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Dietary regimes and the nutrition transition: bridging disciplinary domains

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Abstract The nutrition transition concept developed by Popkin has gained wide currency within the nutritional sciences literature as a way of understanding population wide changes to diet and energy balance and their related health outcomes in society. It offers a useful template of different nutritional patterns societies progress through, but it has not provided a comprehensive understanding of the why and how of dietary change. Building on insights from the literature on food regimes in the social sciences, this paper argues the concept of dietary regimes can augment the nutrition transition model and can serve as a bridge between social and health sciences around nutrition and dietary change. The political economy analysis of the dietary regime approach provides insights into the historical degradation of food and the diffusion of nutrient-poor products throughout food environments today. It also engages analysis of the key actors shaping food environments and diets in the industrial era. The dietary regime approach can provide fruitful directions with respect to concrete policy options to address the major issue of population wide weight gain that the nutrition transition model has sought to confront in recent iterations.

Keywords Nutrition transition · Dietary regimes · Food regimes · Food environments · Degradation of food

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Introduction

The rapid changes in body composition of humans across the globe in just the last few decades—captured by the term "the obesity crisis"—and the recognition of the importance of diet in producing this crisis, are the essential context for this paper. These changes are most stark in the developing world. Here, the reality of under nourishment and starvation that blighted the populations of many countries is being rapidly replaced by a new reality among the emergent middle classes: overweight, obesity and associated chronic diseases (Popkin 2006; Uauy et al. 2001; Wild et al. 2004; World Health Organization 2015). Most of the existing literature has described and documented this phenomenon but has been much less illuminating on the question of why population-wide weight gain and the health calamity it is producing has come about at this point in history.

The Nutrition Transition (NT) model has provided an important conceptual tool to describe the global nutritional shift and its related health consequences for more than two decades. Popkin (1993, 1994) conceptualized the nature and pace of nutritional transition and its relationship with economic, social, and demographic factors. He also noted the roles of broader structural factors such as urbanization, economic growth, new technologies reducing energy expenditure in at work and leisure activities, mass media, the spread of supermarkets and changing regulatory environments with free trade agreements (Popkin 2009; Popkin and Gordon-Larsen 2004; Popkin et al. 2012). In his recent work, he has given some attention to the food system as well (Hawkes and Popkin 2015; Popkin 2014). However, he does not analyze the genesis of these factors and how they operate to foster weight gain among populations around the globe. In this regard, we need an analytical

model that can provide better understanding of how the socio-economic, technological and political factors have reshaped food into nutrient-poor edible commodities and saturated our food environments with them. As a result, too often what we eat subverts our health and promotes disease.

This paper introduces the concept of dietary regimes as a valuable complement to the NT model. Its focus is on the fundamental structural factors that shape food environments and the choices people make around diet, rather than cultural factors that may also play a role in determining what people eat. The dietary regime approach attempts to understand the political economic "black box" that lies between food producers and consumers/eaters, whereas the NT model focuses on how the dietary shift is reflected in changes in body composition and the prevalence of associated chronic diseases. By focusing attention on the business of processing, marketing and retailing of edible commodities, the dietary regime approach offers analytical tools to understand two essential processes underlying dietary change: (1) the degradation of whole foods over the last one hundred years or so, and (2) the diffusion of a host of nutrient-poor edible products into all manner of food environments that has had the effect of virtually transforming them into obesogenic food environments that undermine our health.

Dietary regimes builds upon in the pioneering work in the social sciences by Friedmann and McMichael (1989) on food regimes, which has been particularly fruitful as a conceptual frame for understanding the structural nature and dynamics of the world food economy throughout the industrial era. Its focus is on the production side of the food commodity chain and the dynamics of global markets for food and the role of the state in shaping them. In this paper, we argue that dietary regimes, coupled with food regimes, can serve to enhance the explanatory potential of the NT model with respect to better situating dietary change historically, and offering a more powerful explanation of the real world forces that *underlie* dietary change and the degradation of food environments in the modern world. The complementarity of these models would provide a more complete picture of the process of nutrition transition from food producers through to the eaters of food. This paper contributes to the literature on nutrition transition by attempting to bridge social science models of change in the food system with a model of dietary change and related health outcomes found in the health sciences.

In the next section, we review the NT model. Since the concept of dietary regimes was built upon in the food regime approach in its formulation, we briefly review its essential features before we discuss the dietary regime model and the analytical benefits it provides.

The nutrition transition

Popkin brought into focus global dietary change and the related health outcomes in different regions of the world, particularly in the developing countries. He developed the concept of the Nutrition Transition in early 1990s to describe these changes (Popkin 1993, 1994). He outlined five broad nutrition patterns based on "historical conditions," which were not tied to "specific historical periods": Pattern 1 Collecting Food; Pattern 2 Famine; Pattern 3 Receding Famine; Pattern 4 Nutrition-Related Non-communicable Disease (NR-NCD) due to changes in diet and activity patterns; and Pattern 5 Behavioral Change to reverse the negative health outcomes of Pattern 4 (see Fig. 1). Popkin argued that the Nutrition Transition was closely interrelated to two historical processes—the demographic transition[1] and epidemiologic transition.[2] Large shifts in dietary and physical activity are reflected in nutritional outcomes such as changes in average stature and body composition, and health outcomes including mortality and morbidity patterns as well as the levels of chronic and NR-NCD (Popkin 2006; Popkin and Gordon-Larsen 2004).

Popkin has focused on the shift from Pattern 3–5, particularly on the shift from Pattern 3 (receding famine) to Pattern 4 (NR-NCD), which has led to changes in body composition and high levels of NCD and obesity. Based on a substantial number of studies, he argued that, along with a decline in physical activity, many low- and middle-income countries experience a rapid change to the "Western diet" characterized by a high intake of refined carbohydrates, saturated fat, sugar, caloric beverages, animal-source foods, and processed foods low in fiber (Popkin et al. 2012; Popkin and Gordon-Larsen 2004). Such dietary changes are paralleled by a significant *shift from malnutrition to over-nutrition* as predominate issues and the emergence of a high prevalence of obesity and other NCD in these countries. The burdens of poor diet, physical inactivity, obesity, and chronic diseases are shifted from the rich to the poor (Popkin and Gordon-Larsen 2004). In more recent times Pattern 5 (health conscious behavioral change) has been observed in some subpopulations in the United States and European countries (Popkin 1994). In this pattern, the dietary changes initiated by consumers or a combination of government and consumers are oriented toward healthy eating and entail the increased consumption

[1] Demographic transition describes "the shift from a pattern of high fertility and high mortality to one of low fertility and low mortality (typical of modern industrialized countries)" (Popkin 1993, p. 138).

[2] Epidemiologic transition describes "the shift from a pattern of prevalent infectious diseases associated with malnutrition, periodic famine, and poor environmental sanitation to a pattern of prevalent chronic and degenerative diseases associated with urban-industrial lifestyles" (Popkin 1993, p. 138).

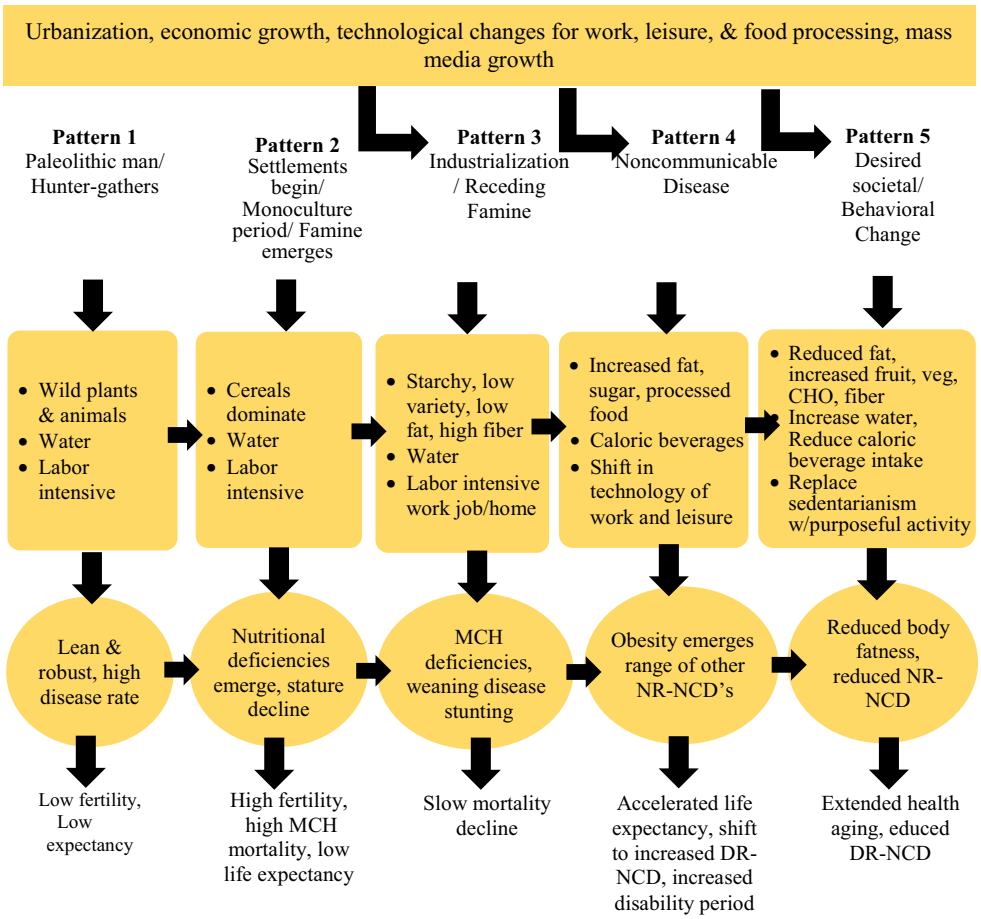

Fig. 1 Stages of the nutrition transition. *Source* Popkin (n.d.)

of fruits, vegetables, and complex carbohydrates, as well as the decreased consumption of meats, sugar, dairy products, and refined foods. Popkin (1994, 2002) argued that these changes are related to consumer preferences resulting from health concerns (e.g., NCD prevention and health promotion).

Popkin (1993, 1994) acknowledged the importance of economic, social, and demographic factors to understand the nature and pace of nutritional transition in his earlier work. His view was broadened to include urbanization, economic growth, technological changes in work, leisure, and food processing, and mass media growth as influencing forces in the shift from Patterns 3–4, especially in low- and middle-income countries (Popkin 2002, 2009; Popkin and Gordon-Larsen 2004). Popkin saw globalization (e.g., enhanced free trade, increased penetration of international corporations including fast-food outlets, international capital markets, and access to western mass media) as "the root cause" for the changes (Popkin 2004, p. S140). In the case of China, for example, the rapid increased consumption of a higher fat diet and meat, and reduced carbohydrate and fiber in the proportion of adult diets was reflected in the shift in eating preferences (Popkin 2001). Such preferences were related to changes not only in income, food availability and prices, and household food preparation and purchasing patterns (e.g., away-from-home purchase and consumption), but also to the food industry and the mass media (Popkin 2001, 2009). Coupled with the dietary change, the decline in physical activity driven by the remarkable shift in the occupational structure, technology of work, and leisure led to a notable increase of obesity (Popkin 1998, 2001). In order to reverse current dietary patterns and related negative health outcomes, Popkin (2002) emphasized national and local efforts to change the economic and physical environment and the role of government in promoting large-scale changes.

In his more recent work, Popkin has recognized the food system as a critical factor for healthy dietary change (Hawkes and Popkin 2015; Popkin 2014) even if he has not explained in-depth why this is so. He argued that the modern food system has been transformed with government policies and practices designed to meet various nutritional and food needs since World War II. With globalization in the 1990's and afterwards new actors, such as global supermarket chains, have furthered this transformation (Hawkes and Popkin 2015). The rapid increase

of NR-NCD in many low- and middle-income countries are driven by the transformation of food systems. He sees the current food system as a "highly distorted system which fails to put quality protein and diversity into the diets of the poor while succeeding in feeding people large quantities of refined carbohydrates and highly processed foods" (Hawkes and Popkin 2015, p. 3), that are associated with increased obesity (Asfaw 2011). Popkin (2009, 2014) urges a change in the food system to address this poor quality diet and its negative health impacts, and argues for more research and new policies to address these issues.

Popkin's NT model served to draw early attention to major transitions in diet and activity levels and it was prescient in shedding light on the fact that this was rapidly occurring in the developing countries. Where the NT Model falls short is in its ability to elucidate how and why food has been degraded in a variety of ways and food environments have been transformed. It is essential that we seek answers to *these* questions if we are ever to realistically appraise the root causes of the global obesity crisis and formulate policies that will effectively deal with it. We offer the dietary regimes approach as a complementary analytical model to effectively understand the "how and why" of food degradation, food environment transformation, and dietary change.

Food regimes

The food regime approach was initially developed by Friedmann and McMichael in the late 1980's, and re-evaluated and further elaborated on in recent years (see Agriculture and Human Values, Special Issue, 2009). The food-regime approach offers a macro political-economic analysis of the global food system over different historical epochs. This approach borrowed from the world system theories of societal development, and the so-called French school of regulationist theorists who have argued that the evolution of capitalist economy has been characterized by different historical phases with their respective characteristics. In his more recent appraisal of the contribution of the food regimes concept, McMichael (2009) argues:

> food regime analysis brings a structured perspective to the understanding of agriculture and food's role in capital accumulation across time and space. In specifying patterns of circulation of food in the world economy it underlines the agro-food dimension of geo-politics, but makes no claim to comprehensive treatment of different agricultures across the world. (p. 140)

In addition to exploring the unique role of agriculture in the development of the world capitalist economy, the food regime approach highlighted two interrelated processes: (1) the industrialization of agriculture and food, and (2) the role of food in the development of a system of independent, liberal nation states. Friedman and McMichael conceived of historically distinct food regimes, each with specific structural features, trade relations and state involvement.

The *first food regime* lasting from 1870's to the 1930's was characterized by the combined import of colonial tropical products (e.g., coffee, bananas) from the Third World and the import of wheat and livestock from the so-called "white settler colonies"—Canada, the United States, Australia, New Zealand and Argentina—to the metropolitan European countries. The opening up of these expansive new territories for farming was a key factor in allowing for the production of low cost wheat and meat. These commodities found markets abroad as inexpensive foodstuffs for the expanding British working class thereby helping to fuel the industrial revolution there.

In the *second food regime,* which takes place from the 1940's to the 1970's after a long period of transition from the first food regime, a new relationship between agriculture and industry takes shape that had major implications for food. One of its principle features is strong state protection for food producers (e.g., price supports, marketing boards, etc.) and the organization of the world economy under U.S. hegemony (Friedmann and McMichael 1989). In the developed countries, agriculture underwent a restructuring that involved intensification and a new form of international integration. Two key processes they see as emblematic of the second food regime are: (1) the development of feed-meat complexes organized for the intensive production of meat protein, and (2) the shift from agricultural produce being consumed in relatively unprocessed form to processed manufactured foods, or what they term *durable foods* (Friedmann and McMichael 1989). They see the intensive cultivation of soy and corn in the U.S., and later elsewhere, becoming integrated into an animal feed industry tied closely with intensive meat production. This can, in fact, provide an explanation of the underpinning dynamics for the shift from Pattern 3 to Pattern 4 in Popkin's NT model.

With both the meat-feed complex and the intensive production and processing of foods, the produce of farming becomes more and more an input to an expanding agro-industrial complex rather than being destined for domestic consumption in a relatively raw form. These changes would obviously have a number of serious implications, for the autonomy of farmers but also impacting diets, especially in the developed world, as processed food corporations sought to expand market share via aggressive advertising to a wide audience through television—a new and powerful medium—as well as other means. This reshaping of diets is peripheral to the main concerns of the

food regime approach, however. This is a matter that is taken up by the dietary regimes approach.

For the developing world Friedmann and McMichael see the second food regime as inaugurating a massive U.S. food aid program exporting American wheat and soya oil to newly independent countries interested in cheap foodstuffs to support their industrialization process. International agencies also played a role in this development. This, however, negatively impacted domestic food production in the developing world as it was increasingly displaced by massive low cost wheat imports (Friedmann and McMichael 1989), which likely had serious implications for food environments. Exactly how and to what extent this happened and how it reshaped diets in the developing world is very important, but it is not a focus of the food regime authors. Nevertheless, the concept of food regimes can help us understand the rapid transformation of food environments in the developing world in the last two decades and the transition from Pattern 3 to Pattern 4 in Popkin's NT model.

In the last several years there has been a revival in the interest in the food regime approach and notably debates about the existence of a *third food regime*. While some are unconvinced that a significantly different food regime exists (Pritchard 2009), McMichael (2009), a co-founder of the food regime approach, has made a strong argument that a third food regime, which he terms a "corporate food regime," has emerged since the 1980's. The third or "corporate" food regime comes into being within the wider context of a globalized neo-liberal political economy, which has been widely implemented across the globe. This political-economic paradigm emphasizes trade liberalization and the free movement of capital, reduction or elimination of Keynsian welfare state institutions and protections for labor, and the withdrawal of government from the economy and reorientation of its role in many respects. It opened the way for large American and European agribusiness and food retail operations to penetrate many new markets in the global South which, as has become increasingly apparent, has transformed food environments there (Harner 2007; Konefal et al. 2005; Reardon et al. 2003).

This corporate food regime is argued to be essentially defined by a new set of rules (via far reaching trade and investment agreements) that institutionalizes corporate power in the world food system (McMichael 2009). Among its more specific features are such novel developments as the global sourcing of a variety of foods previously sourced domestically, the dominance of supermarket retail chains, the privatization of quality standards, food safety regulation and agricultural research, the niche marketing of foods, and the growing differentiation of diets. McMichael (2009) has argued that it has also been characterized by the massive dispossession of peasant populations of their land in the developing world and a dramatic rise in the environmental damage caused by the production of food commodities under an advanced industrial system.

It is worth noting that the food regime approach has been utilized recently to help understand the contested nature of the contemporary food economy—a reality presaged by Friedmann (2005) in her initial characterization of it as a "corporate-environmental food regime". Levidow (2015) has drawn out in detail the nature of this contestation. One tendency is a life sciences integrated paradigm that is "attempting to substitute capital-intensive biological inputs for agrichemicals, and to diversify outputs such as functional foods for health needs, thus reinforcing corporate power." On the other hand, an ecologically integrated paradigm is oriented towards developing "agro-ecological methods to enhance biodiversity in agricultural environments as a means to improve crop protection, productivity, nutritional quality and resource conservation, in ways empowering farmers and their knowledge." (Levidow 2015, p. 79) Beyond the sphere of agriculture, Sage (2013) has argued that food regimes can be helpful in providing a more theoretically grounded framework for conceptualizing food security issues and their relationship to the changing nature of food production and trade. Food security in this view is understood to encompass not only the insufficiency of food but also mal-consumption produced by the increasing distortion of diets and the resulting poor health outcomes.

The food regime approach in its original formulation does not pay particular attention to how the developments on the production and trade side have impacted food environments and prevailing diets. In recent years a few have argued the need to broaden the approach to embrace issues of the nutritional transition and the distortion of diet (Dixon 2009; Levidow 2015). Our view is that these latter issues are better understood through a separate but related conceptual frame, one that builds on the food regime's political-economic analysis of production and trade and the power relations embedded in them. The dietary regimes approach elaborated below takes up where the food regime approach has left off that is with the analysis of the political economy of the nutrition transition, the forces determining food environments, and the degradation of food and distortion of diets that marks the industrialization of food for more than one hundred years.

Dietary regimes

The concept of dietary regimes was initially developed by Winson (2013) and seeks to capture the fact that there is a political-economic reality that stands between eaters and

the production of food in every epoch. This reality necessarily shapes, to varying degrees, the diets of the great majority in societies ever since the neo-lithic revolution when humans embraced the domestication of plants and animals, and human settlement became increasingly marked by social stratification and ever-more stark differences in resources and power within society. As Winson (2013) has argued:

> diets are ultimately social and political projects and have been even before recorded time. As such, diets reflect the material conditions of a particular society, and specific social and economic arrangements, as well as the structures of political domination, regulation, and control. (p. 16)

The concept of dietary regime is meant to help us capture the commonality of dietary experience and to guide an appraisal and understanding of the social forces and socio-economic and technological factors that play a salient role in determining prevailing diet(s) in a society at a given point in time.

As with the NT model and the food regime approach, the principal focus of the dietary regime approach is on the modern era, and especially the impact of industrial capitalism on food. Because of this temporal focus we use the term *industrial dietary regimes* to more clearly indicate the historical period under consideration. Dietary regimes focus on the character of prevailing diets and their contemporary transformation. This brings into the discussion the nutritional dimension of diets and implications for the health of populations across the globe in the era of population-wide weight gain and obesity, which Lang and Heasman (2004) have termed "the *leitmotif* of the modern food age". (p. 300)

Three industrial dietary regimes

It is possible to distinguish three qualitatively distinct dietary regimes in the industrial era, beginning roughly around 1850. Not coincidentally, there is some correspondence in the periodization of these three regimes and the food regimes noted above. Nevertheless, there is no exact temporal overlap between the two types of regimes, or so the evidence would seem to suggest. We summarize in Table 1 the main characteristics of each regime with attention to its socio-economic, political elements and the dietary outcomes. A more in-depth argument for and details about these regimes can be found in Winson (2013). In each regime, it is important to note that two main overarching processes are at work: the *degradation of food* as its production is industrialized within a profit oriented political economy, and the *diffusion* of a growing array of nutrient-poor edible commodities—products that have little nutritional value beyond the calories they provide (see the *Mechanisms of Diffusion* section for more explanation). This diffusion is promoted by the technologies of mass advertising and the colonization of food environments by manufacturers and retailers, principally. We see these processes taking different forms but accelerating over time.

The degradation of food

The dietary regime approach argues that the industrialization of the food system, within an institutional context where profit making takes precedence over nutrition, has led to the degradation of whole foods. This is despite the fact that government has mandated the "enrichment" of some highly processed foods and that more recently food companies have sought competitive advantage by manufacturing novel fortified or "functional" foods (Scrinis 2016). For example, degraded food products such as refined flour with vitamins added are not equivalent in nutritional terms to whole grain flours (Weaver 2001), while novel functional foods are often adulterated in nutritionally problematic ways, as with probiotic yoghurts laden with high fructose corn syrup sweetener (Sanchez-Lozada et al. 2008; Brown et al. 2008).

The degradation of food occurs through three basic processes: (1) the speed-up in the production of food; (2) the simplification of whole foods; and (3) the adulteration of whole foods.[3] A brief elaboration of each of these processes is in order.

The *speed-up* in food production refers to pressures within a market-based industrial food system to reduce the time necessary to produce an edible commodity ready for sale. While the economic argument places emphasis on the efficiency and revenue gains from the speed-up in food production, a dietary regime analysis reveals the hidden nutritional costs of such a process. The geographer Harvey (2009) has argued "those that can move faster through the various phases of capital circulation accrue higher profits than their competitors. Speed-up nearly always pays off in higher profits" (p. 41). The speed-up in food production is manifested in various ways. The production of meat protein within confined animal feeding operations (CAFOs) provides a good illustration. From the breeding of animals that exhibit the fastest fat deposition and weight gaining abilities to the subsidized grain-based feeding process and intensive confined housing facilities, raising animal protein in the CAFO system maximizes profits for the few corporations that now dominate the pork, chicken and beef commodity chain, but with substantial unaccounted costs. The environmental impact of this system is perhaps best

[3] Greater detail on each of these processes can be found in Winson (2013, Chs 6, 7, 8).

Table 1 Industrial dietary regimes

	First regime: 1850–1939	Second regime: 1950–1980	Third regime: Post 1980
Socio-economic elements	Beginning of industrial processing in canning, milling and meat packing sectors Diffusion of industrial food via novel mass advertising campaigns in magazines, newspapers, electric signs and later radio ads	Intensification of the uptake in industrial foods Proliferation of away-from-home fast foods Mass advertising intensified with television Further normalization of industrial diet, especially in North America	Nutrient poor edible products in new institutional domains in developed countries Globalization of industrial diet to developing countries via transnational food and retail corporations
Political elements	Limited state role Passage of pure food laws spurred by reform movement Pure food laws' protection of brands which enhance acceptance of processed foods	More prominent state intervention Creation of marketing boards, agricultural subsidy programs and price support policies Massive exports of grain as food aid to developing world	Proliferation of Neo-liberal ideology, trade policies and agreements Facilitating globalization of industrial diet
Dietary and health outcomes	Substantial uptake of processed edible products among urban population Early degradation of whole foods via industrial processes, e.g., "patent" or branded refined flours stripped of vitamins, minerals and fiber	Intensification of consumption of industrial edible products Chronic diseases as leading cause of death American wheat exports to developing world as food aid, stimulating dietary transition to industrial diet there	More intensive consumption of nutrient poor edible products in developed countries Rapidly rising population-wide weight gain and obesity evident post 1980 among adults, children and youth Rapid transformation toward industrial diet in developing countries First signs of resistance to industrial diet in developed countries Emergence of healthy eating initiatives. Challenge to legitimacy of nutrient poor edible products

Unless otherwise indicated, details of the first and second industrial dietary regimes refer to developments in North America and Western Europe. The industrial diet becomes globalized in the third industrial dietary regime

documented to date (Weis 2013), but there is also a cost to human health in terms of massive outbreaks of food borne disease and unhealthy fats that are inherent in meat produced by the CAFO system. Meat from factory farmed beef cattle has dramatically higher levels of saturated fat compared to animals raised on grass, for example, while it also exhibits a much less healthy ratio of omega 6 to omega 3 fatty acids than is the case with grass fed cattle (Duynisveld et al. 2006; Miller et al. 1986; Rule et al. 2002).

The drastic *simplification* of our foods has also led to degradation of our diet. *Simplification* of whole foods takes on at least two forms: the first when whole foods are decomposed into simpler components via industrial processing, the second when the exigencies of profit making and efficiency lead to reduction in the varieties of different foods available for purchase in food environments. An example of the former type of simplification is the hyper processing of some foods, such as grains with the advent of the industrial roller milling process in the late ninetieth century. Historically, the refined flour with the bran and the germ extracted, found favor with millers because it was much less prone to spoilage and could thus be marketed on a much wider basis (Kuhlmann 1929). This led to serious degrading of the flours' nutrients that had been largely stripped out to make shelf stable flours. Data provided by Weaver (2001) indicate that refined white wheat flour has $<40\%$ of such essential nutrients as vitamin E, riboflavin, niacin, thiamin, folic acid and iron, and $<20\%$ of potassium, zinc and fiber, compared to whole wheat flour where the nutrient rich wheat germ and bran are utilized. Another study has documented how industrial milling technology leads to the loss of a group of nutritionally valuable phytochemicals that are only found in grains (Adom et al. 2005). Phytochemicals are nutrients which are believed to enhance the immune system, mediate hormones, and have anti-oxidant effects and benefit digestion. Hyper processing of whole grains has had additional nutritional downsides as is illustrated with ready-to-eat breakfast cereals and salty

snack products where refined flours are subjected to additional processing, extreme pressures and temperatures via extrusion technologies that change the structure of starch molecules. This, in turn, causes such processed foods to have even more adverse effects in spiking blood sugar levels than is the case with refined flours (Brand et al. 1985).

Another form of simplification is reflected in the drastic diminishing of the varietal richness of foods that nature once provided us and which were at one time available to us on farms and in small scale commercial markets.[4] In the highly concentrated food retail sector that characterizes many developed countries (Heffernan 2000; Howard 2016; USDA 2011), the few large corporate players favor a narrow variety of produce that conforms to the dictates of the corporate supply chain. With the supermarket chains, cosmetic features and long shelf life are preferred, while flavor and nutritional qualities take a back seat. As a consequence, varietal diversity is drastically limited (Browning 1998). For example, where several thousand apple varieties are known to exist, the typical supermarket may have only 6–8 available (Anonymous 2016; Browning 1998). The varietal diversity of potatoes is even less rich in the supermarket despite the fact that the known varieties number more than four thousand (International Potato Center 2013).

Varietal simplification is driven by factors in the production end of the food system as well. Friedland et al.'s (1981) classic study of California agriculture noted that, as agricultural laborers began to get organized, growers sought to avoid an increase in their wage bill for tomato harvesters by rapidly embracing mechanical harvesting machinery. This also meant replacing existing varieties of tomatoes with one that could stand up to mechanical harvesting machinery. This example illustrates the role of various political-economic factors in varietal simplification, including the role played by state institutions, as state-funded university research played a crucial role in developing the new tomato variety and perfecting mechanical harvesting technology to replace hand pickers.

Loss of diversity in agriculture has been seen for some time as a dangerous strategy in terms of sustainable production of food because it reduces the possibilities of finding disease resistant varieties in the future (Fowler and Mooney 1990). The drastic varietal simplification also may be limiting the protective health benefits that whole foods can provide. Researchers have found in recent years that different varieties within the same species of fruits, vegetables and grains have significantly different concentrations of essential nutrients. As Heywood (2013) notes, citing an extensive FAO database, the protein content of rice varieties can vary between 5 and 13%, and the carotenoid content of different cultivars of sweet potato can vary by a factor of 60 or more while one variety of apricot can represent 1% and another 200% of the RDI for vitamin A. Important nutritional differences within the same species of domestic animals we take for food exist as well (Hoffmann and Baumung 2013). In addition to important varietal differences in these nutrients, there are notable variations in the anti-oxidative phytochemicals in fruits and vegetables (Tsao et al. 2006). This is potentially of real significance as studies have found that fruits and vegetables with high flavonoid and phenolic concentrations were effective in preventing cancer cell proliferation in the lab (Eberhardt et al. 2000; Liu 2004). By drastically reducing the varietal diversity of the foods we eat, the industrial food system may have seriously compromised key protective health benefits we derive from that diversity.

Adulteration, a word derived from the Latin *adulterare* meaning to pollute or corrupt, has taken different forms with respect to food over time. It once may have meant watering down the wine, or adding chalk, bone ash or sawdust to flour, or adding acutely toxic chemicals to fool buyers into believing used tea was fresh. Today it typically has a more mundane form—the liberal use of sweeteners, salt and fats and oils to make processed food more palatable and therefore more marketable. Adulteration of the latter form often transforms whole foods into products that are degraded from a nutritional standpoint. While not as acutely toxic as adulterants of an earlier age, in the long run these modern adulterants have proven to be just as deadly (Ludwig et al. 1999). Neurological science has established that food can be a potent natural reward and conditioning stimulus, and foods rich in sugar and fats are potent rewards that promote eating (Volkow et al. 2011). Furthermore, there is a growing body of evidence that a wide range of edible products with added adulterants such as sweeteners, salt and fat are specifically designed to stimulate neurological pathways and thereby enhance the "craveability" of the processed product and so increase sales (Kessler 2010; Moss 2013). Indeed, there is an emerging body of research to support the hypothesis of addictive foods (Avena and Gold 2011). Animal studies have shown that sugar, for example, can precipitate some behaviors and changes to the brain that are similar to the effects produced by addictive drug use (Avena et al. 2008; Colantuoni et al. 2002; Johnson and Kenny 2010). As well, clinical trials have shown a relationship between highly palatable foods and behaviors associated with addiction (Volkow et al. 2011).

[4] For example, in the Canadian province of Nova Scotia in the early part of the twentieth century some 130 varieties were reported to be grown on farms for on-farm use, to be sold in local markets or exported to Britain (Commissioner Public Works and Mines 1917).

Mechanisms of diffusion

The industrial dietary regime approach is particularly useful to understand the mechanisms by which processed nutrient poor edible products have been diffused in food environments to the point where we can speak of a pervasive *industrial diet*. Nutrient poor products are those goods high in sweeteners, unhealthy fats and salt which are typically main ingredients, and have few of the essential nutrients (protein, minerals, vitamins, phytochemicals, fiber and essential fats) needed to maintain health.[5] They include what most would classify as "junk foods" but also products not typically classified as such that have little in the way of nutrition to offer. For example, many of the products in the juice category in the supermarket would qualify having little real fruit juice but copious amounts of high fructose corn syrup sweetener and other additives instead. Pre-sweetened breakfast cereals would be another candidate here, and these products are the largest breakfast product category and had been the fastest growing category in the supermarket for decades until a recent decline in sales (Allison 2015; Burn 1999). High levels of sweeteners and highly processed high glycemic flours are the main ingredients of these products (Lawrence 2010, 2013). We see the industrial diet as essentially a suite of aggressively promoted, highly processed nutrient poor products that are the outcome of an ensemble of agricultural and food technology processes, mass marketing machinery, and enabling policy regimes.

Underlying the drive to diffuse product is the competitive pressures faced by individual firms within a market-based economy to achieve acceptable returns for shareholders. Competition and the drive for profit are the master compass that orients investments in the food business as in any other, and is fundamental to the explanation of why food companies do what they do. The dietary regime approach recognizes that in the drive to diffuse industrial edible products in food environments, three factors have historically been central: *mass advertising, spatial colonization* and *differential profits*.

Mass advertising was pioneered by entrepreneurs in the food and beverage industries over one hundred years ago and became a potent mechanism by which the industrial diet became accepted, or "normalized", early on in North America (Winson 2013). Entrepreneurs such as Coca-Cola's Asa Candler and Will Kellogg in the ready-to-eat breakfast cereal industry had remarkable success pushing product for profit once they realized the potency of mass advertising in differentiating their products from a crowded field of like products; in other words, in creating a branded product. Both businessmen poured an extraordinary proportion of their annual profits back into mass advertising at a time when this was generally unheard of (Pendergrast 1993; Powell 1956).[6] As it turned out, the rewards were great and each company was able to dominate its sector for decades to come and effectively eliminate most of its competition.

Spatial colonization is a concept that attempts to explain how food environments became saturated with nutrient poor edible products (Winson 2004). It captures the reality that for food product to be widely consumed, mass advertising alone is not sufficient to ensure success. Food manufacturers try to ensure product is *available and visible* in as wide a variety of food environments as possible. This highlights the fact that food manufacturers must secure favored placement of their products in existing food environments to be effectively sold. The prevalence of highly profitable nutrient poor products in supermarkets has been documented for a few countries (Bird 2011; Winson 2004). Very limited studies have shown the methods by which food processors secure favored shelf space in the critical supermarket food environment. However, Matas (1987) found that processors paid retailer billions of dollars in what is sometimes termed "slotting fees" through a variety of channels to spatially colonize new products in the most favorable locations on retailers' shelves and in special store displays. In addition, there are "pay to stay" fees and other allowances to keep products on retailer shelves and secure prime locations in the store (Federal Trade Commission 2003).

In the realm of fast food, the most powerful players ensure spatial colonization of their products in another way. The leading firms have saturated urban and suburban space with their outlets in developed countries and are now attempting to do the same in the most promising markets of the global south. As of 2015 McDonald's, the leading fast food restaurant chain operator/franchisor globally, had over 36,000 outlets in 199 countries, with up to 500 new outlets planned for China alone in 2016 (McDonald's Corporation 2015). Yum! Brands, the owners of Taco Bell, KFC and Pizza Hut and the second largest fast food restaurant chain operator/franchisor, had established approximately 15

[5] In the nutritional science literature terms such as "energy dense foods" and "nutrient poor foods" are counterposed to "nutrient rich foods", but there does not seem to be universal agreement on the terms. Nutrient profiles of different food groups have been developed and utilized in an algorithm to identify, in a more quantifiable way, food groups according to their relative benefits for human health (for example, Drewnowski 2010). The challenge is to translate the metrics that have been developed into useful tools for consumers to identify the relative nutritional benefits of the actual edible processed products they confront in the marketplace.

[6] In the case of Kellogg's, see Powell's authoritative biography (Powell 1956). Pendergrast's book (1993) on Coca-Cola is very useful in its coverage of the advertising effort put in by Candler in the early days of his company.

thousand outlets in 120 countries by 2015, with 600 new outlets planned for 2016 in its fastest growing market—China (Yum! Brands 2015).

Differential profits refers to the reality that products, including food products, achieve different rates of profit for their sellers, for a number of reasons. The concept is utilized in the dietary regime approach to provide insights into why it is that nutrient poor edible products have such high visibility in the geography of the supermarket and convenience chain store operations that populate urban, suburban and rural neighborhoods across the globe today. In our commoditized food system not all products in food environments are equally profitable, i.e. differential profits are the norm.[7] Nutrient poor edible products—snacks, confectionary, soda drinks, but also a host of other highly processed edible goods in the supermarket of low nutritional value—offer retailers and manufacturers higher margins than is the case with many other items in the supermarket. Indeed, such products as soft drinks, presweetened breakfast cereals and salty snacks are among the most profitable products in the supermarket (Anonymous 1998; Burn 1999; Stuckler et al. 2012). Coupled with spatial colonization, differential profits helps explain why such unhealthy edible commodities are so prominently displayed in supermarkets and many other types of food environments (Bird 2011; Winson 2004). Increasing their sales will not only lift the profitability of their manufacturers, but also of the retail operation selling them. As a representative of Pepsico's Frito Lay division claimed in the late 1990's, their products accounted for about 11% of operating profits and 40% of profit growth for the average US supermarket, while they represented only about 1% of total supermarket sales in 1998 (Wellman 1999).

The role of politics, power and the state

Power is manifested in different ways with respect of food environments and dietary outcomes. At the economic level the market power of large food corporations should be considered. This power is conferred by the process of corporate concentration that has marked the food economy as much or more than other sectors of the economy. Historically, food entrepreneurs who pioneered the use of mass advertising of their manufactured products achieved a distinct advantage in the marketplace, to the point that some came to be a dominant force in the food system. Their advertising efforts greatly helped industrial processed food products they manufactured to become normalized in the diet as well (Winson 2013). Their success allowed them to grow, swallow up competitors, influence government policy around food, and more recently use their accumulated earnings to make substantial investments in the global South, and thereby expand beyond the developed world into lucrative new domains (Birchall 2009; Mukherjee and Sarkar 2013). Their size and wealth today is allowing them to counter pressures to have governments reform the food system through heavy lobbying of politicians (Nestle 2013). In the case of the carbonated beverage giants, this wealth is funding strategic acquisitions of companies producing what appear to be healthier food products and develop purportedly healthier "functional foods" (Scrinis 2016), and thereby put on a patina of respectability on what was has been perceived to be a nutritionally toxic product mix (Simon 2006). Furthermore, a few global food giants in the processing and retail sectors have an inordinate control over the food economies of many societies (Heffernan 2000; Howard 2016). Governments have often taken a *laissez-faire* attitude towards this concentration in recent decades, and turned a blind eye to the enormous impact it has had on competition in the market place, the survival of smaller independent food companies, and the options available to the consuming public and the prices they must pay for their food.[8]

Beyond the corporate sector, the state typically represents the principal instrument of power in society even if governments have often failed to act to curtail excessive corporate concentration in the food sector. It has exercised power in other important ways and notably through various forms of intervention in the food economy. This intervention has ranged from government funding for research to spur technological innovation in agriculture, to farm credit and payments to producers of specific commodities, to legislation governing food safety in the processing sphere and more recent copyright legislation covering genetic innovation.

The state has at its disposal not only the ability to promulgate legislation, but also to enforce its application. It can and has played a key role in shaping food environments. We might note how state policies shaped the impact of branding in the food economy. Historically, the successful branding of a product by a particular food manufacturer has proven vital for its long-term success in the marketplace. In case of the U.S., for example, as noted in that era by the trade journal of the grain milling industry, it was the intervention by the federal government in the first decade of the twentieth century with the passage of the Pure Food and Drug Act of 1906 that greatly assisted manufacturers in protecting their nascent branded products from "brand thiefs" (Anonymous 1915). Over time, state

[7] For a discussion of the concept of differential profits within classical and Keynsian economics traditions, see Semmler (1984).

[8] For an examination of the significance of corporate concentration in the food sector in the Canadian context, see Winson (1993). For a current extensive analysis of concentration in the U.S. food industry see Howard (2016).

policies protecting branded products aided manufacturers with the strongest brands to dominate their markets and saturate food environments with their particular products.

The state does not always play a positive role in promoting the wellbeing of the population, unlike the optimistic view of the state's role found in Popkin's pattern 5 of the NT model. Indeed, state policies can be often decidedly contradictory. This is illustrated in the case of policies that affect the nutrition of the population. Nestle (2013), for example, has documented how the U.S. federal dietary guidelines that should ostensibly play a key role in addressing population wide weight gain and obesity have been rendered less effective due to pressure from powerful agricultural commodity groups and large corporate food processors. In particular, these forces have been effective in blocking messages to eat less of their particular food products from being inscribed in dietary guidelines, despite the positive nutritional benefits that could be gained with a clear "eat less" message. Analysis of the competing struggle for influence in the state must be integral to an understanding of how food environments and industrial diets became what they are today and the challenges that await those wishing to bring about positive change.

The role of new social forces in civil society must also be brought into the analysis. Often labeled as alternative agricultural and food movements, we are speaking of a wide variety of civil society organizations pressing for change in the existing food system, particularly in the developed countries (Friedland 2008; Wright and Middendorf 2008). The push from grassroots organizations for the promotion of sustainable local food options has had considerable vigor, for example, driven by concerns for the environment, the desire to support the hard pressed small farm sector, but also the desire to return to unprocessed whole foods that are perceived to be healthier. Concerns about the toll of chronic diseases for healthy eating by a growing segment of eaters in the developed world has spurred the thriving organic food movement, farm to school organizations, community shared agriculture, and a host of other initiatives along with a growing shift in consumer preferences for healthier foods. All told, these different movements and changing eating preferences represent a vigorous civil society response to a food system that many feel is unsustainable, inhumane, and manifestly unhealthy. Analysis of the structure and dynamics of these social phenomena is still in the initial stages (Allen 2004; Andrée et al. 2014; Friedland 2010; Guthman 2014; Morgan and Sonnino 2008; Poppendieck 2010; Wright and Middendorf 2008). However, consideration of their significance should be incorporated into any model that seeks to capture the reality of the contemporary food system.[9]

[9] For an early and particularly thoughtful analysis of the history, discourse and practices of alternative agriculture and food initiatives as a social movement in the United States see Allen (2004).

Overall, a dietary regime approach embraces an analysis of three critical loci of power that play a role in determining the content of food environments and, consequently, influence diets and ultimately the health of the population: corporate food operations, the state, and the emerging social forces in civil society. In so doing, this approach opens the way for a more profound understanding of the dynamics of competing interests and the asymmetries of power that characterize the food system and which are indelibly inscribed in policies around food.

Several issues remain to be explored around dietary transition. We need more critical study of evolving corporate response to pressures for healthier foods that have emerged in civil society and, in particular, the role of so-called "functional foods" as a corporate strategy to meet these pressures. Further investigation is also needed on the role of the state with respect to its interaction with corporate players and other non-state actors around efforts to revise dietary guidelines, make school food environments healthier, bring in taxes on junk foods, and so on. In the global context it will be useful to have country-specific studies on the diffusion of the industrial diet and the transformation of food environments in developing countries and research on the early signs of resistance to the industrial diet in the developing world and the emerging corporate response there.

Conclusions

The NT model is a *descriptive* model and it synthesizes a series of patterns of diet and nutritional outcomes that societies are seen to progress through. The NT model and the extensive cross-national empirical studies that have accompanied it have been particularly useful in bringing attention to rapidly changing global diets that have a real impact on human health and wellbeing. Despite its substantial contribution to knowledge, we argue that the NT model does not provide a sufficiently *analytical* explanation to address the how and why of nutritional change that has taken place. Martin (2012) notes that the nutrition transition must encompass the socio-political context in which foods are eaten. This context is a dynamic one and it requires the appropriate tools to comprehend it.

We have discussed the analytical potential provided by both the food regime and dietary regime approaches, each bringing the tools of political economy to understand the dynamics of different components of the food system and the forces shaping diets. The food regime approach complements the NT model by providing a valuable macro-structural analysis of system-wide dynamics and transformations in the global food economy. It is particularly useful for understanding change over time, or in NT terms,

the shift from one pattern to another. The dietary regime approach provides the tools to enhance our understanding of a number of issues that the NT model brings forward but does not resolve. Specifically, it foregrounds the processes by which the industrialization of food by profit motivated enterprise after 1850 or so has led to the steady degradation of whole foods through the processes of speed up, simplification and adulteration. It highlights the role of mass advertising in facilitating the normalization of the industrial diet, but also, in conjunction with the incentive of differential profits and the process of spatial colonization, mass advertising's role in the widespread diffusion of nutrient poor edible products in all manner of food environments.

The dietary regime approach also embraces an analysis of the different dimensions of power in the food system. Within our market economy powerful corporate players with tremendous market power have an inordinate role in determining what we eat every day and analysis of the *business* of food is essential to comprehending the dynamics of the food system.

As an important actor, the state influences the food system in many different ways. An analysis of the contradictory role of the state, in particular, is necessary for a fuller understanding of how specific dietary regime is constituted and reproduced over time. Popkin (1994) and Popkin et al. (2012) has noted government policies in different countries that would seem to have contributed to progress on promoting healthy eating. However, state policies have often been counter-productive with respect to this goal, a reality not effectively recognized by Popkin. The dietary regime approach can help explain this by drawing on the rich literature developed in the social sciences that analyses the state in different time periods and in different societal contexts. Insights from this literature can greatly strengthen understanding of the often contradictory process of policy formulation, with respect to the food system generally, and matters related to nutrition, diet and food environments more specifically.

In addition to corporations and the state, today new social forces in society are engaged in a "push back" to turn around what are perceived to be toxic food environments and unsustainable agricultural and food industry practices. The role of this third type of actor in the food system has been recognized by Popkin, and it is considered to be one of the defining features of the third dietary regime as discussed above. Nevertheless, it also needs to be carefully analyzed to appreciate its potential, and limitations, to transform food environments and diets.

The dietary regime approach can provide fruitful directions with respect to concrete policy options to address the major issue of population wide weight gain that the nutrition transition model has sought to confront in recent iterations. In adopting the more powerful analytical explanations of the dietary regime approach as a complement to the nutritional transition model, we will be advancing our understanding of dietary transformation and its related health outcomes. In so doing, we will be better prepared to support the necessary changes to positively transform food environments that currently threaten the well-being of billions of people.

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