety, affordability, equity and ethical considerations. Future *workforces* will need to ensure *basic livelihoods* (food, water, shelter, clothing, healthcare, education, communication, essential transport, resource management and effective governance) and with risk minimisation. Cost appraisal will have less to do with monetisation and more to do with resource management in accordance with *equity and ethical principles.* Communities could adopt Liveability Units (LU) for traceability and community-based transactions, as a currency for a more sustainable future, encouraging and enabling food and health system viability. *Open source food and health systems*, supported by LU matrix (bar code or QR) scanning with smartphones could be widely available for individual, household and community benefit, risk and cost management. The risk is remoteness from food's origins and megadata commercialisation.

**Key Words: climate change, food systems, health systems, risk offsets, Liveability Units**

## INTRODUCTION

There is benefit, risk and cost in all that we do, but when it comes to food, we expect that it will benefit our health, be available, safe to eat and affordable.[1] But as climate change and demographic shifts through displacement and ageing gather momentum, the emphases on each of benefit, risk and cost will alter.[2] The extent, magnitude and interconnectedness of global risks which are environmental, societal, geopolitical, economic and technological are documented in the World Economic Forum Insight Report for 2020.[3] The most likely and most impactful risk is climate action failure.

## HISTORICAL FOOD SYSTEMS FOR THE HEALTH AND WELLBEING OF SOCIOECOLOGICAL BEINGS

An evolutionary and historical approach to benefit, risk and cost enables a more comprehensive and in-depth appreciation of this trio which underpins healthcare policy and practice. This applies particularly to food and health systems. We once ***gathered, hunted and cooked*** our food, with cooking as a transformative and defining human characteristic.[4-6] It now appears that, while ultimately coming from Africa, we are hybrid of several lines of hominid evolution on which we draw and which has contributed to our societal profile and requirements.[7-9] We are intimately connected with the geological[10] and natural world.[11,12] Our latest difficulty is that we have so-changed the earth since the industrial revolution of the 18th century, that we are now in an era increasingly of our own making, referred to as ***anthropocene***, where ecosystems have been expended with little regard to our ultimate health and survival.[13] Wahlqvist has argued that we have evolved not so much as a species, but co-operatively with the world around us, as ecological creatures with ecosystem characteristics.[14] In this sense it is not surprising that how we eat to health advantage or risk is reflected in genomic associations,[15] whether eukaryotic or prokaryotic, microbiomic, mycobiomic,[16] or epigenetic.[17] At some

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Manuscript received and accepted 31 February 2020.
doi: 10.6133/apjcn.202003_29(1).0001

point in our social evolution, we began to care for each other, and food helped us do that. For most of our history, meeting our food and health needs as best we knew have been complementary pursuits. Being ambulatory creatures with a sense of place and direction, and a ***nutritional biology best served by biodiversity,*** we were able to choose and change where we lived. The ***dwelling place*** needed to provide personal and community security and ecological services of water, a biodiverse natural environment for food and health, and shelter against earth's diurnality, seasonality and weather excursions.[18] The requirements should not exceed the capacity of our intrinsic biorhythms or mechanisms for environmental synchronicity.[14] Such conditions encouraged ***subsistence settlement***, with local food production, harvest and storage; migration could ensue if settlement failed or did not meet expectations. Various forms of community health care developed whose utility was determined by observation and refinement through trial and error, or through traditional healers. In this early, although protracted period of our evolution, the ***principal benefits*** were survival with food security and a supportive household or community, which remain so today.[19] There will always have been risk in whatever has taken place in human history and affairs, and some sense of its ascertainment and management for survival, health and well-being. The ***main risks*** posed were those of natural disaster, poor organisation or strategy and conflict, somewhat amenable to good ***governance*** in today's parlance. In more recent times, we have taken an increasingly ***scientific approach to risk***, particularly in regard to food and health.[20] The ***costs*** to be entertained were in life and health, loss of suitability and habitability of dwelling place or inability to migrate. At their core, and especially with climate change and conflict, these remain the overriding benefits, risks and costs in the 21st century.

## CONTEMPORARY FOOD AND HEALTH SYSTEM RESILIENCE

What we now have is population size and density which places demands on environmental services and ecosystems in excess of what can be provided on account of ecological loss and compromise. There has been an increased complexity of the contemporary food supply from harvest to consumption and of the health and well-being of humankind. This requires systems approaches to risk assessment and management with much greater sophistication and innovation. Food and health systems need to intersect ***with systems for livelihood generation, mobility, communication, education, governance, economics, provision of utilities (including water, sewerage and energy), town-planning, public open space (POS) and recreation***. If any one of these falters, nutritional and health status may suffer.[1,7,21,22] It is increasingly evident, as indicated earlier , that we have evolved not as an alone species, but as social[7] and ecological creatures.[14,23] On this account, the International Union of Nutritional Sciences (IUNS), in 2005, recommended that nutrition science be recognised and operationalised in ***environmental, the biomedical, societal and economic dimensions*** (Figure 1).[24-27] Benefit, risk and cost may be considered in each dimension, with trade-offs and offsets across them all, and, at all times, ensuring sustainability.

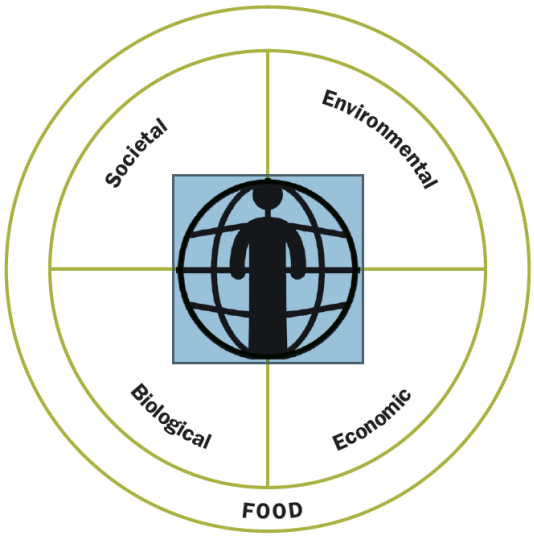


**Figure 1.** The dimensions of human nutrition are biological, societal, environmental and economic. From ML Wahlqvist and D Gallegos "Food and Nutrition" (2020) with permission.[25]

## DIETARY STRATEGY FOR OPTIMAL HEALTH

There is now a consensus about the kind of diet which will:

i. Minimise energy and nutrient deficiency disorders, with proneness to immunodeficiency and infection;
ii. Reduce the risk of so-called chronic disease such as obesity, diabetes, macrovascular, musculoskeletal and neurodegenerative disease
iii. Optimise organ function reflected in cardiac, respiratory, gut, bone, muscle, kidney and brain health.[28-32]

This dietary strategy is intergenerational, it should be in place preconception, through pregnancy and lactation, and it applies during growth and development, the reproductive and livelihood generation years, and into later life. It is characterised by biodiversity, plant food orientation and minimalistic food preservative, preparative and cooking procedures which are under personal, household and community control.[4,29,33] There needs to be sufficient dietary diversity for the required food component spectrum and structure;[34] regular leisure-time physical activity of at least 30-40 minutes per day; sunlight exposure and 7-8 hours' sleep.[25,35-37] Residual energy needs may be met by less nutrient dense staples like root vegetables, seed or grain crops and cooking oils or fats.[34,38,39] A nutritious diet, depending on food culture, will be biodiverse and generally include fish or other aquatic food, eggs, legumes or nuts, root and green leafy vegetables and culinary herbs and spices.[40-42] Foods which are themselves potentially embryonic or early life forms like seeds and eggs, are implicitly nutritious. Humans have omnivorous potential with flexible and resilient eating patterns as evidenced by healthy longevity among diverse food cultures.[43] It is simplistically thought that nutrient essentiality for humans is limited to a few vitamins, elements, amino acids and fatty acids, ignoring food component complexity, its structure which confers a delivery matrix,[34] companion foods and the pattern of eating in socioecological context.[28] ***Optimal health and longevity depends as well on exercise, sunlight exposure and sleep pattern***. Our nutritional biology is extensive (Figure

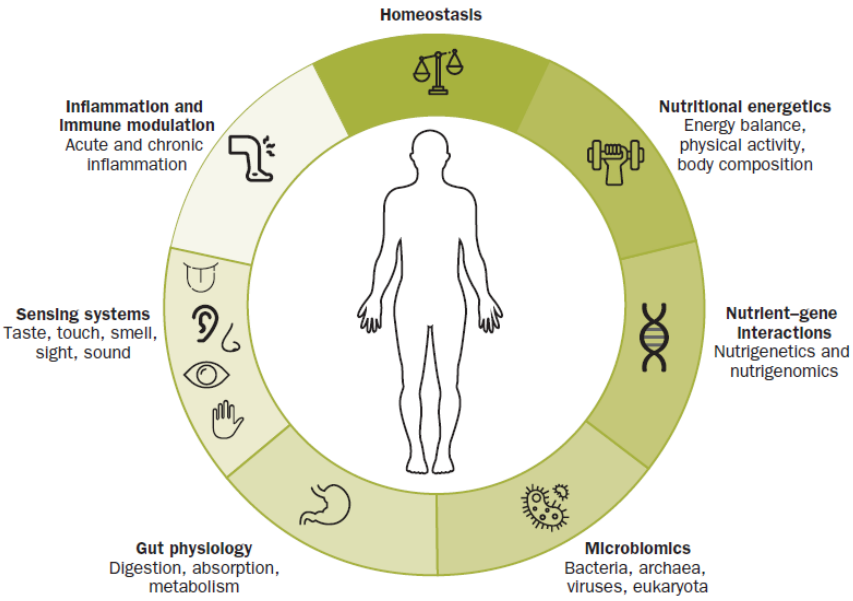


**Figure 2.** Each of the fields of nutritional biology has ecological connectedness. From ML Wahlqvist and D Gallegos "Food and Nutrition" (2020) with permission.[25]

2)[25,44] with biomedical, societal, environmental and economic dimensions (Figure 1).[24,26] We are, in reality, socio-ecological creatures[14] dependent on our econutritional status.[23] At once, we have been able to migrate across the face of the earth and live in biogeographically contrasting localities, if potable water were available. Vulnerability to weather extremes has been countered by shelter or dwelling, clothing, food preservation and trade.[32] If these measures failed or were found onerous, we invented or borrowed technology from elsewhere, or migrated.[45] These were risk mitigation strategies.[20] The recognition that we are more than a human species, and functionally inseparable from our environment has led to a deeper understanding of who we are and that we have evolved as ecological beings. In that event our health and well-being, risks to them and their disorder may more usefully be considered as Ecosystem Disorders (EHD).[46]

Most instructive in regard to the ***transition from earlier to present dietary patterns*** is the finding that dietary diversity protects Indigenous Taiwanese against otherwise premature mortality.[38] Indeed, for the global burden of disease measured as HALES (healthy life expectancy), this applies internationally.[47]

The transition has given rise to a lack of confidence in the nutritional reliability of the food supply among many, along with the notion that what nutritional knowledge we have provides an opportunity to add biological advantage. In turn, this has been exploited by manufacturers and marketers for profit, purporting to be 'adders of health value'. Apart from clinical deficiency and the rare situation where pharmacological amounts of nutrients have pharmacological rather than physiological effects, there is virtually no evidence that nutrient supplements are beneficial, and what evidence there is reveals risk and detriment;[48] by contrast, food patterns and certain food categories like legumes and spicy foods may be protective.[49,50] Nicotinic acid is an example in the treatment of hypercholesterolaemia.[49,51] Yet the multibillion-dollar industry persists despite the evidence.

***Salt (NaCl) intake*** is an example of a changing benefit-risk-cost ratio. Sodium is an essential nutrient, but its benefit and risk are not only dose dependent, but interactive with other elements, notably the monovalent potassium, so that the Na/K ratio is a more important consideration in hypertension and stroke than Na alone. Not only that, so also are divalent cations Mg and Ca, alcohol and a number of phytonutrients. The ***population attributable risk (PAR)*** is dependent on the prevailing patterns of disease in the population in question.[52] For example, it may also increase the risk of osteoporosis[53-55] and of cognitive impairment[56,57] so that the prevalence of these must also be considered.

## THE ANTHROPOCENE ERA IS CHANGING THE BENEFIT-RISK-COST RATIO OF THE HUMAN DIET

Our history, through population size 'management' by migration, colonisation or war if we were too many or in conflict; food and health system innovation;[58-60] and ecological service provision and loss[61] has conditioned us to think we can continue to solve the growing mismatch between us, our wants and the planet in these ways. It has become clear that this is no longer possible, if the planet is to remain habitable in the 21st century. Moreover, the earth has entered a new era, the anthropocene, where we have altered its geology forever.[13] This new era can be attributed to the Industrial Revolution in the 18th century, which became dependent on forests and coal to power transport and machinery. This was exacerbated by the development of the internal combustion engine for vehicular transport and the use of oil. Within 100 years of the advent of cars, we have taken the planet's habitability to the brink.

While the anthropocene was becoming indelible, ***our food systems also became more dependent on fossil fuels*** for farming, food transport, storage and preservation. Packaging needed cardboard, ultimately from timber and forests and plastics from fossil fuels. Now, the oceans,

virtually every sea creature, waterways and the atmosphere are contaminated with microplastic or the more minute nanoplastics. Our food systems and food profiles have radically changed and so have their risk profiles.[18,60]

## FOOD SECURITY, EQUITY AND ETHICS

Against this background of increasingly rapid changes in the food and related health systems, food security is changing and bringing with it health insecurity of uncertain characteristics.[1] But that there will be ethical and equity challenges is certain.[1] ***As dietary biodiversity is threatened by ecological loss***, there will be questions about whose health is most and least affected, and by what underlying factors. If fish, legumes, nuts and berries are health protective, how will they be distributed and what might an individual entitlement be? Will it be a matter of who can pay or a societally determined allocation? ***If fish is contaminated with nanoplastic***, whose endocrine disruptive properties are amplified by each particle's binding sites, at what point will the benefits of fish, through its amino acid, n-3 fatty acid and vitamin D and other nutrient profiles, be outweighed by contaminants? A similar risk evaluation will be required for almost every current dietary recommendation or guideline.[62] These are individual, sometimes clinical, and inevitably community or public health challenges. If food supplies become precarious, as is likely after the catastrophic bushfires and floods in Australia, this will have food security consequences for its citizens, and abroad since it is a major food exporter.[63] We will be more equitably served if guidelines emphasise how little food we need, rather than how much can we get and consume.[21] In the unfortunate anticipation of such crises, and in order to minimise global warming on account of the increasing atmospheric greenhouse gas load, guidelines about dietary patterns to reduce the risk of food insecurity are to be expected.[64-66] Yet another risk, as we identify food which have particular health protective properties, is that these are then exploited for profit and sell at inflated prices, to be consumed by those who can afford them. This has been the case for some commercialised traditional crops with limited ecological capacity for production, an ecological distortion towards monocultures, loss of ecosystem resilience, crop failure and malnutrition. Best known for this sequence are crops appropriated in colonial times such as potatoes, corn, palm fruit, sugar cane, bananas and tomatoes from the Americas, the Pacific and West Africa to Europe, Asia, Australia and New Zealand and also back the Americas for intensive agriculture. These shifts in food systems themselves have contributed to population explosion, migration, food cultural loss and the emergence of new health problems. They are examples of the long term risks and costs to planet and people of purported food system benefits, justifiable in the short term .[67]

## NUTRITIONAL ECONOMICS

The systematic analysis of the economic consequences of the food system and nutritional status on national, community, household and individual economics is limited.[68] It is recognised and obvious that the effects of undernutrition on performance reduce the contributions people can make to economic and social security.[69] It is estimated that nutrient deficiencies alone, if prevented, would have a major economic benefit.[70] Efforts have been made to look at the economic consequences of particular diseases, notably those of energy dysnutrition and limited biodiversity like obesity, diabetes and cardiovascular disease.[71] In the example of obesity, survivability in later life can be advantaged rather than disadvantaged, partly dependent on investment in health care and its availability.[72] With age and the advent of other health problems, there may be health economic trade-offs which make clinical decision - making complex.[73] Multisystem disease, much of it nutritionally related, becomes more evident with advancing years and overall survival is greater, with the greatest costs occurring in the last few months of life. Health care systems and their costs are increasingly challenged to compress morbidity as near as possible to the end of life, as measured by disability adjusted life years (DALYS).[74]

Using the National Health Insurance, national food data bases and national nutrition surveys in Taiwan, it has been possible to show that spending more on plant food diversity not only prolongs healthy life spans,[75] but also is associated with reduced national health care costs.[75-77] The application of nutritional economics to the costs of food and health policy have the potential to encourage individuals, professionals and governments to pursue more affordable and sustainable advice and programs about food choice.[68] There are expectations that microbiomically produced food or stem cell generated foods will replace agriculturally produced foods in the foreseeable future, even as ecosystems, agriculture and harvest collapse.[78] If so, it will signal major socioeconomic turmoil. Perhaps population sizes will decrease in time for less need to have recourse to such approaches; they would, in any case, be likely to short-change the overall benefits of food and food systems for health which extend beyond the food itself.

## EVIDENCE FOR BENEFIT-RISK-COST RATIOS

The clues to benefit and risk often come from probably biased ***stories, reports or case studies*** with likely bias.[44,79,80] Nevertheless, they often spur enquiry or encourage more rigorous or structured investigation for corroboration. Together with literature review and debate these accounts are the most common way in which clinical and public health work is reviewed and a basis for continuing education.

Many of the emerging problematic decisions about dietary patterns and food choice will not be amenable to ***conventional hierarchical evidence-based methodology***.[81] This usually assigns randomised clinical trials to the most dependable form of evidence, followed by epidemiological methods which are observational or case-control, supported by animal or cellular experimental studies.[14,82] This is principally because the trial designs have difficulties insofar as controls are concerned and are limited in extrapolatability because of context. It means they may be more about nutrients or food components than foods or food patterns. Sample size and cost are likely limitations so that stratification by background diet, personal behaviours, sociodemographic factors, nutritional and health status and ethnicity may be impractical. Meta-analysis does not necessarily overcome these

concerns and may obscure them. Thus, a narrative which explores coherence of various lines of evidence may be the more defensible approach. Modelling food patterns as predictables, with repeated monitoring of outcomes, and revision of approach may be more realistic and integrative of benefit-risk and cost. This is particularly because measures of risk and cost are likely to require the use and linkage of data bases outside the dietary practice or intervention. It allows for ***population-wide studies with administrative data bases***, especially where these are available from National Health Insurance providers. Perturbations of these systems in well-characterised known locations, with huge sample size and metadata as the reference, may well ***replace the clinical nutrition trial.***

This will be more important as food and health systems are challenged by novel and so-called functional foods, and by 3-D foods to look like familiar foods, but lack both the component and structural equivalence of the traditional or natural form of the product.[60] Most concerning is that, with food insecurity, there may be a proliferation of such foods at an affordable price, but of greater risk, one's which may not be evident until the medium to long term. Indeed, we already have an indication of how pervasive this may be with so-called 'ultra-processed foods',[83-86] which development has belatedly been recognised as a major contributor to the nutritional transition to so-called chronic disease. The trend towards these among Taiwanese adolescents has been associated with their easier affordability.[83]

## POLICY IMPLICATIONS: ECOSYSTEM INTEGRITY, LIVELIHOODS AND LIVEABILITY UNITS, BLOCK CHAIN AND INTEGRATIVE SYSTEMS

The contributions that the misuse of energy sources and ecosystem degradation make to food insecurity have been under-estimated.[21] Much of the benefit humans seek has to do with the ***use of energy in daily life*** which we derive through an electricity grid or local battery storage. The source of this energy from forest and fossil fuels is an atmospheric pollutant with consequential adverse health effects and global warming. More efficient and renewable energy sources, which do not cause ***ecosystem loss and damage***, would markedly reduce the risk that current fossil fuel usage presents. Solar and wind energy are established and cost-effective alternatives to fossil fuels. Solar passivated emitter and rear cells (PERC), developed in Australia, alone are expected to reduce global greenhouse gases (GHG) by 5% at less cost than all other forms of energy presently available.[87] Prospects are encouraging for microbial generation of hydrogen from water as an energy source in road, and even air, transport. So would a recognition that we are wasteful energy generators and could be ***personal energy generators***; we could better use what we eat in our own mobility by walking and cycling more. We could wear clothing that captures and transduces our movement and heat production into powering personal lighting and computing. In any of these approaches, battery storage will add convenience, efficiency and affordability.[88] If clothing were more valued, and less disposable, as part of the circular economy, it would reduce its massive contribution to the burden of waste. Since much clothing is now made with polyesters from fossil fuels, there would be less ***environmental microplastic contamination***,[89-91] now contributing to endocrine disruptor disorders.

Our ***dwellings and workplaces*** will need to be more resilient to climate change. There is increasing evidence that ambient temperature and clothing may not only be a factor in our energy balance, body composition and related health outcomes, but also affect metabolic regulation through insulin sensitivity or resistance.[92,93]

***The nature of work*** we do today will change radically, not just because of automation, robotics, digitisation and artificial intelligence, but because many ecosystem resources and services will have been compromised or lost. In addition, Natural disasters will be more common and extreme with drought, fire, storms, rising sea levels, floods loss of arable land and edible seafood.[94] Increasingly, as a ***workforce, we*** will find that what we need will have more to do with ***basic livelihood*** (food, water, shelter, clothing, healthcare, education, communication, essential transport, resource management and effective governance) and risk minimisation Cost appraisal will have less to do with monetisation and more to do with resource management with ***equity and ethical principles***.[1] These principles encourage more socially progressive ways of recognising, measuring and rewarding contributions or work which are in the community interest, as reflected in what is known as 'The Commons'.[95] The ***Human Development Index (HDI)***[96] of 2010 is a measure of what might be socially relevant achievement and has three dimensions: a long and healthy life (life expectancy at birth); an education index (mean years of schooling and expected years of schooling); and a decent standard of living (gross national income (GNI), per capita as purchasing power parity (PPP), in US$). Wahlqvist has proposed that we now need an index which captures basic livelihood needs. This could be expressed as ***liveability units (LU)*** for community-based transactions, the currency of a more sustainable future.[18] LU could effectively capture, through their integrative components, each of benefit, risk and cost. Moreover, these outcomes could be ***food and health systems-based*** with a documentable and agreed architecture. This could be the basis of ***Open Source food systems*** from source to consumption and provide ***traceability***. These use ***block chain technology*** (characterised by linked blocks of information as a composite identifier), and matrix barcode, such as QR, scanning by origin, intermediates and end-users. The facility could enable informed choice, waste minimisation, risk management, health relevance and a safer, more sustainable overall food supply.[97,98] It might also support more ethical and equitable food-health relationships through enhanced connectedness, encouragement and sanctions where necessary.[19,93] But the risks are that the problem of remoteness from food's origins is supported and megadata commercialisation of our food dependency more likely.

## AUTHOR DISCLOSURES

The author has no conflict of interest regarding this review.

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