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Monitoring and benchmarking population diet quality globally: A step-wise approach

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Abstract
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Keywords
step, globally, quality, approach, diet, wise, population, benchmarking, monitoring

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Review

Monitoring and benchmarking population diet quality globally: a step-wise approach

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Summary

INFORMAS (International Network for Food and Obesity/non-communicable diseases Research, Monitoring and Action Support) aims to monitor and benchmark the healthiness of food environments globally. In order to assess the impact of food environments on population diets, it is necessary to monitor population diet quality between countries and over time. This paper reviews existing data sources suitable for monitoring population diet quality, and assesses their strengths and limitations. A step-wise framework is then proposed for monitoring population diet quality. Food balance sheets (FBaS), household budget and expenditure surveys (HBES) and food intake surveys are all suitable methods for assessing population diet quality. In the proposed 'minimal' approach, national trends of food and energy availability can be explored using FBaS. In the 'expanded' and 'optimal' approaches, the dietary share of ultra-processed products is measured as an indicator of energy-dense, nutrient-poor diets using HBES and food intake surveys, respectively. In addition, it is proposed that pre-defined diet quality indices are used to score diets, and some of those have been designed for application within all three monitoring approaches. However, in order to enhance the value of global efforts to monitor diet quality, data collection methods and diet quality indicators need further development work.

Keywords: Diet quality, INFORMAS, monitoring, ultra-processed foods.

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Introduction

In the 1970s, population diets started shifting towards increased consumption of processed foods (including sugar-sweetened beverages) and 'out-of-home' foods, many of which are unhealthy (1,2). The negative effects of these changes on population health have only recently been acknowledged (3–5). The nutrition transition, defined as the changes in dietary patterns and nutrient intakes when populations adopt modern lifestyles during economic and social development, urbanization and acculturation (6), is presently occurring at a very rapid rate in low- and middle-income countries (LMICs) (7). The United Nations

*INFORMAS is the International Network for Food and Obesity/non-communicable diseases Research, Monitoring and Action Support.

High-Level Meeting on non-communicable diseases (NCDs) in September 2011 (8) emphasized the increasing global burden posed by poor diet, physical inactivity and its associated chronic health disorders such as obesity, type 2 diabetes and cardiovascular diseases. The World Health Organization (WHO) recently developed a global NCD monitoring framework in response to this meeting, including the monitoring of outcomes (NCD mortality and morbidity), risk factors (including salt intake as target and saturated fat, fruit and vegetable intake as indicators) and national system responses (9).

Complementary to WHO monitoring efforts, the International Network for Food and Obesity/NCDs Research, Monitoring and Action Support (INFORMAS) aims to monitor, benchmark and support public and private sector actions to create healthy food environments and reduce obesity, NCDs and their related inequalities (10). Within INFORMAS (10), the population diet quality module seeks to enable an analysis of the impact of changes in food environments (such as changes in the composition, labelling, promotion, affordability, accessibility and/or availability of foods) on population diets by monitoring the quality of diets over time and between countries. The module aims to answer the research question, 'What is the quality of the diet of different populations?' In order to address this question, data on national or regional food consumption habits and diet quality are needed on a regular basis, collected using comparable methods over time and, if possible, across countries or regions. Furthermore, a summary score of overall population diet quality is likely to be needed to enable comparisons.

The objective of this paper is to present (i) an overview of existing sources of dietary data and their strengths and limitations for monitoring population diet quality; (ii) a review of various pre-existing indices of overall diet quality and (iii) a proposed step-based framework to monitor and benchmark population diet quality globally. This monitoring conducted as part of this module will seek to make use of existing data on food availability, expenditure and/or intake. For the purpose of INFORMAS, a high-quality diet includes a combination of dietary attributes associated with obesity and NCD risk reduction.

Overview of existing sources of dietary data

Several types of data may be available in countries to monitor population diets. These data are usually derived from food balance sheets (FBaS), household budget and expenditure surveys (HBES) and food consumption surveys (FCoS). Availability of these data, cost, frequency and methods of data collection, level of detail, waste considerations and comparability over time and across countries vary. In some situations, when data at the individual level are lacking, FBaS and HBES data are used as a surrogate of food intake, but these various sources of data are not directly comparable, as each of them provides information about a different level in the flow of foods from production to consumption (national food supply, food acquisition within households and individual food intake).

Data from Spain, Canada, Finland and Poland showed that the availability of foods as measured by FBaS was significantly higher than the reported intake measured by FCoS while results from HBES and FCoS tended to be more similar to each other (11). In Brazil, it was found that the ratio of national supply (food availability derived from FBaS) to household availability (derived from HBES) of fruits and vegetables was 2.6 while the ratio of national supply to reported intake (derived from FCoS) was 4.0, and the ratio of household availability to reported intake was 1.6 (12). In Europe, Spearman's correlation coefficients between FBaS and HBES (data from 18 countries included) were 0.78 for vegetables (including legumes), 0.76 for fruits, 0.69 for fish and seafood, 0.93 for olive oil and 0.39 ($P = 0.08$) for meat products (13).

Food balance sheets

FBaS present the country's food supply during a specified reference period, balancing local production, countrywide stocks, and imports with exports, agricultural use for livestock, seed and waste. Waste on the farm, during distribution and processing, as well as technical losses due to transformation of primary commodities into processed products is taken into account. The data are expressed per capita supply of each food item available for human consumption. After applying appropriate food composition factors, the supply is expressed in terms of energy and macronutrients (14). The Food and Agricultural Organisation (FAO) open access database contains national level data since 1961 related to 120 food groups on a more or less aggregated level for 183 countries on a yearly basis. For some countries (e.g. some Pacific Islands), these data are not available or are collected on an irregular basis. Some countries have additional or refined food availability data systems, such as the Food Availability Data System in the United States, which includes the loss-adjusted food availability data accounting for additional types of waste (food spoilage, plate waste) (15). The major advantage of FBaS with respect to monitoring population diet quality for the purposes of INFORMAS includes the availability of the data and the low cost of obtaining those, while the major limitation includes the crudeness of the measure as a proxy for food intake, the use of broad categories and the fact that several types of food losses and wastes are not taken into account (Table 1).

Table 1 Strengths and limitations of different sources of dietary data (food balance sheets, household budget and expenditure surveys, food consumption surveys) for monitoring and benchmarking population diet quality globally

	(FBaS)	(HBES)	(FCoS)
Type of information collected	Information on macro-level, national trends in food supply and the overall adequacy of food availability. For some commodities estimates might be more reliable than when using FCoS (e.g. sugar).	Information on household food availability and expenditure over a given period of time. Inclusion of information on food prices and socioeconomic status of the households. Data collection on how food was acquired, differentiating whether it was purchased, home produced or received free of charge.	Information on food intake at the individual level. Often detailed information available on the foods consumed (e.g. brand name, preparation method) and collection of recipe information.
Availability and coverage of data	Freely available for almost all countries on a yearly basis. However, some countries do not collect them (e.g. some Pacific Islands) or less regularly.	Good coverage, available for over 100 countries across all continents and both high-income and low- and middle-income countries. Often regular data collection (every 1–5 years).	Not available for many countries and if available, not repeated sufficiently regular
Costs of data collection	Low	Higher	Expensive to perform which hampers periodic assessment in many countries on a national level
Wastage and losses	Losses of edible food, e.g. during storage, preparation and cooking, as plate-waste or domestic animal feed, or thrown away are not taken into account. Unless adjusted for expected losses at the retail and consumer levels, FBaS data are not good indicators of what is eaten because losses are very variable across food groups. Assumptions for waste are based on expert opinions rather than measurements.	No information on wastage of foods at home, preparation losses or foods given away (overestimation)	Usually taken into account
Other methodological challenges	No information on food intake, access to foods or distribution of foods within a country. Mainly information available on primary agricultural commodities, not on processed foods. Statistics of population, supply and utilization of foods vary a great deal between countries with regard to coverage and accuracy; there may be gaps and inconsistencies.	Food items that are more perishable are likely to have shorter shelf lives and be purchased more frequently. Consumption levels of these foods are likely to be more accurately captured by HBES regardless of the recall/record period. Estimation of intake of foods with longer shelf lives is more likely to be inaccurate and the shorter the recall/record period, the more likely they will not be captured by purchase data. Purchases made online or recurring bill payments made by automatic debit may be underreported. Foods consumed outside the home tend to be underestimated. Accurate estimation of intra-household allocation of foods is difficult. Most HBES contain a mixture of acquisition and consumption data, which may result in either over- or underestimation of consumption. HBES do not collect information on food that is acquired during recall period but not consumed during it or food that is not acquired during recall period but consumed (stocks). Heterogeneity in design, methods and implementation of HBES among different countries.	Difficult to keep up with rapidly changing food supply. Difficult to include ingredients added at the table (salt, sugar). Use of different methodologies for data collection which hampers comparability across countries.
Response rate	Not affected	Affected	Affected
Exclusion of subjects	Not affected	Affected	Affected
Underreporting	Not affected	Affected	Tendency towards underreporting, especially of certain foods and among certain population groups (obese people)
Stratification	No stratification possible by population group (e.g. sex, age, socioeconomic status) or by region. No information on seasonal variations in food supply.	Stratification possible by household socioeconomic status or sex, age, socioeconomic status of reference person of the household. Seasonal and regional variations can be captured.	Stratification by age, sex and socioeconomic status and identification of high-risk groups. Seasonal variations can be captured.
Representativeness	National data	Large sample sizes, usually nationally representative surveys, representative for both country and subnational levels	Often small sample sizes and not always nationally representative

FBaS, food balance sheets; FCoS, food consumption surveys; HBES, household budget and expenditure surveys.

FBaS have mainly been used to describe long-term food availability, and to investigate its local and global drivers. Different studies have used FBaS to assess dietary changes over time (16–20), to compare worldwide availability of fats, sugar, starch, n-3 and n-6 fatty acids and different food groups (21–26), to assess association of food availability with population overweight and obesity (18,27,28) and with different morbidities or mortality (29–34), and to evaluate adherence to different diets (e.g. the Mediterranean diet) (35). In addition, intakes of micronutrients, macronutrients, polyphenolic and flavonoid compounds (17,19,36–39), and salt (40) have been calculated using FBaS, and exposure to food chemicals and additives (41,42) has been assessed. FBaS have been used in both high-income countries (HICs) and LMICs. In LMICs, the extent and characteristics of nutrition transition have been determined with FBaS (18,19,43–45). In general, FBaS showed that over the years the availability of calories from total carbohydrates as a percentage of total energy decreased, while the availability of fats and sugars increased (17,19,20,46–50). Energy availability especially increased in LMICs (18,19,43,44).

Household budget and expenditure surveys

HBES are national surveys mainly focusing on consumption expenditure, allowing for calculation and monitoring of the consumer price index, and describing food acquisition patterns and apparent food consumption across regions and population groups. They are also variously referred to as household income and expenditure surveys, living standards measurement studies, integrated household surveys, core welfare indicator questionnaires, welfare monitoring surveys or comprehensive food security and vulnerability assessments (51). They are usually performed every 1–5 years, and conducted in large country-representative population samples (mostly between 7,000 and 20,000 households (52)), allowing for subnational estimates. One member of the sampled household records or recalls all foods and beverages acquired during a reference period, usually 1–2 weeks, including purchases, contributions from own production and foods received as gifts. However, foods acquired for out-of-home consumption are not always recorded or recalled. Fiedler *et al*. identified 17 countries worldwide that address out-of-home consumption using HBES (52). Examples of long-running annual surveys including reliable estimates of foods and drinks eaten at home and out of home exist in the UK (53) and the United States (54).

HBES are likely available for more than 100 countries across different continents, including both HICs and LMICs (51). Over the last two decades, the number, quality and availability of HBES in LMICs have increased. In 1990, the World Bank presented analyses of single HBES conducted in 22 countries. Today, there are more than 700 surveys for 116 countries, an average of six per country (55). The DAta Food NEtworking (DAFNE) Project pioneered the use of HBES in 1987 to monitor trends in food availability among European countries based on harmonized and comparable information and ensuring continuity over time (56–58). This project also developed a software tool to compare food availability between countries and within countries over time (59).

HBES vary with regard to data collection methods, recall or record periods, questionnaire design and length, and composition and detail of food lists (51). The 'food diary' approach (food acquisition recorded by respondent) is considered more accurate than the 'food recall' approach (food acquisition obtained through interview with respondent), although it is more expensive, invasive and difficult to implement, as it requires more visits and supervision, especially among illiterate populations (52).

Given the heterogeneity of HBES globally (52), it is difficult to make general statements about their strengths and limitations to monitor population diet quality (Table 1). Some aspects that need further consideration are standardization of measurement units, optimization of the recall or record period (60), better capturing of food acquisition out of home (61) and improvement of the food list (e.g. level of detail) for dietary monitoring (62). In addition, it is important to investigate how to determine intra-household distribution of foods (52). Approximations to intake by age and sex are usually made under the assumption that foods are equitably distributed based on individual energy needs. Adjustments for the age- and sex-specific energy requirements of each household member can be made using the FAO's adult male consumption equivalent (63). It has been shown in LMICs (28 studies) that intra-household distribution of foods is relatively equitable with a relative dietary energy adequacy ratio as an indicator of the equity of food distribution within households between 0.8 and 1.2 usually (optimum ratio is 1.0) (64).

In 2008, FAO began routinely analysing HBES to estimate household food access, food security and nutrient intake adequacy (65). Relationships between household expenditure and malnutrition (66–68), poverty (69,70), and overweight and obesity (71,72) have been investigated. HBES have been used to identify common food sources of specific nutrients, to model the impact of fortification programs (73–84) and to estimate the distribution of sodium intake (85). In Brazil, the spending on out-of-home eating has been analysed (86), and its relationship with overweight and obesity (87) assessed. Time trends in the contribution of processed foods to food purchases have been evaluated (5,88,89) and the potential impact on overall diet quality (5) or prevalence of overweight and obesity has been explored (89). In addition, exposure to pesticides has been assessed using HBES (90–92).

A recent review article on HBES concluded that studies comparing HBES with FCoS found relatively high levels of consistency with regard to proportion of households consuming and/or purchasing most food items, total energy intake and nutrient density (nutrient content in grams per 2,000 kcal of the edible portion of a food) of most food items consumed and/or purchased, while mixed results were found in testing statistical differences between the estimated medians of nutrient intakes (51,93).

Food intake surveys

National or subnational FCoS are mainly conducted by national or regional health authorities, and include representative population samples. Several methods can be used for dietary assessment, including dietary recalls and records. The use of different dietary assessment methods may impede comparisons across countries. In addition, the number of days for which data are collected may vary considerably from country to country and study to study. Data collection on at least two non-consecutive days allows for estimation of longer term intake of foods and nutrients using statistical methods (94–96).

In Europe, several projects such as EFCOSUM (97,98), EFCOVAL (99–102) and PANCAKE (103) have tried to harmonize food consumption methodology across countries, both for adults and children. In 2012, The European Food Safety Authority started the EU Menu survey that aims to collect food consumption data in all European countries in a harmonized way. Data are collected using dietary records or recalls through a standardized software tool EPIC-SOFT (104–106).

Few countries conduct nationally representative FCoS on a regular basis because they are expensive, time consuming and difficult to conduct. Some countries collect only information on frequency of consumption of a limited number of food groups within other national health surveys.

Unique issues for some LMICs include estimating individual intakes when communal eating from one dish is the norm. Other critical issues are how to keep up with rapidly changing food supplies, how to capture ingredients added at the table that may be concentrated sources of nutrients and how to document detailed information on out-of-home eating (107) (Table 1).

Review of indicators of diet quality

In assessing diet quality, the need to analyse dietary patterns, rather than single dietary components, is increasingly recognized. This is because people consume combinations of foods, and dietary components may interact.

Two approaches to dietary patterning have been used: theoretically defined dietary patterns and empirically derived dietary patterns. The latter are statistically derived '*a posteriori*' from collected food consumption data based on clustering of individuals or correlations in intakes of the various dietary components (108). As empirically derived dietary patterns may be very variable between countries and over time, they are not considered useful for the purpose of INFORMAS. Consequently, theoretically defined dietary patterns (or pre-defined measures of diet quality) were the focus of this review.

Indices of overall diet quality based on selected foods and nutrients

Indices of diet quality are pre-defined summary measures of overall diet quality, and can be used to monitor overall dietary changes (109). They are based on foods and/or nutrients that are considered important for health in general or for specific health outcomes. In the last decades, several indices have been developed, and some of them have been validated by relating them to measures of overall nutrient adequacy or chronic disease risk. The Healthy Eating Index (HEI) (110), the Diet Quality Index (DQI) (111), the Healthy Diet Indicator (HDI) (112) and the Mediterranean Diet Score (MDS) (113) are the four original diet quality scores that have been used most extensively. However, the original HEI is no longer used and has been superseded by the HEI-2005 (114) and the HEI-2010 (115).

The original HEI, based on the 1995 Dietary Guidelines for Americans, comprises grains, vegetables, fruits, milk, meat, total fat (as a % of total energy), saturated fat (as a % of total energy), cholesterol, sodium and dietary variety as components (110). Scores between 0 and 10 were assigned to each component and an index with values between 0 and 100 obtained. After the 2005 Dietary Guidelines for Americans were released, the index was modified to address the increased importance of whole grains and specific types of fats (116), and included 12 components: total fruit, whole fruit, total vegetables, dark green and orange vegetables and legumes, total grains, whole grains, milk, meat and beans and oils, saturated fat (as a % of total energy), sodium in grams per 1,000 kcal and the calories from solid fat, alcohol and sugar (as a % of total energy). In addition, the index was developed to assess intake densities rather than absolute intakes, which makes it adaptable to any set of foods at any level of the food system and not just individual level intakes (114). The components are weighted such that each major food group mentioned in the guidelines receives basically equal weight except empty calories, which are double weighted in accordance with their effect on diets. The most important changes from 2005 to 2010 include the addition of seafood and plant proteins to capture specific choices from the protein group; a ratio of polyunsaturated and monounsaturated to saturated fatty acids, replacing oils and saturated

fat; and a moderation component, refined grains, replacing total grains, to assess overconsumption (115).

The DQI comprises total fat, saturated fat, cholesterol, fruits and vegetables, grains and legumes, protein, sodium and calcium as components (111). Scores 0, 1 and 2 are assigned to each component, and the index ranges from 0 (excellent diet) to 16 (poor diet). In 1999, this index was revised to incorporate measures of dietary variety and moderation (117), and consisted of 10 components, with scores between 0 and 10 assigned to each component. Total score ranged from 0 (poor compliance) to 100.

The HDI, based on WHO recommendations, includes saturated fat, polyunsaturated fat, protein, complex carbohydrates, dietary fibre, fruits and vegetables, pulses, nuts and seeds, mono- and disaccharides, and cholesterol as components (112). Scores 0 and 1 are attributed to each component and an index ranging between 0 and 9 is obtained.

The MDS includes the ratio of monounsaturated fat to saturated fat, legumes, cereals, fruits and nuts, vegetables, meat (products), milk and dietary products, and alcohol as components (113). Score 0 or 1 is assigned to each component using the median intake of study participants as a sex-specific cut-off point. A score ranging from 0 (low adherence to the Mediterranean diet) to 8 is obtained. In 2003, fish intake was included as an additional component, retrieving scores ranging from 0 to 9 (118).

Waijers *et al.* (119) reviewed the Medline literature published until September 2005 on 20 pre-defined indices of overall diet quality. They found only modest associations between diet quality indices and either nutrient adequacy or health outcomes and concluded that existing indices do not predict mortality or morbidity significantly better than individual dietary factors. Arvaniti *et al.* (120) reviewed 23 commonly used dietary indices (overlapping largely with those from Waijers *et al.* (119)) in a study published in 2008, and concluded, as did Waijers *et al.* (119), that many arbitrary choices are included in the make-up of the scores and that the majority of the indices fail to recognize the different interrelationships between their constituents. They recommend the development of weighted indices, with weights in proportion to the importance of a food/nutrient to the health outcome of interest (120). A systematic review of published English-language literature until 2007 among adults was conducted by Wirt *et al.* (121), including 28 articles and 25 indices of overall diet quality, with HEI (110), HDI (112), Healthy Food Index (122), the Recommended Food Score (123), the DQI (124), the Diet Quality Score (125) and MDS (113) as the most important. The majority of studies presented methodological weaknesses but demonstrated that higher diet quality was consistently inversely related to all-cause mortality with a protective effect of moderate magnitude. The predictive capacity of most of the indices was fairly similar (121). Kourlaba *et al.* (126) concluded that, based on a Medline review until June 2008, pre-existing indices are adequate tools to evaluate diet quality, but they have shown moderate predictive ability in relation to chronic diseases and health determinants. The predictive capacity of MDS or adapted versions was shown to be slightly better than that of the original HEI, DQI or HDI (126). A systematic search of Medline for prospective cohort studies or randomized trials investigating dietary exposures in relation to coronary heart diseases found that the MDS is a better predictor of coronary heart disease than individual foods (127). Two more recent systematic reviews were identified (128,129), but they only included studies using indices among children and are not further discussed here.

In order to update the existing systematic reviews with more recent literature, Medline was searched for the terms 'Healthy Eating Index', 'Mediterranean Diet Score', 'Diet Quality Index' and 'Healthy Diet Indicator' (four most extensively used dietary indices) for the period 2008–2012, and studies linking diet quality with overweight, obesity or different diet-related NCDs were included. In total, 64 studies (130–193) were retrieved using one or more of these indices or their modified versions. The (original) HEI (32 studies) and MDS (38 studies) were most frequently used (some studies used multiple indices).

In general, more positive than null associations were found with both overweight/obesity and NCDs, but predictive ability in relation to NCDs was moderate, such as that found in the prior reviews. Part of the reason for this might be related to measurement error, about which we know very little in the case of multivariate dietary patterns. This is an important area of research that needs to be pursued.

A new indicator of diet quality based on the share of ultra-processed food products in the diet

The dietary share of ultra-processed food products, expressed as a percentage of total calories, has been recently proposed as a predictive indicator of the energy and nutrient adequacy of the overall diet (5,194). Ultra-processed products are ready-to-consume industry formulations manufactured from ingredients directly extracted from whole foods, such as oils, fats, sucrose and flours, or processed from components extracted from whole foods, such as high-fructose corn syrup, hydrogenated oils, a variety of starches and the cheap parts or remnants of meat. To these products, several additives are typically added, with little or no content of whole foods. They include pre-sugared breakfast cereals, sweet and savoury snacks, desserts, a variety of ready-to-heat dishes and soft drinks (5,194). The production and consumption of ultra-processed food products is rising rapidly, particularly in

LMICs, with the effect of eroding food systems and dietary patterns based on minimally processed foods and freshly prepared meals (5,88,195–197).

Ultra-processed food products typically are energy dense; have a high glycaemic load; are low in dietary fibre, micronutrients and phytochemicals; and are high in unhealthy types of dietary fat, free sugars and salt (198). Studies in Brazil and Canada have documented the direct association of the dietary share of ultra-processed products with overall dietary energy density and the content of free sugars, total and saturated fats, and sodium. These studies have also shown an inverse association between the dietary share of ultra-processed products and the overall protein and fibre content of the diet (4,5). Preliminary evidence documents direct association of the dietary share of ultra-processed products with the risk of metabolic syndrome (199), and overweight and obesity (89). However, it is noted that this new indicator has not been thoroughly tested yet.

Proposed step-wise diet quality monitoring framework for the International Network for Food and Obesity/non-communicable diseases Research, Monitoring and Action Support

In order to take into account differences in existing data sources in countries, a step-wise framework is proposed to monitor and benchmark population diet quality between countries and over time. The proposed framework, including 'minimal', 'expanded' and 'optimal' approaches, is depicted in Table 2.

The 'minimal' approach relies on the use of FBaS, which are available for many countries. While FBaS are likely to overestimate population dietary intake, they are nevertheless considered an acceptable source of readily available information as part of the 'minimal' approach, and allow exploration of trends of availability of several food groups (basic commodities) and energy from macronutrients between countries and over time. However, FBaS cannot inform how food consumption is distributed according to age, sex and socioeconomic status, and do not allow assessment of the share of ultra-processed products in the diet.

Some dietary indices, such as HEI-2005 or HEI-2010, have been designed for use at the food supply as well as consumption level (200), and may be utilized within the 'minimal' approach. However, interpretations may be limited to the extent that wastage is not taken into account.

The 'expanded' approach incorporates the use of HBES, which are more expensive to conduct and are available for fewer countries, but provide more details than FBaS. Although they have clear shortcomings, such as the non-consideration of foods consumed out of home, foods wasted and the unknown distribution of foods among members of the household, HBES are increasingly used to fill the food consumption information gap between FBaS and FCoS (93). It will depend on the level of aggregation of food groups whether HBES can be used to determine the dietary share of ultra-processed food products (refer to Table 2).

In the 'optimal' approach, individual intake or FCoS are used. Overall diet quality may be assessed using one of the pre-defined dietary indices through the use of individual intake surveys. However, currently, all indices have clear methodological shortcomings, and their predictive ability is only moderate and fairly similar. More work is needed in order to optimize dietary indices to determine quality of population diets. Even if detailed FCoS data are available within a country, data on HBES and/or FBaS also need to be collected for the purpose of between-country comparisons.

Table 2 Proposed step-wise framework for monitoring and benchmarking population diet quality between countries and over time

	Minimal approach	Expanded approach	Optimal approach
Source of data	Food balance sheets	Household budget and expenditure surveys	Individual intake or food consumption surveys
Indicator(s) of diet quality	Supply of broad food groups (basic commodities) and energy from fat, carbohydrates and sugar. Pre-defined Diet Quality Index, e.g. Healthy Eating Index, Mediterranean Diet Score, Diet Quality Index or Healthy Diet Indicator.	The share of ultra-processed foods and drink products in the diet, expressed as percentage of total calories. Pre-defined Diet Quality Index, e.g. Healthy Eating Index, Mediterranean Diet Score, Diet Quality Index or Healthy Diet Indicator.	The share of ultra-processed foods and drink products in the diet, expressed as percentage of total calories. Pre-defined Diet Quality Index, e.g. Healthy Eating Index, Mediterranean Diet Score, Diet Quality Index or Healthy Diet Indicator.
Stratification	No stratification	Stratification by region. Stratification by socioeconomic status of the household and sex and age of the household reference person.	Stratification by region (if sample size allows). Stratification by socioeconomic status, age and sex of the individual.
Representativeness	Countrywide	Countrywide/regional	Countrywide/regional

Limitations and recommended areas for future development

Sources of dietary data and data collection methods

The collection of 'optimal' data required to effectively monitor the quality of diets can be expensive, but should be compared with estimated social costs associated with negative health consequences of unhealthy diets.

Many of the shortcomings of HBES can be ameliorated with relatively minor changes (52), and HBES could be strengthened substantially as a tool for evidence-based nutrition policy with more proactive involvement of the nutrition community in the design and implementation of HBES (51). Since 2006, the International Household Survey Network has been offering leadership and technical assistance in promoting availability, quality, standardization and use of survey data in developing countries. It provides a catalogue containing more than 4,000 household surveys (52). From 2000 to 2006, the International Food Policy Research Institute's Assessing Food Insecurity project analysed the HBES of 20 LMICs and developed guidelines for processing and using HBES databases to more precisely measure food insecurity. This was, however, only a one-time effort (201). INFORMAS could also play a role in setting up networks to share data and criteria across different groups of scientists and institutions working in the area of food consumption in order to improve quality and harmonization of dietary data.

Choice of appropriate diet quality indicator

Indices differ widely with regard to the number of components included, cut-off values and scoring systems, and contributions of components to the overall score (126). Many arbitrary choices are included in the make-up of diet quality indices. Inappropriate selection of the components, selection of a small number of cut-off points for each component and/or equal contribution of all index items to the total score are often presented as the major weaknesses (119,120).

Different foods and nutrients have been used in indices, although some specific ones (fat, fruits, vegetables and whole grains) are used in the majority of indices because of their established health impact. The use of a large number of cut-off points is recommended in order to increase the diagnostic capacity of indices (202). Diagnostic accuracy of indices was also shown to increase with an increasing number of components, but only when the components were not or only slightly correlated. Low-correlated or non-correlated components, strongly associated with a particular outcome, should be used in order to obtain an accurate composite index (203). It has been found that the scoring model used for dietary indices may have a significant impact on observed associations with disease outcomes (204). In addition, other methodological issues remain unresolved, such as the ways of dealing with differences in energy intake (109,119–121,126), and with measurement error in the multivariate context.

The performance of a meta-analysis across all, or most, cohort studies worldwide is recommended, in order to develop a new evidence-derived (*a posteriori*) 'best' healthy diet indicator, with global applicability (or, perhaps, with regional variations).

Food categorization

In the event that a single diet quality indicator is recommended for monitoring diet quality globally, it will be important to define the food groups in detail, so that countries use the same definitions to classify foods into those food groups, while allowing flexibility for the classification of culturally specific foods. The classification system to identify food products as ultra-processed products has been outlined and defined elsewhere (194). In some cases, highly aggregated data may pose a problem for categorizing foods using pre-defined classification systems.

Within the frame of the DAFNE project (205), a special food classification system, consisting of 15 food groups and 56 subgroups, was developed to allow European comparisons of dietary data. For aggregating specific items into major food groups, country-specific density and conversion factors are used.

Food composition data

Diet quality indices usually include both food groups and nutrients as components. In order to calculate nutrient intakes, country-specific food composition data will be needed.

For some nutrients (e.g. mono- and polyunsaturated fatty acids) this may be particularly challenging. Furthermore, the use of country-specific databases may hamper international comparisons across countries. Global databases that characterize foods according to dietary guidance-based food groups, such as the MyPyramid Equivalents Database in the United States (206), would help in standardizing the measures across countries.

In this case, quantities of foods reported in surveys can be translated into quantities of guidance-based food groups, such as vegetables and fat, after disaggregating food mixtures into their ingredients.

Conclusions

FBaS, HBES and FCoS can all be used to assess population diet quality at different levels of the food supply. However,

each of these data sources has their limitations and strengths. In the proposed 'minimal' approach, national trends of food and energy availability can be explored using FBaS. In the 'expanded' and 'optimal' approaches, the dietary share of ultra-processed products will be measured as an indicator of energy-dense, nutrient-poor diets using HBES or food intake surveys. In addition, pre-defined diet quality indices will be used, and some of those have been designed for application within all three monitoring approaches. However, more work is needed to improve both data collection methods and diet quality indicators in order to enhance the value of global dietary monitoring efforts.

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Conflicts of interest

Bruce Neal is the Chair of the Australian Division of World Action on Salt and Health (2007 to present), was a Member of the Pepsico Global Scientific Advisory Board (2010–2012), was the Independent Adjudicator for the Australian Responsible Marketing to Children's Initiative (2009–2010) and holds funding from the Australian Food and Grocery Council as part of a National Health and Medical Research Council of Australia Partnership project (2010–2014). The other authors declare that they have no competing interests.

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