

Invited Editorial

Meat consumption trends and health: casting a wider risk assessment net

Humans come from a long line of meat-eaters. For much of the past two million years our hominid forebears have been evolving from scavenging to systematic hunting. This trend was intimately coupled with the evolution of the human brain, which now is much larger and more complex than was the brain of our mostly vegetarian australopithecine ancestors. In many hunter-gatherer communities meat became a major, even the majority, source of dietary energy. The ethics and aesthetics of carnivory aside, meat is a high-grade source of nutrients. Furthermore, across many cultures and stages of economic development, meat (especially red meat) is regarded as a desirable food, and an increase in meat consumption therefore figures prominently in the 'nutrition transition'¹.

We modern urban citizens come from a very short line of consumers of large amounts of (mostly) industrially produced ('factory-farmed') meat. This supermarket meat differs profoundly from wild game meat, especially in lipid profile and chemical pollutant content. Further, modern meat production is distinguished by the amount of environmental and ecological damage that it causes, including via substantial energy inputs.

The paper by Polly Walker and colleagues² in the present issue breaks important new ground in exploring the 'Public health implications of meat production and consumption'. The paper is significant in two senses. First, the authors frame their question in population terms, thus looking beyond the main focus of textbook epidemiology that examines inter-individual differences in 'exposure' that account for the occurrence of disease *cases*. Their interest is in accounting for changes in *rates* of disease as a function of shifts in cultural patterns of food production and consumption. Second, their exploration of the spectrum of health consequences extends to considering the collateral damage to the environment ('externalities') and the resultant risks to health. This invites epidemiologists to address the wider vista of ecological changes and their population health consequences in a world in which rapid social and environmental changes occur on an increasingly large scale.

The authors encapsulate the foreground risks to health thus:

Growing numbers of people world-wide are adopting energy-dense diets high in animal protein and fat. Although meat is not an essential component of the human diet, for the millions of people who are threatened with malnutrition, improving

access to nutrient-rich animal source foods is an easy way to improve nutritional status. Animal products, however, are the primary source of saturated fat responsible for higher risk of cardiovascular disease, diabetes mellitus and some cancers. Meat itself is also associated with increased risk of some cancers. An important public health challenge is to provide adequate amounts of protein and essential nutrients without also causing over-consumption of saturated fat.

Their paper then extends the health risk calculus by discussing how the burgeoning industrial agricultural system, now spreading world-wide, poses threats via the extensive use of fertilisers and pesticides, feed formulations that include animal tissues, arsenic and antibiotics, and the consequent environmental pollution.

Of particular importance, they refer to the increasingly unsustainable use of finite natural resources. Land clearing to create pastures means a loss of biodiversity and often the displacement of human communities. The more intensive feed-lot production system requires energy inputs much greater than the food energy outputs. To produce 1 kg of feed-lot beef requires around 9 kg of cereal grain; for pork the approximate ratio is 4:1, for chickens 2:1^{3,4}. The amount of waste thus generated is typically more than can be dealt with by the local environment, and the requirements for fresh water are huge. Further, élites in modernising countries get a taste for red meat, particularly beef. Most countries do not have a beef industry, so they must import. This locks countries into transnational commodity chains, generating extra environmental damage (including via heightened food-miles).

Beyond input–output statistics is the issue of *who* bears these food-energy losses – a question not addressed by Walker and colleagues. The losses are mostly borne by poorer populations in lower-income countries striving to generate foreign exchange by exporting animal feed-grains instead of growing food-grains for local human consumption. Some producer populations are thereby exposed to malnutrition and its many health risks⁵.

Another significant feature of industrial agriculture on which the authors touch only briefly is 'unnatural' food chains, and the public health implications and environmental sustainability involved. While feeding ruminant material to other ruminants may be the ultimate in recycling, that practice brought us 'mad cow disease'⁶; yet extraordinarily, the practice continues in some countries. This is not an isolated example of feedstuff

being far removed from the animal's natural diet. Chickens are commonly fed fishmeal from unintended by-catch. Much of this by-catch is shark, often so high in mercury that it is unfit for human consumption⁷. Indeed, we do not yet know what human health risks might result from eating chickens fed contaminated seafood.

Almost half the world's antibiotics are fed to livestock as 'growth enhancers'⁸, although some national governments now ban the practice. For example, vancomycin is a potent antibiotic, often used in people as a last line of defence against infections that do not respond to other antibiotics. Factory farming of chickens has been implicated in the development of vancomycin-resistant enterococci that cause severe, hard-to-treat, intestinal infection in humans^{8,9}. Although this has been the only documented antibiotic-resistant 'superbug' caused by the use of antibiotics in farming, the widespread use of veterinary drugs suggests this is due more to good luck than good management.

Walker and colleagues refer to an expected doubling of the demand for meat over coming decades. Lester Brown¹⁰ has recently estimated that China, on its current economic growth trajectory, will reach the current US meat intake of 125 kg per person by 2031. By then, China's meat consumption would have tripled to around 180 million tonnes – that is, roughly four-fifths of current world meat production. Producing such tonnage in environmentally sustainable fashion would pose an extreme challenge.

An additional concern is that the impending increase in meat consumption in developing countries will occur mostly in the economically better-off, not in the nutritionally deprived. Obviously, it is the latter group that would benefit most from a modest increase in meat intake. Meanwhile, the newly privileged will become the new over-consumers of commercially produced meat, at risk of the chronic diseases now prevalent in high-income countries.

As their summary comment above indicates, Walker and colleagues provide a review of the main chronic disease risks associated with high-meat diets. The high intake of calories and saturated fat contributes to overweight and obesity and to dyslipidaemia. The latter results from both the excess saturated fat in commercially produced meat and the metabolic consequences of obesity and associated diabetes. These changes contribute to high blood pressure and atherogenesis.

It is important to note that game meat has a *very* different lipid profile from domestic meat animals: less fat, and much more of it polyunsaturated. Indeed, the unsaturated long-chain omega-3 (*n*-3) fatty acids (misleadingly called 'fish oils') are widespread in plant foods (e.g. walnuts and flax seeds), in the meat of game animals, and in seafood. The palaeolithic diet contained approximately equal amounts of unsaturated *n*-6 fatty acids (mostly from plant sources) and *n*-3 fatty acids. Today, the dietary ratio of *n*-6 to *n*-3 fatty acids varies greatly, as indicated by the following approximate figures¹¹: Western

societies = 9:1; Japanese = 3:1; Inuit and other hunter-gatherers = 1:1.

These *n*-3 fatty acids have been shown in animal experimental studies and human epidemiological studies to have beneficial effects on blood lipid profile (raising high-density lipoprotein cholesterol levels), blood clotting tendency, blood pressure, cardiac muscle rhythmic stability (against oxygen deprivation), insulin resistance and on aspects of immune system function^{12,13}. They also enhance infant and child brain growth and may contribute to brain function and durability in adults.

Given these benefits, should there be a shift towards fish supplanting land meats in our diet? Fish farming, hailed as a solution to dwindling stocks of wild fish, has several environmental benefits relative to land meat production (no land clearing, erosion, or population displacement). But fish farming is also generally intensive, and incurs a range of health and environmental costs. Fish farms are also subject to blanket use of antibiotics and other growth promoters. Further, it is not in any way a contained system, but enables the flow of excess nutrients, drugs, waste and genes into surrounding water and wild populations.

Three other health ramifications of the world's burgeoning meat consumption warrant notice here.

First, the paper presents compelling statistics on the approximately 10-fold decline over recent decades in the number of swine and chicken producer units in the USA. This is a world-wide trend, as large and economically powerful food companies enforce consolidation of food production. While the number of producers is declining, the size and intensity of farms are increasing. Relatedly, there has been a reduction in the number of small dairy farmers supplying milk to supermarket chains in Brazil. This centralisation of production means lost livelihoods and increases in (mostly rural) poverty and, consequently, health problems: nutritional, mental health, exposure to new occupational hazards, and so on.

Second, consider the impacts of meat production and trade on infectious disease ecology. For millennia, small farms accommodated mixed species living closely with humans – goats, pigs, cattle, ducks, chickens and others. Accordingly there was much animal-to-animal and animal-to-human transfer of infectious agents¹⁴. The widespread duck-pig-human small-farm complex in Southern China is implicated in the generation of variant influenza virus strains. Cross-infection also occurs when animal species are brought together in the market place. For example, the 1997 outbreak of avian influenza in Hong Kong occurred in mixed markets, where live chickens, quail and ducks were densely arrayed, in ready contact with humans. The widespread liking for eating exotic animal species also increases exposure to novel infections. Indeed, this is thought to have triggered the severe acute respiratory syndrome (SARS) epidemic in which (wild) civet cats, traded across national borders, were the likely source of

the new corona virus that caused SARS¹⁴. Similarly, although 'mad cow disease' originated in Britain, it quickly became a near-global problem because of patterns of international trade in animals and animal feed.

Third, the sheer volume of modern meat production contributes significantly to global climate change¹⁵. This results, indecorously, from the release of digestion-derived methane from both ends of the animal. Methane is a more potent greenhouse gas than is carbon dioxide (the main villain of the piece), but has a shorter atmospheric half-life. Global climate change is already beginning to have adverse health impacts in some parts of the world¹⁶, and the impacts will increase substantially in future¹⁷.

The increasing dominance of industrial agriculture and meat production succeeds economically largely because the full costs of production and consumption are not accounted for. Beyond the conventional market-price 'costs' of production, full accounting would reflect the energy and water inputs and the environmental damage caused. Raising the cost of a commercially produced supermarket steak would moderate otherwise excessive consumption. Without such a change in cost-accounting, we have little hope of achieving the dietary aspects of the World Health Organization's 'global strategy' for combating the rising tide of chronic diseases.

The paper by Polly Walker and colleagues invites us to widen our field of vision as researchers. For the rising levels of meat consumption, as on other fronts, the formal study of connections between production, consumption, social and environmental consequences and human biological health should be incorporated into the modern public health research agenda.

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