Review

Complexities and opportunities in monitoring and evaluating US and global changes by the food industry

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Summary

In developed nations and increasingly in the rest of the world, a large proportion of people’s diets comes from manufactured food sources and food not produced at home. These types of products are constantly changing and have significant nutrition and health implications for the world’s population. However, researchers, public health workers and policy makers face major complexities in understanding what these changes are and their relationships to diet and health outcomes. This paper will describe some of the complexities faced in monitoring and evaluating the nutritional composition of food products and what it means for population health. Importantly, no existing food composition database is able to keep up with the continuous reformulation and introductions and removals of packaged foods and food services. The paper will also discuss opportunities to improve and update the monitoring and evaluation of changes made by each of these key sectors of the modern food supply and how these changes can influence the nutrients purchased or consumed across the globe. The focus will be on the United States with some examples from other developed nations and a discussion of implications for low- and middle-income countries.

Keywords: Global, modern food supply, nutrition, United States.

Acronyms and Abbreviations: CDC, Centers for Disease Control and Prevention (United States); FAO, United National Food and Agriculture Organization; FCT, food composition table/database; FDA, Food and Drug Administration (United States); FMG, Global Food Monitoring Group; FNDDS, Food and Nutrient Database for Dietary Studies (United States); NFP, Nutrition Facts Panel; UNCFRP, University of North Carolina Food Research Program (Chapel Hill, North Carolina, United States); US, United States; USDA, United States Department of Agriculture; WWEIA, What We Eat in America (United States).

Introduction

The global food system and food supply have changed dramatically in the last three decades, particularly for low- and middle-income countries (LMICs) (1–7). In high-income countries, the majority of food consumed is processed or prepared by the food manufacturing, food retail and catering industries (8). These industries and their associated distribution networks have enabled a constant supply of affordable food in much of the world, with
consequent alleviation of many nutritional deficiency disorders (9). However, a large proportion of the world’s population is now exposed to foods that are excessively energy dense and high in saturated fat, sugar and sodium (10,11). Modern markets (a general term used here for places to purchase packaged foods and beverages that have undergone varying degrees of processing) and restaurants (a general term used here for locations serving food, including quick-serve, fast-food, take-away, self-service and full-service or sit-down businesses) are becoming ubiquitous fixtures in developed and developing countries alike. International sales data provide a sense of the recent growth of two food sectors (12). Table 1 presents the 15-year trends in the retail value of packaged foods in select countries and shows that lower income countries, such as China (+192%), Vietnam (+166%), Thailand (+65%) and India (+53%), have experienced dramatic increases. Table 2 presents similar trends in the retail value of food service for 1999–2012, which has been stable or has fallen in higher income countries but has grown in lower income countries, such as China (+78%), Vietnam (+61%), Indonesia (+48%), India (+44%) and South Africa (42%).

The foods and beverages we consume play a central role in the prevention and cause of diseases (13). Consequently, many government bodies and consumers have pointed to the need for the food manufacturing and service industries to make changes to the fat (trans fats as well as other fats), added sugar, sodium and fibre content of their products (14–17). Many of the world’s largest multinational and transnational food corporations have responded by publicly acknowledging the role they play in population health and have made pledges to reduce the added sodium, added sugar, trans fats and calories in their products or to help educate consumers to make healthier choices (18–26). In the United States, some manufacturers and food services have made voluntary efforts to reduce the caloric content of their products through initiatives such as the Healthy Weight Commitment Foundation (19). Several retailers have recently made public announcements to address U.S. obesity by reducing the calories in products sold at their stores, including Walmart’s commitment to reformulate its Great Value products (20). Other large grocery chains, such as Safeway and Kroger, also claim to be selling a healthier mix of products and have committed to reformulate their store brand products (27,28). Likewise, some food service chains, such as McDonald’s and Darden, have made pledges in recent years (29).

However, it is unclear whether these voluntary pledges or self-regulatory efforts are actually being implemented and if they are to what degree, whether there will be significant impacts on population health, and how engaged the companies will continue to be over time (30). In fact, some argue that public regulation and market intervention are the only evidence-based mechanisms that can effectively

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**Table 1**

| Country            | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | % Change 1998–2012 |
|--------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------------------|
| Australia          | 1,581.7 | 1,606.8 | 1,600.7 | 1,576.1 | 1,581.8 | 1,589.6 | 1,592.2 | 1,582.2 | 1,570.3 | 1,575.6 | 1,563.1 | 1,591.7 | 1,588.4 | 1,563.6 | −1.93 |
| Brazil             | 489.8 | 525.8 | 513.0 | 518.7 | 541.9 | 516.0 | 511.1 | 499.8 | 499.7 | 521.0 | 537.4 | 524.7 | 542.2 | 563.1 | 19.87 |
| China (excluding Hong Kong) | 469.8 | 510.2 | 55.3 | 59.7 | 665.5 | 71.5 | 75.0 | 81.9 | 89.6 | 96.9 | 99.1 | 103.4 | 107.9 | 113.6 | 120.7 |
| Egypt              | 23.4 | 28.5 | 34.2 | 37.8 | 47.0 | 55.0 | 63.1 | 71.9 | 79.1 | 83.9 | 88.5 | 92.1 | 95.7 | 98.8 | 103.8 |
| France             | 718.6 | 724.9 | 731.8 | 738.5 | 745.2 | 751.2 | 757.0 | 762.7 | 768.3 | 773.9 | 779.5 | 785.0 | 790.5 | 796.0 | −7.54 |
| Germany            | 1,336.4 | 1,343.2 | 1,350.0 | 1,356.7 | 1,363.4 | 1,369.2 | 1,375.0 | 1,380.7 | 1,386.4 | 1,392.0 | 1,397.6 | 1,403.2 | 1,408.7 | 1,414.3 | 1,420.0 |
| India              | 15.7 | 15.6 | 15.7 | 15.9 | 16.0 | 16.2 | 16.5 | 16.8 | 17.3 | 18.4 | 19.5 | 20.1 | 21.1 | 22.2 | 53.87 |
| Indonesia          | 72.6 | 86.1 | 90.2 | 92.0 | 93.0 | 94.0 | 95.0 | 96.0 | 97.0 | 98.0 | 99.0 | 100.0 | 101.0 | 102.0 | 1.12 |
| Japan              | 86.4 | 90.1 | 93.8 | 97.6 | 101.4 | 105.2 | 109.1 | 113.0 | 116.9 | 120.8 | 124.7 | 128.6 | 132.5 | 136.4 | 4.93 |
| Morocco            | 28.4 | 31.4 | 37.1 | 43.1 | 48.0 | 53.4 | 56.4 | 59.6 | 63.6 | 67.5 | 63.9 | 68.9 | 72.6 | 71.9 | 165.49 |
| Netherlands        | 993.3 | 1,012.2 | 1,015.7 | 1,013.9 | 1,018.8 | 1,024.0 | 1,024.9 | 1,020.1 | 1,024.4 | 1,030.5 | 1,033.7 | 1,037.5 | 1,032.5 | 1,054.2 | 4.93 |
| South Africa       | 21.0 | 21.5 | 22.0 | 22.5 | 23.0 | 23.5 | 24.0 | 24.5 | 25.0 | 25.5 | 26.0 | 26.5 | 27.0 | 27.5 | 7.54 |

Source: Euromonitor Global Market Information Database. Because these are calculated based on total sales over the population, Euromonitor provides no standard deviation values. For these tables, “% Change” indicates the change in the percentage of retail value of food as a proportion of total retail value from the previous year.
improve nutrition and public health (31–33). In addition, there is concern that many of the multinational corporations may be strategically improving their product portfolios in certain countries, such as the United States, Canada and the United Kingdom, but are not doing so in other markets (34). A number of studies now show distinct differences in the nutrient content of the same products of some multinational companies in different countries (35). This is of concern, as research suggests that there is increasing penetration by multinational food companies, such as Nestlé, Kraft, PepsiCo and Danone, in LMICs, where consumption of unhealthy commodities is reaching levels presently observed in high-income countries (36).

To evaluate whether the food sector is making improvements to the nutritional composition of its products, it is critical to have standardized and sustainable, market-share weighted, accurate, representative, and timely (SMART) as well as brand-specific, open-source and objective, low-cost, and dynamic (BOLD) databases that capture what is in the foods and beverages available for purchase, how much of these offerings are sold and purchased and who is buying them. Herein lie the complexities, which this paper will discuss. In particular, this paper will focus on the challenges that public health researchers and policy makers face in trying to monitor and evaluate the nutritional changes that the food sector purports to be making (supply) and what they mean for consumers, given their own behaviours or responses to marketing practices and economic, social and demographic factors (demand). We follow by providing examples of the opportunities in light of these complexities and discussing their implications for LMICs.

### Monitoring the modern food and beverage supply: food composition tables and nutrition and menu label databases

#### Food composition tables

Traditionally, governments have relied on national food composition tables (FCTs) to monitor nutrient availability and nutrient intake among their populace. The International Network of Food Data Systems housed in the Food and Agriculture Organization (FAO) is a worldwide network of food composition experts that seeks to improve the quality, availability, reliability and use of food composition data by government agencies; nutrition scientists and educators; health and agriculture professionals; policy makers and planners; food producers, processors and retailers; and consumers (37). These national FCTs are particularly valuable in monitoring the biodiversity and nutrient composition of food commodities and species and can measure a large number of vitamins and minerals in addition to the typical macronutrient values. In the United
States, the US Department of Agriculture (USDA) Nutrient Data Laboratory conducts ongoing laboratory analyses to systematically update the nutrient data on key foods through the National Food and Nutrient Analysis Program (38). In addition, since 2010 the USDA Nutrient Data Laboratory, with support from the Centers for Disease Control and Prevention (CDC) and the Food and Drug Administration (FDA), has analysed the nutrient composition of a subset of a few hundred processed and restaurant foods as part of a CDC-funded sodium monitoring initiative (39). However, resource constraints and other priorities limit the scope and speed at which these are done. Given our modern, ever-evolving and expanding processed, packaged and prepared food supply (40), there is a growing disconnect between the vast array of products available to consumers and what is captured in national FCTs due to limited resources to update them.

For example, in the United States, the most recent version of the Food and Nutrient Database for Dietary Studies (FNDDS) contains 7,253 food codes (41), and the most recent release of the USDA National Nutrient Database for Standard Reference (SR) 25 contains 8,194 food items (42). In contrast, there were around 85,000 uniquely formulated food and beverage packaged and processed products sold between 2005 and 2009 (43) and at least 1,500 unique fast-food items available to U.S. consumers in 2012 (44). Consequently, it is unlikely that national FCTs capture ongoing product reformulation or introductions and removals of products on the market, and dietary intake findings may not appropriately reflect changes in the nutrient make-up of foods actually purchased and consumed by the population. In addition, national FCTs do not enable the tracking of changes in nutritional composition over time by certain companies or brands for the purposes of evaluating how the food industry might be performing. Many government and advisory reports have noted the need to enhance the accuracy and adequacy of food system surveillance in the United States; however, to date few sources address this need (45–49).

Nutrition and menu label databases

To date, efforts to enhance the monitoring of the packaged and processed U.S. food sectors have turned to commercial data sources. In earlier work, Ng and Popkin (50) describe some of the available commercial nutrition facts panel (NFP) databases available in the United States, such as Gladson (51) and Mintel Global New Product Database (52), that provide nutritional and ingredient information on foods and beverages at the barcode level and that have been used in a number of studies (43,53,54). U.S. federal agencies (USDA, CDC and FDA) have also turned to sources such as Gladson (in select years) as part of their sodium monitoring efforts (39). Meanwhile, the University of Minnesota’s Nutrition Coordinating Center (55) has also been collecting brand-level information on both the processed foods sector and the food service sector to update its Food and Nutrient Database, as have other research groups. The Center for Science in the Public Interest in the United States is an example of an advocacy group that uses selected nutrition label information at a particular point in time to advocate for sodium reduction in the food industry (56). For-profit start-ups, such as Fooducate (57), CalorieSmart (58) and InRFood (59), have also begun developing their own NFP and menu label databases to provide users with information about foods they are considering purchasing or consuming. Much of these data are collected from Internet sources (data mined) and are user generated (60,61). Because the longevity and sustainability of these new companies are unknown, their leadership and ownership can be evolving, and therefore the sustainability of these data sources is uncertain.

In addition, while these data mentioned above are at the brand level and are more up to date than FCTs, they are not generally open source, they can be very costly to license, the frequency and comprehensiveness of their updating is not always known, and the accuracy or reliability of the data is difficult and costly to validate. The proprietary nature of these data also means that researchers are licensing the data (i.e. do not own the data) and that there are restrictions on how and how long the data can be used (e.g. brand-level comparisons are typically not allowed by vendors), limiting their applicability to improve public health.

While the use of NFP and menu label data holds significant promise, it should also be noted that due to the high costs of nutrient analyses, NFP and menu label data are often calculated rather than obtained from multiple samples of chemical analyses. Available research suggests that the NFP labels are accurate in approximately 80% of products, with inaccurate cases generally containing less risk-associated nutrients (such as sodium and saturated fat) than the specified value on the label (62–64). Moreover, FCTs often have calculated and imputed values for certain nutrients (41). Additionally, rounding regulations (e.g. in the U.S. products with less than 5 mg of sodium per serving can report 0 mg of sodium or claim to be ‘sodium free’) could affect the accuracy of these data. However, unless there is systematic over- or underreporting, this should not adversely affect the main goals of monitoring the mean levels of key nutrient values in large numbers of products from various food or beverage groupings.

The limitations of these proprietary nutrition label databases have been recognized in many developed and developing countries, and the Global Food Monitoring Group (FMG) has begun work to collate NFP and menu label data for processed foods and fast foods in multiple countries (65,66) with the aim of objectively and transparently monitoring changes in the nutritional composition of processed
and fast foods globally and removing the issues associated with restrictions on data use. The work of the FMG is directly in line with the objectives of the International Network for Food and Obesity/Non-communicable Diseases Research, Monitoring and Action Support, which is a global network of public-interest organizations and researchers that aims to monitor, benchmark and support public and private sector actions to create healthy food environments and reduce obesity and non-communicable diseases (67). Currently, the FMG has representation from 31 countries, with over 80,000 products (both packaged and processed at the barcode level and food service items) included (68). LMICS represent two-thirds of the FMG, and most of these are from Central and South America and the Asia Pacific region. The FMG has high-level input from the FAO, the World Health Organization, and the Pan-American Health Organization. To date, training seminars have been held in several countries to increase the capacity for data collection in LMICs in the Asia Pacific region and Latin America. Advanced technologies to improve data collection have been developed and distributed to eight countries. Data have been collected in Argentina, Australia, Brazil, Canada, Costa Rica, Fiji, Mongolia, South Africa, New Zealand and the United Kingdom, and data collection in six additional countries is planned for 2013. Data have already been used by public health researchers to show the often wide variation in nutrient levels in foods (35,69,70), the lack of consistency in how nutrients are displayed on NFP and menu labels both nationally and globally (65,66,68), and the variations in locally made vs. imported products in lower and middle-income countries as opposed to developed countries (35).

What do food industry changes mean for populations?

Nutrient composition or nutrition facts and label data can provide information about the products in various countries or regions but cannot currently reveal the contribution each product makes to the nutritional intake populations. Consequently, it is important to incorporate information on the consumption, sales and purchases of these foods and beverages wherever possible.

Dietary intake or consumption databases

Many countries across the globe conduct nationally representative surveys to monitor the foods and nutrients consumed by their people and form the basis on which to determine public health status, nutrition and food policies. However, information at the brand level on what respondents report consuming is often missing. Moreover, in most countries, the dietary recalls are based on only 1 or 2 days, which may not represent usual intake unless certain adjustments are applied (71), or only include food frequency questionnaires, which can be prone to measurement error or are inappropriate for individual-level analyses (72,73). In addition, national diet surveys, such as What We Eat in America (WWEIA), the dietary component of the National Health and Nutrition Examination Survey, may not take into account seasonal differences in dietary intake.

Marketing companies have also moved into measuring dietary intakes. For example, in the United States, the NPD Group conducts a number of consumer surveys, such as National Eating Trends (74), Consumer Reports on Eating Share Trends (75), and Snacktrack (76). Details of these data are described in earlier work (50). Essentially, while these data provide up to 2 weeks of food consumption data and can contain information on eating behaviours and motivations, they are costly, only provide information at the aggregate food item level (rather than individual brand level), may not capture changes made by the food sector (because they often rely on national FCTs to derive nutrient information), and have legal limitations on their use.

Sales or purchase databases

Commercial food and beverage sales or purchase data at the barcode level in the United States, such as Nielsen’s Scantrack (77) and Homescan (78), have been described in detail elsewhere (50). Briefly, the US Nielsen Scantrack data provide information about how much of a specific barcoded product is sold and at what price (including promotions and sales) during a week, month or year using point-of-sale scanners. Meanwhile, the US Nielsen Homescan data contain detailed barcode-level information about household food purchases and include all transactions from all outlet channels regardless of size and chain (50). Nielsen provides scanning equipment to a sample of over 60,000 households across 76 major shopping markets in the static panel survey each year to collect data daily. All purchases are linked to retail stores and markets and include the prices paid. Homescan also contains key sociodemographic and household composition data and basic geographic identifiers. Other scholars and government agencies have used and evaluated these data (79–81). However, because the sales and purchase data do not include any nutrition information, they have to be merged with barcode-level nutrition label data to be used to evaluate changes to the nutritional composition of foods at the brand level.

Nielsen also has household panels and retail data on sales at the barcode level in over 20 countries, with the second largest household panel in China (behind the United States), which started in 2008 and includes 40,000 households. Other international marketing companies
with sales or purchase data include the Kantar Worldpanel (82), which not only has sales data at the barcode level but also has NFP data already merged (since 2006), which has allowed some researchers to study the nutritional content of purchases (83,84). However, this currently includes a limited number of developed countries, and these data still have restrictions on their use for public health research. Euromonitor (12) also have sales data, but these include broad, predefined food categories (rather than barcode level), and therefore cannot be easily linked to FCTs or NFPs. Nonetheless, those data can provide some insights into the retail values or expenditures for different food categories for countries or regions and the market performance of specific companies or brands (34,85).

Overall, these databases are not open source, are usually costly to license, and have restrictions on their use. Moreover, there are questions about the accuracy and representativeness of these data due to potential sampling and selection bias in response rates, participation and attrition. In the United States, researchers have systematically examined several methodological aspects regarding the Nielsen Homescan data (80,81,86), and some federal agencies, such as the USDA, have worked with Nielsen Homescan for a number of years to create databases available to the public (87). In addition, with regard to nutritional representation, work by the University of North Carolina Food Research Program (UNCFRP) found that with the exception of infrequently purchased food items, weighted statistics using Nielsen household weights and census-derived weights trend together well on caloric purchases and average prices (88). Moreover, in comparing the data on the average per capita calories consumed among those 2 years old and older in the United States from WWEIA with the data purchased from Nielsen Homescan, there appear to be similar trends over time (Fig. 1).

Figure 1  Average daily calories reported consumed (WWEIA 2001–2010) for all Americans aged 2 years or older vs. caloric purchases per capita from processed and packaged foods (Homescan 2000–2011).

Improving measurements of food industry changes towards being SMART and BOLD

Despite the variety of databases available (as described above), currently no database provides all the functionality required to comprehensively and independently monitor the nutritional composition of individual food items or food industry changes and what it means for population health at either the national or the international level. Each type of database, whether it be from a market research company, an advocacy organization or a research group, has certain advantages and disadvantages, and all are useful for the specific purpose for which they were designed. To improve data on the food supply, some key attributes need to be addressed, which can be summarized using the SMART and BOLD concepts. Each of these aspects is described in detail below.
SMART

Standardized and sustainable: standardized approaches to how data are collected to enable consistent methods in monitoring changes over time.

Market-share weighted: includes information on the relative contribution in terms of market share of various brands or products within different food categories to better reflect the combined effects of product reformulation and shifts in consumer purchasing behaviour.

Accurate: databases should accurately reflect what is on NFP/menu labels at the time of data collection and should include date stamps and geocodes when possible.

Representative: sampling frames used or resultant survey weights should allow data to be reflective of what is actually purchased or consumed. This includes the types of products available and the populations or subpopulations purchasing or consuming them.

Timely: regularly updated so as to reflect foods and beverages available to consumers.

BOLD

Brand specific: users of food composition databases are increasingly requiring brand name data, because many foods are unique in their nutritional composition and have no generic product equivalent (89). In addition, information collected at the brand or company level enables the identification of key areas to target for food reformulation and identifies the brands or companies that are and are not making positive changes to food formulation.

Open sourced and objective: data contributors (such as consumers, public health groups, and other interested individuals and groups) should be allowed to both access and provide updated information on the nutritional content of processed and fast foods (without overwriting prior data). The open-source approach to data collection will allow for objective monitoring.

Low cost: data collection and management should be low cost via a central database and repository approach, while access to the data should be free for all those who contribute to its development.

Dynamic: measurement approaches should allow some flexibility in how data are collected or calculated based on technology improvements or scientific evidence.

Creating data sources that achieve these SMART and BOLD principles is ambitious and will require time, commitment and a collaborative approach to succeed, but it is possible to move in that direction. Below are two examples of steps taken towards improving the monitoring and evaluating of global changes by the food industry by considering both supply- and demand-side efforts.

Supply-side measurements: the global food monitoring group experience

As described in earlier sections, the work of the FMG aims to collate data about the composition of processed foods in different countries with the intent that the information be used to drive improvements in the global food supply using the SMART and BOLD concepts. Technologies have been developed by the FMG to both improve data collection and data entry methods and share the branded food composition data with consumers. Through the development of these technologies, the power of crowd-sourcing nutrition information is also being explored.

Helping consumers make healthier food choices

The FMG’s branded food composition database was used to drive discussions with a leading health insurer, Bupa, in Australia to encourage it to fund the development of a smart phone application called FoodSwitch (90). FoodSwitch has been an important outcome of the work of the FMG to date and is a good example of how information in the branded food composition database can be used to directly help consumers make healthier food choices. By scanning the barcode of a packaged food product using a smart phone’s camera, the FoodSwitch application presents a nutritional profile of the food with easy-to-interpret, colour-coded traffic light ratings for total fat, saturated fat, sugar and salt content. The application also suggests healthier alternative products (at the brand level) in the same category of the scanned food using an algorithm based on the Food Standards Australia New Zealand nutrient profiling criteria for health claims (91). The Australian branded food composition database underpins the application, and the nutrient information for each food item is used to determine both the traffic light ratings and the nutrient profiling score to rank the healthier alternative products in order.

Since the FoodSwitch application was launched in January 2012, it has been downloaded by more than 350,000 users. More than 1,000 users have sent in comments, expressed their appreciation, and shared anecdotes of the positive impact it is having on their food purchasing habits. FoodSwitch also led to a broader partnership called the Healthy Foods Initiative and resulted in Bupa Australia agreeing to fund additional clinical versions of the FoodSwitch application. The application is now being developed in New Zealand, the United Kingdom, South Africa and China.

The power of crowd sourcing

An unanticipated but highly influential outcome of FoodSwitch has been the power of crowd-sourcing data collection. Built into the FoodSwitch smart phone
application is a function allowing users to take photos of products that are not found in the database when they scan the barcode. The application prompts the user to take photos of the front of the pack, the Nutrition Information Panel and the ingredients list of the product through the application so that those photos can be used to update the food composition database that underpins FoodSwitch. In just the first 2 d after the application was released in Australia, 26,000 photos of packaged food products were sent in by users, equating to an additional 6,000 products being entered into the central food composition database. On average, over 200 photos are still sent in by FoodSwitch users on a daily basis, keeping the database entirely contemporary. Potentially, in the future, this will result in a much reduced cost, as the research team may no longer need to visit supermarkets to collect data.

A missing piece
The one key consideration currently missing from the work of the FMG is the use of market-share data to weight information in the branded food composition database. Product market-share data provided and incorporated on a regular basis would provide more insight into the changing nature of food consumption patterns. However, as has already been discussed, these data are usually expensive to access and come with limits on usage and sharing of information. Future efforts to secure access to market-share data would be welcome, but in the meantime some reassurance is provided by the observation that market-share weighted estimates compared with unweighted estimates are not necessarily very different, at least in developed countries (82).

Layering demand-side considerations: evaluating changes in the processed and packaged food sector and their impacts
In the United States, the UNCFRP has begun monitoring the calories and other key nutrients sold by food manufacturers and retailers using the Nielsen Homescan panel and commercial NFP data at the barcode level (54). Because the socioeconomic conditions that consumers experience, such as food prices, income or employment status, may change consumer behaviour in the short term or the long term (92) and the demographic composition might change over time, it is important to consider these factors when determining the impact of product changes on nutrients purchased or consumed. For example, in the face of economic constraints, consumers may shift away from eating out at full-service restaurants towards relatively cheaper fast-food options or eat out less. They may also move from purchasing branded products to private label versions (93). Consequently, the UNCFRP has created a Packaged Foods Purchase and Price database (see Fig. 2) that includes these measurements for use in analytic models to estimate more accurately what the role of industry changes might have been.

Additionally, to evaluate changes in nutrient composition over time made by the packaged and processed food sector and to examine their impacts on individual diets, UNCFRP is creating a Factory to Fork crosswalk between barcodes with NFP data to a corresponding FNDDS food code that appears in the WWEIA dietary intake survey reported to have been obtained from stores or vending sources during the equivalent time period (94). Items without barcodes, such as loose (unpackaged) fruits or vegetables, cut-to-order meats and homemade recipe items that do not appear in the commercial data sources, will not be linked (white boxes in Fig. 2). The UNCFRP crosswalk for processed, packaged foods achieves three important results. First, nutrient information from the commercial data can be applied to the WWEIA intake data by creating a composite nutrient profile (the UNCFRP Nutrient Database) based on the weighted average volume purchased for all appropriate barcodes matched to each FNDDS food code. Second, the proportion of nutrients reported consumed in WWEIA that are attributable to national brands vs. private labels or attributed to various kinds of stores (e.g. convenience stores) can be determined. Finally, completion of the crosswalk facilitates comparisons across public and commercial data sources, because a nutritionally meaningful food-grouping system can be applied to all data.

There are many other potential applications and extensions from this system within the United States. First, research and public health scholars who work with selected age group, race or ethnic group, and income subpopulations in the United States may be interested in being able to account for the differential brand or flavour preferences of these subpopulations (e.g. Hispanics may prefer fruit drinks from Mexico). Because the nutrient content across different brands or flavours can vary and there is market segmentation of these products by subpopulations, it may be important to study differential purchase patterns and weight the nutrient profiles for each subpopulation accordingly. Therefore, this system will allow subsequent research aimed at understanding the nutrient intake of different subpopulations by creating subpopulation-specific versions of the UNCFRP Nutrition Database to be applied to WWEIA. By doing this, it would be possible to examine, for example, how the calories or sugars consumed from sugar-sweetened beverages might differ between Hispanics and non-Hispanic whites (due to both differences in amount consumed and differences in the nutrient profile of the mix of sugar-sweetened beverages purchased).

Another application of this system can be in the burgeoning use of image and scanning technologies to measure food

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environments or conduct dietary recalls. These include studies that scan barcodes of products in respondents’ homes (95,96) and studies that have respondents take photographs of their meals (97,98). The UNCFRP crosswalk could link scanned barcodes or images of products with the FNDDS to provide estimates of nutrient availability or intake and estimate how well populations are able to meet or are meeting dietary guidelines (by applying the Food Pattern Equivalent Database or its predecessor, the MyPyramid Equivalent Database). The FMG has already started to harness these technologies to enable consumers to take photographs of food products, and other groups have started to develop smart phone applications that allow users to take photographs of their meals and other foods they are eating.

**Summary**

On the supply side, the food industry claims to be changing the nutritional composition of food products via reformulations, introducing new ‘better for you’ products, and removing their less healthy offerings as part of major commitments (18,20). However, until recently the paucity of data has not allowed these changes to be monitored well. Efforts by the FMG have allowed the development of a database that contains brand-specific information on the nutritional composition of more than 80,000 foods from 12 countries so far, with more planned for the next few years. FMG data have already been used to monitor a number of variables related to the global food supply. Data from Australia and the United Kingdom were used to define baseline levels of sodium in major food categories to enable monitoring of changes over time (99,100). Comparisons of sodium levels between years exposed the limited progress with sodium reduction in Australia and New Zealand (69), with data presented at the individual company level. Analyses of data for 2,124 fast-food items from six countries and six leading companies demonstrated the wide range of sodium levels in very similar products (35). Branded food composition data from India highlight the incompleteness of nutritional labelling as another key issue in the field, with only 52% of products carrying information compliant with local regulations and only 27% providing data compliant with international standards (unpublished data).

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Monitoring food industry changes

with highly tangible outputs.

About key issues related to the quality of the food supply, pressures the food industry and informs consumers. Data from the FMG have also been used to lobby governments to reduce population exposure to adverse levels of consumption of these foods and the leading global causes of health are not simply exported, as has been seen in the experiences of the foods or nutrients purchased or consumed based on commercial data sources alongside public datasets, we believe that the growth of the FMG, improved technological tools and access to them, and investments by countries to improve their measurement of reported foods consumed can allow this approach to be applied to other countries in the near future.

With the globalization of the food supply, it is increasingly important that this kind of monitoring crosses borders and is not restricted to just one country or region. Effective monitoring of our rapidly changing global food system and its impact on consumers towards being SMART and BOLD will require strong global collaborations working towards the common goal of improving public health. The tobacco and alcohol industries, facing controls and market saturation in developed regions, have rapidly shifted the focus of their activities to the developing world, where they can operate unfettered by the commitments they have made elsewhere. Systematic monitoring of changes to product formulation across countries can help ensure that manufacturing and marketing policies adverse to health are not simply exported, as has been seen in the tobacco and alcohol industries. Highlighting differences in product nutrient composition between countries and between food companies will also help identify new opportunities for improvement and bring additional pressure to bear on those companies that are not making positive changes to the nutritional composition of their products.

There is a large and increasing penetration of the modern food supply comprised of processed and prepared foods around the world. In light of the associations between consumption of these foods and the leading global causes of death and disability, it is imperative that mechanisms be put in place to reduce population exposure to adverse levels of calories, fat, sugar and sodium. Improvements to the quality of packaged, processed and prepared foods are not necessarily the panacea to this issue but represent important contributions that could ameliorate the situation.

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Conflicts of interest

None of the authors have conflicts of interest of any type with respect to this manuscript.

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