PERSPECTIVE

Perspective: Food-Based Dietary Guidelines in Europe—Scientific Concepts, Current Status, and Perspectives

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ABSTRACT

Food-based dietary guidelines (FBDGs) are important tools for nutrition policies and public health. FBDGs provide guidelines on healthy food consumption and are based on scientific evidence. In the past, disease prevention and nutrient recommendations dominated the process of establishing FBDGs. However, scientific advances and social developments such as changing lifestyles, interest in personalized health, and concerns about sustainability require a reorientation of the creation of FBDGs to include a wider range of aspects of dietary behavior. The present review evaluates current European FBDGs with regard to the concepts and aspects used in their derivation, and summarizes the major aspects currently discussed to be considered in future establishment or updates of FBDGs. We identified English information on official European FBDGs through an Internet search (FAO, PubMed, Google) and analyzed the aspects used for their derivation. Furthermore, we searched literature databases (PubMed, Google Scholar) for conceptional considerations dealing with FBDGs. A total of 34 out of 53 European countries were identified as having official FBDGs, and for 15 of these, documents with information on the scientific basis could be identified and described. Subsequently, aspects underlying the derivation of current FBDGs and aspects considered in the literature as important for future FBDGs were discussed. Eight aspects were identified: diet-health relations, nutrient supply, energy supply, dietary habits, sustainability, food-borne contaminants, target group segmentation, and individualization. The first 4 have already been widely applied in existing FBDGs; the others have almost never been taken into account. It remains a future challenge to (re)conceptionalize the development of FBDGs, to operationalize the aspects to be incorporated in their derivation, and to convert concepts into systematic approaches. The current review may assist national expert groups and clarifies the options for future development of local FBDGs. *Adv Nutr* 2018;9:544–560.

Keywords: diet-health relations, dietary habits, energy, food-based dietary guidelines, food-borne contaminants, individualization, nutrients, nutrition policy, sustainability, target group segmentation

Introduction

Food-based dietary guidelines (FBDGs; see **Text Box 1**) aim to guide toward recommended food consumption to provide required nutrients and to promote health. They are rooted in scientific evidence (2, 3). The target groups addressed by FBDGs range from the general public to policy makers. Thus, FBDGs should be easy to understand and easy to follow. It is furthermore crucial for FBDGs to incorporate region- or country-specific food consumption, dietary habits, and burden of diseases. Consequently, they are specific to the population in a region or country (4). FBDGs reflect a type of "ideal" diet and serve as a basis for the development of

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Abbreviations used: CVD, cardiovascular disease; CINDI, Country-wide Integrated Noncommunicable Diseases Intervention; DRV, Dietary Reference Value; EFSA, European Food Safety Authority; FBDG, food-based dietary guideline; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; NCD, noncommunicable chronic disease; NNR, Nordic Nutrition Recommendations; PNNS, Guides nutritions du Programme National Nutrition Santé; TDS, total diet study; T2D, type 2 diabetes.

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TABLE 1 The EFSA opinion on the scientific process of developing FBDGs for diverse European populations consisting of a stepwise approach[1]

	Step	Comment
1	Identification of diet-health relations	Evidence on diet-health relations is available from reviews that are carried out regularly by national and international agencies
2	Identification of country-specific diet-related health problems	Specific diet-related health patterns and disease and mortality rates should be reviewed to identify and prioritize nutrition problems of public health significance
3	Identification of nutrients of public health importance	Nutrient imbalances in the population (groups) should be identified by comparing habitual intake from dietary surveys to DRVs, and by using anthropometric and available biochemical indicators of nutritional status
4	Identification of foods relevant for FBDGs	Food groups that are sources of nutrients of public health importance and foods for which intakes explain differences between groups who do and do not achieve target nutrient recommendations should be identified from observed patterns of dietary intake; intake of food groups with established relations to health (e.g., fruit and vegetables) should also be estimated
5	Identification of food-consumption patterns	Food-consumption patterns in the population that are consistent with the achievement of recommended intakes of nutrients should be identified. In addition, it is important to identify population characteristics for each pattern. Recommendations for FBDGs should be made taking into account specific needs of population groups.
6	Testing and optimizing FBDGs	The coherence and effectiveness of FBDGs in meeting nutrient recommendations should be confirmed by modeling of food and nutrient intake data and the FBDGs should be adapted appropriately
7	Graphical representations of FBDGs	Graphical representations of FBDGs may be developed in order to facilitate communication to consumers

[1] Data from reference 3. DRV, Dietary Reference Value; EFSA, European Food Safety Authority; FBDG, food-based dietary guideline.

Text Box 1
Definition
"Food-based dietary guidelines are short, science-based, positive messages on healthy eating and lifestyles aimed at preventing all forms of malnutrition and keeping people well-nourished and healthy. They embody national nutrition recommendations and express the principles of nutrition education in terms of food" (1).

nutritional policies that aim to achieve this ideal in members of the general public.

In 1992, the UN FAO and the WHO suggested the development of FBDGs and proposed that they should be available for each country of the world (5). They provided the rationale and gave an overview of the steps that could be taken to develop FBDGs in subsequent publications (2), whereby the reorientation from nutrients to foods in formulating FBDGs was an essential feature. In 2008, the European Food Safety Authority (EFSA) issued a scientific opinion on how to establish FBDGs in Europe. EFSA focused on the process of developing FBDGs and proposed a stepwise approach in which the identification of diet-health relations is the central starting point (**Table 1**) (3). EFSA's opinion also considered former reports (2, 6, 7), which provided guidance for the development, implementation, and evaluation of FBDGs. In line with previous reports, EFSA concluded that FBDGs should be established specifically for each country or region due to differences in dietary habits and disease burden (3).

The most comprehensive overview on the current situation of the FBDGs worldwide is available on the FAO website (1). This website is continually updated and reflects FAO's institutional interest to promote the worldwide development of FBDGs. Some research groups already use the available information on this site for analyses of FBDGs with regard to specific aspects of their content or their graphical presentation (8–10). The situation with regard to FBDGs specifically in Europe was recently presented in an updated European Food Information Council review (9).

The original idea of FBDGs by FAO/WHO exists for >25 y now. During this period, much progress was observed, which was highlighted by the EFSA opinion (3), one of the most recent documents on FBDGs issued by a public institution related to nutrition policy. In the past, disease prevention and nutrient intake recommendations dominated the process of establishing FBDGs (2, 3, 5). Currently, FBDGs have also been recognized as an important tool of nutrition policy by many groups that are interested in specific aspects of a high-quality diet. It is therefore important for future FBDGs to consider a wider range of aspects than previous FBDGs. Nutrition recommendations should reflect societal challenges, including environmental aspects and trust in scientific conclusions, in addition to recent scientific insights such as individual metabolic reactions and personalized nutrition (11). Furthermore, the evidence base of dietary guidelines is often subject to criticism (12). There is a need for implementing efficient, explicit, and reproducible methods for dietary guideline development (10, 13).

These recent developments favor a reconceptionalization of the derivation of FBDGs. Therefore, the main objective of this review is to evaluate current European FBDGs with regard to the concepts and aspects used in their derivation and to summarize the major concepts currently discussed to be considered in future establishment or updates of FBDGs. Our main interest concerned information on the underlying ideas (conceptional background, aspects considered) that

have guided the establishment of current FBDGs so far and that should inform future FBDGs. The methodologic approaches to prepare FBDGs, as well as the results of the processes in the form of the published FBDGs, are beyond the scope of this review.

Methods

This review is divided into 2 parts. In the first part, we evaluate the applied concepts of current European FBDGs. To identify suitable national FBDGs, an Internet search was performed in June 2017. First, the European countries were identified according to the WHO classification of member states and geographic subregions (14). For these countries, we consulted the FAO website (1), reviewed the individual FAO European country pages, and identified the existing FBDGs. The respective national websites were additionally searched for information on concepts. In addition, an extensive search was conducted in PubMed (www.pubmed.gov) and Google (www.google.com) until June 2017 using the following search terms: (food-based dietary guidelines OR FBDG) AND "country name." The selection was confined to FBDGs published or endorsed by a government. The identified material of each national FBDG was searched for English-language documents. Only these documents were further analyzed.

For the second part, we searched the literature [PubMed (www.pubmed.gov), Google scholar https://scholar.google.com until June 2017; search terms: (food-based dietary guidelines OR FBDG)] for English-language publications and documents that dealt with the integration of conceptional thoughts and scientific concepts into future FBDGs. In addition, the reference lists from the retrieved articles were checked to identify further relevant studies. Furthermore, the documents retrieved for the first part were screened for novel ideas.

In this review, we focus on dietary guidelines without further consideration of other aspects related to a healthy lifestyle, such as physical activity or healthy body weight, which are sometimes integrated into FBDGs.

Results

Part I: European FBDGs and their derivation

Europe consists of 53 countries and 34 of these countries were identified to have FBDGs. English-language documents on the scientific basis of the FBDGs were available for 15 countries (**Table 2**).

Greece (1999). For establishing the Greek FBDGs, considerations on scientific evidence on diet and health ("key findings" are described without citing references or documented systematic evidence review) as well as nutrient and energy intake in accordance with the nutrient recommendations of the European Scientific Committee for Foods (34) were taken into account (30). The visual presentation of the FBDGs is an adjusted version of the Mediterranean diet pyramid (35).

Portugal (2003). The derivation of FBDGs in Portugal focused on achieving goals set for energy and nutrient intakes (32, 33). Different Dietary Reference Values (DRVs) for nutrient intake (5, 36, 37) were considered and energy requirements were computed by taking the median of 13 age groups of both sexes (38, 39). Common usage of food in Portugal was considered in establishing the food groups. The Portuguese Food Wheel reflects the dietary principles of the Mediterranean diet, but evidence on diet-health relations was not considered when deriving the FBDGs.

Slovenia (2007) and Albania (2008). The latest versions of Slovenia's written and graphical models of FBDGs were published in 2007 and 2015, respectively, and the Albanian FBDGs were published in 2008. Both countries adopted the WHO CINDI (Countrywide Integrated Noncommunicable Diseases Intervention) dietary guide (7) with the WHO food pyramid as the basis of their national food guide. However, detailed information on their approach to establish their FBDGs is not available.

The WHO CINDI dietary guide was published by a group of experts from the WHO Regional Office for Europe in 2000 (7). Its aim was to strengthen the capacity of health professionals to help their clients prevent disease and to promote health. The guide includes a summary of the evidence supporting a relation between diet and health, in particular, the prevention of noncommunicable chronic diseases (NCDs), such as cardiovascular diseases (CVDs), certain cancers, hypertension, obesity, and type 2 diabetes (T2D). It is stated that the adapted recommendations have to cover the nutrient needs of the population as well as the energy requirements depending on sex, age, body size, and physical activity level. Furthermore, it is emphasized that dietary guidelines have to consider country-specific dietary patterns and NCD prevalences to make their implementation feasible and effective (7). The WHO has developed a user-friendly guide in 2012 for the Eastern Mediterranean region on promoting a healthy diet to reduce the risk of major NCDs (40), but it is not yet referred to by the respective countries.

Ireland (2012). The derivation of the FBDGs in Ireland focused on achieving goals set for energy and nutrient intakes (20–22). Diet-health relations were considered indirectly via nutrient supply (arguments for nutrient goals), but systematic evaluations of the evidence were not performed or used. The food patterns were developed to reflect the typical eating habits of various age and sex groups in Ireland and their affordability was checked (budget pattern).

Germany (2013). In Germany, 2 graphical models were established in order to implement nutrition recommendations to support health while considering the specific national nutritional situation (19). The Nutrition Circle implements the DRVs for nutrients (41) at the food level. It is mentioned that the circle is in accordance with the results of evidence-based guidelines and literature reviews by the

TABLE 2 European countries [according to WHO classification of member states and geographic subregions (14)] with official FBDGs and corresponding English-language background information on scientific derivation of FBDGs[1]

Region and country	FBDG year of publication/last update	Concepts, information on scientific background (reference)
Nordic		
Denmark	2013	Nordic Council of Ministers, 2014 (15); no English paper on national guide
Finland	2014	Nordic Council of Ministers, 2014 (15); no English paper on national guide
Iceland	2014	Nordic Council of Ministers, 2014 (15); no English paper on national guide
Norway	2014	Nordic Council of Ministers, 2014 (15); no English paper on national guide
Sweden	2015	Nordic Council of Ministers, 2014 (15); National Food Agency, 2015 (16); Konde et al., 2015 (17)
Western Europe		
Austria	2010	—
Belgium	2005	—
France	2011/2016	French Agency for Food, Environmental and Occupational Health and Safety (ANSES), 2016 (18)
Germany	2013	Oberritter et al., 2013 (19)
Ireland	2015	Flynn et al., 2012a and 2012b (20, 21); Food Safety Authority of Ireland, 2011 (22)
Luxembourg	—	—
Netherlands	2016	Kromhout et al., 2016 (23), Health Council of the Netherlands, 2015 (24, 25)
Switzerland	2011	—
United Kingdom of Great Britain and Northern Ireland	2016	Ferguson et al., 2004 and 2006 (26, 27); Buttriss et al., 2014 (28); Buttriss, 2016 (29)
Southern Europe		
Andorra	—	—
Greece	1999	National and Kapodistrian University of Athens, School of Medicine, 1999 (30)
Israel	2008	—
Italy	2003	—
Malta	2016	Pace, 2016 (31)
Monaco	—	—
Portugal	2003	Rodrigues et al., 2006 (32); Pinho et al., 2016 (English abstract) (33)
San Marino	—	—
Spain	2005/2008	—
Turkey	2014	—
Cyprus	2007	—
Central and Eastern Europe		
Bulgaria	2006	—
Czech Republic	—	—
Hungary	2004	—
Poland	2009/2010	—
Romania	2006	—
Slovakia	—	—
Southeast Europe		
Albania	2008	WHO, 2000 (6)
Bosnia and Herzegovina	2004	—
Croatia	2002–2012	—
Slovenia	2011–2015	WHO, 2000 (6)
The former Yugoslav Republic of Macedonia	2014	—
Montenegro	—	—
Serbia	—	—
Baltic		
Estonia	2012	—
Latvia	2003/2008	—
Lithuania	2011	—
Commonwealth of Independent States		
Armenia	—	—
Azerbaijan	—	—
Belarus	—	—
Georgia	2005	—
Republic of Moldova	—	—
Russian Federation	—	—
Ukraine	—	—

(Continued)

TABLE 2 *(Continued)*

Region and country	FBDG year of publication/last update	Concepts, information on scientific background (reference)
Central Asian republics		
Kazakhstan	—	—
Kyrgyzstan	—	—
Tajikistan	—	—
Turkmenistan	—	—
Uzbekistan	—	—

[1] FBDG, food-based dietary guideline; —, no FBDGs or no information available.

German Nutrition Society (42–47) and other professional societies. The Three-Dimensional Food Pyramid combines quantitative and qualitative statements, reflected by ranking of foods on the basis of energy density and nutrient content as well as other nutritional-physiologic criteria and evidence with regard to the prevention of NCDs, in a single model (19).

Denmark (2013), Finland (2014), Iceland (2014), Norway (2014), and Sweden (2015). The latest versions of the national FBDGs in Denmark, Finland, Iceland, Norway, and Sweden were published between 2013 and 2015. The common Nordic Nutrition Recommendations (NNR) 2012 (15) were used as a basis and adapted according to national requirements.

Nordic countries collaborate in setting dietary guidelines through the joint publication of the NNR. The NNR2012 (15) used an evidence-based and transparent approach in assessing associations between nutrients and foods and certain health outcomes. Systematic reviews formed the basis for the recommendations of several nutrients and foods (48–60). The NNR2012 contains DRVs for nutrients and emphasizes the evidence for the role of food and food patterns contributing to the prevention of the major diet-related NCDs (15).

In addition, the NNR2012 (15) contain a chapter on sustainable diets, which explains the interrelations between food, health, and environmental protection. It summarizes the required changes in food consumption in Nordic countries needed to switch from the current diet to a more healthy and sustainable one. It also highlights the positive and negative effects of the proposed actions. For Denmark, Finland, Iceland, and Norway, English-language information on their approach to derive the national FBDGs is not available.

The Swedish guidelines (16) are based on the NNR2012 (15) combined with knowledge on the population's dietary habits and on the environmental impact of various food groups. The environmental impacts of individual foods have been analyzed and incorporated into the derivation of the FBDGs. A technical report outlines the evidence that forms the basis for each of the recommendations (17).

Malta (2016). The current FBDGs were published in 2016, in accordance with the Food and Nutrition Policy and Action Plan for Malta (2015–2020) (31). The process of creating FBDGs appears to have followed the EFSA recommendations (3) and includes a review of the literature on diet-health relations with the use of existing systematic reports (e.g., those from the World Cancer Research Fund, Centers for Disease Control and Prevention, and WHO). Key recommendations were derived on the information gained from the literature review, based on the principle that nutrient needs are met primarily through consumed foods. They considered local and "traditional" food and food products as well as today's lifestyle and diet-related health problems. The FBDGs were calculated on the basis of a caloric intake of ~2000 kcal/d, but it is noted that the total amount of food to be consumed depends on the individual's age, sex, height, weight, and physical activity (31). Environmental sustainability was not considered within the derivation of the FBDGs, but reference to the "Green Food Project" (61) is made.

Netherlands (2016). The Dutch FBDGs were updated in 2015–2016. A committee of the Health Council of the Netherlands derived FBDGs described in an advisory report (24) on the basis of a predefined methodology (25), with further background documents in Dutch. Experts systematically evaluated the literature and judged the evidence on nutrients, foods, and food patterns in relation to the risk of the 10 most important NCDs in the Netherlands as well as 3 causal risk factors. The guidelines were derived on the basis of conclusions that are supported by strong evidence and depending on the actual food consumption pattern (24). The committee compared their established guidelines with previous findings on ecological aspects of dietary guidelines (62) and concluded that complying with a number of recommendations would not only result in health gain but also lower the ecological burden.

The Netherlands Nutrition Center translated the updated guidelines into public information on healthy eating in 2016 by updating the Wheel of Five. It is mentioned that DRVs were also considered during this process (23), but detailed English information for this step is not available. The Netherlands Nutrition Center refers to a climate balance

tool (63) and offers an interactive tool on their website to personalize the food guide by sex and age.

United Kingdom (2016). The Eatwell Guide is the most recent model of the United Kingdom's FBDGs. Public Health England reviewed healthy eating messages in 2014 in light of the conclusion of the Scientific Advisory Committee on Nutrition's Carbohydrate and Health report. Linear programming (28) was used to reshape the guide. This modeling process considered the current intake levels of the most commonly consumed foods in the United Kingdom, applied the revised government dietary recommendations, and modeled the fewest possible changes required to achieve the proposed recommendations. Constraints to shape the Eatwell Guide were energy supply and DRVs for total carbohydrates, free sugars, dietary fiber, total fat, saturated fat, protein, and salt. Additional constraints included frequencies or amounts of food items. Checks were made to ensure that requirements for micronutrients, especially in vulnerable age groups, were also met (29).

France (2016, opinion on revision). The French FBDGs are part of the National Nutrition and Health Program (PNNS; *Guides nutritions du Programme National Nutrition Santé*). The latest edition was published in 2011. In December 2016, an opinion on the revision of the PNNS guidelines was published by the French Agency for Food, Environmental, and Occupational Health and Safety (18). The work provides the principles and evidence necessary for formulating the FBDGs. It consists of the following:

- updating the DRVs (DRVs from international organizations were compared);
- studying the relations between food consumption and risk of NCDs, worked out in a specific report (French only), using previously conducted work by other organizations such as EFSA, the World Cancer Research Fund, and WHO as a starting point for the literature search; and
- the attempt to limit exposure to contaminants [using contamination levels of food from the Total Diet Study (TDS) 2].

A computer tool was developed to identify combinations of foods able to simultaneously cover these 3 aspects, while limiting deviations from the dietary habits observed in France (18).

Part II: conceptional considerations with regard to FBDGs

Future concepts of FBDGs might include and address a wider range of aspects of diet than the current generation of FBDGs. This part of the review characterizes conceptional considerations in terms of aspects used for the derivation of FBDGs. It describes the current status and also provides an update of initiatives that might be of importance for the next generation of FBDGs.

The results are grouped into 8 aspects: *1*) scientific evidence on diet-health relations (including prioritizing disease groups), *2*) nutrient supply (including prioritizing nutritional needs), *3*) energy supply, *4*) dietary habits/sociocultural preferences, *5*) sustainability, *6*) food-borne contaminants, *7*) target group segmentation, and *8*) individualization. The utilization of these aspects in the 15 European countries that provide their FBDG concepts in English is shown in **Table 3**. Local dietary habits were considered by all countries and diet-health relations, nutrient supply, and energy supply were considered in almost all countries. In some instances, we could not ultimately conclude from the available material whether an aspect had been utilized (nutrient supply in Sweden, energy supply in Netherlands and Sweden). Aspects related to sustainability and contaminants have been considered only rarely (Sweden and France, respectively), and none of the 15 countries considered target group segmentation and individualization (Table 3).

1. Diet-health relations. With regard to the aspect of diet-health relations, "diet" is understood as a generic term for dietary patterns, foods (groups), and nutrients. "Health" stands for the risk of metabolic disorders (e.g., impaired fasting glucose, dyslipidemia) and NCDs (e.g. T2D, CVDs).

In the opinion by EFSA (3), diet-health relations form the central starting point of all subsequent steps of developing FBDGs (Table 1). The paradigm is that, at the individual level, a healthy food choice has an impact on the risk of metabolic disorders and NCDs and at the population level on their occurrence. The diet-health relations should be graded according to the evidence of a causal link and only those relations that were assigned a high evidence grade should be considered. Evidence should be compiled through a systematic analysis of the literature on human study results and knowledge of the postulated biological and pathophysiologic background of the relation. This evidence base usually guides the process of developing dietary model systems that are further translated into food guidance tools (64). Hereby, it is important to generate evidence by meta-analytical methods of both major study designs—randomized controlled trials and prospective studies—because they are considered to have the highest level of evidence in nutritional epidemiology (65).

Tapsell et al. (64) recommended that the collection of evidence should follow a systematic top-down approach, starting with dietary patterns, followed by single food groups and then by nutrients. Within Europe, this approach can currently be seen in the Dutch FBDGs concept. This approach considers the fact that dietary patterns, food groups, and nutrients are all interrelated and could reflect the same pathways. Because individuals consume foods and not nutrients, studies on dietary patterns and foods are also more amenable to translation and public health practice (64, 66). It is interesting to note in this context that the 2015 Dietary Guidelines Advisory Committee focused its review of evidence and recommendations on dietary patterns instead of individual nutrients or foods (67). This

TABLE 3 Considered aspects for scientific derivation of national FBDGs[1]

Country (reference)	Diet-health relations	Nutrient supply (DRVs for nutrient intake)	Energy supply (DRV for energy intake)	Dietary habits/ sociocultural preferences	Sustainability	Contaminants	Target group segmentation	Individualization
Albania[2] (7)	+	+	+	+	–	–	–	–
Denmark[3] (15)	+	+	+	+	–	–	–	–
Finland[3] (15)	+	+	+	+	–	–	–	–
France (18)	+	+	+	+	–	+	–	–
Germany (19)	+	+	+	+	–	–	–	–
Greece (30)	+	+	+	+	–	–	–	–
Iceland[3] (15)	+	+	+	+	–	–	–	–
Ireland (20–22)	+	+	+	+	–	–	–	–
Malta (24, 31)	+	+	+	+	–	–	–	–
Netherlands (23, 24)	+	+	?	+	–	–	–	(+)[4]
Norway[3] (15)	+	+	+	+	–	–	–	–
Portugal (32, 33)	–	+	+	+	–	–	–	–
Slovenia[2] (7)	+	+	+	+	–	–	–	–
Sweden (15–17)	+	?	?	+	+	–	–	–
United Kingdom (26–29)	–	+	+	+	–	–	–	–

[1] DRV, Dietary Reference Value; FBDG, food-based dietary guideline; +, aspect considered; –, aspect not considered; ?, not ultimately concluded whether the aspect had been considered.
[2] No English-language information on how the specific national food guide was derived; therefore, data tabulated here refer to information available from the WHO (7).
[3] No English-language information on how the specific national food guide was derived; therefore, data tabulated here refer to information available from Nordic Nutrition Recommendations (15).
[4] Food guide used for public education is personalizable (interactive tool on website).

practice shows that the core features of a healthy diet can be obtained through different dietary patterns, potentially accommodating varying individual needs and sociocultural preferences (66). The ability to offer alternative dietary pattern options and to tailor them to personal preferences (see sections 7 and 8) may increase the likelihood of long term success of maintaining a healthy dietary pattern (67). However, research on nutrient- and food-based relations is still needed to identify causative agents and to enhance the mechanistic understanding of the effects or risk relations of food and whole diets.

The disease-risk associations (linear and nonlinear) as well as the quantitative impact of specific foods still have to be determined. Schwingshackl et al. have published a series of quantitative meta-analyses including prospective studies investigating the associations of 12 major food groups with clinically relevant outcomes such as mortality (68), T2D (69), hypertension (70), CVD (71), and colorectal cancer (72). In subsequent steps, the health impact of the different foods can be calculated by quantifying the disability-adjusted life years for the outcomes and the overall results can be compared across the food groups and across different populations (73).

In view of the increasing number of meta-analyses often investigating the same research question and due to their important role in generating evidence, the need to evaluate the quality of the evidence has increased. The Cochrane Nutrition field (74) is helping in this regard by supporting global coordination of systematic reviews in nutrition and strengthening the methods of both reviews and primary studies (75).

The evaluation of the quality of evidence in general is guided by the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) group (76), which originated from interest in clinical guidelines in close collaboration with the Cochrane Collaboration. The GRADE criteria for evaluating the quality of evidence are being increasingly applied in nutrition research. Recently, the NutriGrade scoring system was developed to assess nutrition-specific aspects (77). Compared with the well-established GRADE tool, it gives more weight to the evaluation of cohort study designs, because of their importance in the investigation of diet-health relations, and takes into account funding bias and dietary assessment methods and their validation (77, 78).

In developing FBDGs, it is important to examine country-specific health patterns, diseases, and mortality to identify public health problems of importance and to classify the different diseases according to their importance in the country concerned. The analysis of country-specific health statistics is the basis of this step (3).

The Global Burden of Disease Study (79–81) can serve as a database that provides country-specific information. It is the most comprehensive worldwide study describing mortality and morbidity from major diseases, injuries, and risk factors related to health at global, regional, and national levels.

2. Nutrient supply. An important goal of FBDGs is to ensure an optimal supply of nutrients and health-promoting food ingredients for members of the population. The DRVs for the intake of essential nutrients are the basis for defining

optimal supply, and often include guiding values for dietary fiber and tolerable amounts of alcohol. There are DRVs for ~35 nutrients (41, 82). In the past, not all of the essential nutrients were considered in the context of DRVs or FBDGs, respectively. A number of nutrients appear as companion substances for other key nutrients (e.g. essential FAs and amino acids contained in fat and protein, respectively) (41, 83, 84).

Ensuring the supply of as many nutrients as possible is an optimization problem, in which restrictions include energy requirements and the foods available that should be part of the diet due to their other important features, including culinary use. To solve this problem, newer methods of optimization should be applied, such as linear programming (26–28). These have to be applied so that the resulting food composition is as close as possible to the dietary habits of the population (see section 4).

Generally, in establishing FBDGs, the basis for evaluating and optimizing the nutrient supply should be based on nutrient densities and not on absolute nutrient intake for a reference person. Nutrient densities have the advantage that the required nutrient supply follows the energy requirement and that statements can be made independently of body weight and physical activity (2, 85–87).

The priorization of nutrients is important because the supply of certain nutrients could be of higher priority than the supply of others. To identify nutrients of public health importance for the population in a specific country it is recommended to compare habitual intake amounts derived from dietary surveys (see section 4) with the DRVs, use anthropometric and biochemical indicators, and prioritize those nutrients consumed at amounts not in accordance with DRVs and for which there is evidence of an important health relation. Hence, desirable and attainable nutrient intake targets at a population level for the general population or specific groups may be set (3). A focus on nutrients may be particularly important when making recommendations tailored to at-risk populations, such as pregnant women or the elderly (64).

3. Energy supply. One of today's most important nutritional problems is the almost unlimited availability of food for the vast majority of the population, which contributes to the high prevalence of overweight and obesity. Obesity plays a major role in the development of disease and mortality risk (88). It is therefore essential for FBDGs to align the supply of energy through food to the energy expenditure of nonobese individuals.

If the DRVs for energy intake are set too high and the recommended quantities of food are not aligned with the actual requirements, an increase in weight may occur despite the consumption of physiologically important and health-promoting foods (89, 90). To quantify the energy supply that leads to a stable energy balance, reliable data are required to determine energy requirements. The energy requirement depends on body weight, which cannot be influenced in the short term, and on physical activity, which, in turn, can be modified in the short term. Thus, for the development of FBDGs, physical activity data for different populations need to be taken into account.

In communicating FBDGs to the general population, the adaptation of FBDGs to energy supply has to be based on normal-weight reference persons (91). With computer-assisted recording of individual behavior and energy expenditure (wearable physical activity trackers), it should be possible to provide individualized nutritional and physical activity recommendations. The orientation of the FBDGs to individual energy supply is a decisive step to avoid a situation in which the recommended foods supply more energy than is actually required. For this purpose, valid and easy-to-use instruments are needed in order to record the physical activity at the individual level. However, these tools are rarely available or have little validity and reliability to be used as research tools (92–95). Alternatively, individual information on physical activity has to be requested.

A further consideration in energy (and nutrient) supply is the question of whether FBDGs should fully cover the energy requirement, or whether a proportion should be reserved for popular foods that are not classified as health-promoting. These so-called discretionary foods tend to be highly processed foods high in energy, saturated fat, added sugars, added salt, or alcohol, and are otherwise nutrient-poor (e.g., sugar-sweetened beverages and sweets), and thus do not fit into the core food groups of FBDGs (64, 96). The concept of residual energy supply in FBDGs would be an option to incorporate discretionary foods. This would make FBDGs easier to implement and more realistic. However, with such a concept, physically active individuals with a high energy requirement are favored, because their energy requirement is so high that it is not necessary to cover the nutrient requirements beyond the recommended foods and that the additional energy requirements can be partially covered by energy-dense and nutrient-poor foods.

4. Dietary habits and sociocultural preferences. To facilitate acceptance and implementation of FBDGs, the dietary habits of the target population need to be considered. For this purpose, national food-consumption survey data are required, which are available for 20 European countries (97).

FBDGs sometimes result in a conflict between scientific evidence and acceptance as well as feasibility for adoption by target groups. The social, economic, and cultural context in which individuals live may facilitate or hinder their ability to choose and consume foods or dietary patterns that are consistent with FBDGs (98–102). FBDGs should include diverse foods and patterns that are consistent with personal, cultural, and religious preferences and are affordable and available anytime (103). According to our analysis, Ireland is the only European country that considered affordability in their recommended dietary pattern (21).

Ultraprocessed products dominate the food supplies of high-income countries, and increasingly those in middle-income countries (104). In the past, FBDGs (and nutritional

epidemiology) largely ignored food processing and ready-to-consume ultraprocessed products (see "discretionary foods" above). However, changes in cooking, eating, and food-purchasing behaviors make it necessary for FBDGs to deal with these foods (64), such as in the Brazilian (105), Australian (96), and the recently published Flemish FBDGs (106, 107) (published after our search period). A food classification system in which food processing is defined and focused on is needed. It will be more useful in assessing and monitoring dietary patterns and improve understanding of diet-related health effects, and when used as a basis for dietary guidelines, it will also help to identify essential and benign types of food processing and to limit unnecessary and harmful methods (108).

5. Sustainability. Dietary choices link human health and sustainability (109, 110). A focus on health alone is not sufficient because diets consistent with good health today can undermine the well-being of future generations and current food systems jeopardize current and future food production. Thus, it is essential to incorporate environmental and other societal considerations into the definition of a desirable dietary pattern (111–113). Accordingly, Mertens et al. (103) proposed SHARP diets, that are environmentally sustainable (S), healthy (H), affordable (A), reliable (R), and preferred from the consumer's perspective (P). This idea should guide the derivation of future FBDGs.

It is possible to identify dietary patterns that are generally lower in environmental impact**,** consistent with good health, and that represent a substantial improvement in the way people currently eat. The knowledge of broader social and ethical dimensions and how they fit into the understanding of what a sustainable diet looks like is, however, less clear and warrants further research (111).

Environmental and health benefits are achievable by shifting from current Western diets to a variety of more sustainable dietary patterns (114–116). There is consistent evidence indicating that a dietary pattern higher in plant-based foods (e.g., vegetables, fruit, legumes, seeds, nuts, whole grains) and lower in animal-based foods (especially red meat), total energy content, and discretionary foods and beverages is both healthier and associated with a lesser environmental impact (115, 117–119). Because these are the essentials of existing FBDGs, adhering to dietary guidelines (compared with a population's current average dietary pattern) would reduce the environmental impact (103, 117, 119–122).

A number of studies have investigated the environmental impact of habitual eating patterns, dietary recommendations, and theoretical diets. These studies used various indicators such as greenhouse gas emissions, land and agricultural capacity, and primary energy use or water use with the application of Life Cycle Analysis. There are some proposals described in the literature to identify and integrate sustainable foods or dietary patterns (119, 123–126). However, a comparison of the results on evaluating environmental impact of foods is difficult due to considerable differences in the methodologies applied for the calculations (125, 127). A lack of clear metrics and a shared approach to measuring the multiple components of sustainable diets hinder progress toward generating the evidence needed to ensure the credibility of new (qualitative) guidelines (62, 114, 123).

6. Food-borne contaminants. Foods not only contain nutrients but also contaminants that may pose a risk to human health. The protection of the food supply from chemical and nutritional hazards has to be considered one of the most important public health functions for any country (128, 129).

Existing dietary guidelines do not explicitly or quantitatively take into account different food safety hazards (130). Because the contaminants found in food have an impact on health, they were taken into account in the preliminary work for the formulation of the French FBDGs. The optimization work (linear programming) showed the difficulty of identifying a solution that can cover the nutritional requirements of virtually all of the population without increasing the risk associated with exposure to contaminants while remaining within a range of observed food intakes (18).

The TDS has been suggested to be the most cost-effective tool for assessing dietary exposures to a range of potentially hazardous chemicals and intakes of essential nutrients (129). At the European Union level, EFSA is responsible for collecting, analyzing, and summarizing data on food consumption and chemical and biological hazards occurrence and has undertaken harmonization activities (131).

7. Target group segmentation. To achieve desired health outcomes associated with adherence to FBDGs, it is essential that they accommodate population nutrient/energy needs and that they address populations for whom knowledge on diet-health relations is available. Furthermore, strategies to derive FBDGs should be based on preferences and health status and consider the sociocultural influences on lifestyle behaviors (see section 4). To be able to target specific populations, it is necessary to distinguish groups at least by age and sex and specific population groups that are affected by the different problems (5). It is recommended that future nutrition guidelines provide guidance that assists all population groups, including for example those with food allergies or intolerances, vegetarians, and athletes (132). Advances in analytical technologies, data science, molecular physiology, and nutritional knowledge may allow the subgrouping of populations to be refined to a more personal level (133).

8. Individualization. Similar to other public health recommendations, FBDGs are traditionally expressed as general guidelines based on averages of population data. However, individuals differ in the extent to which such FBDGs apply to them—for example, due to their sex, age, anthropometric measurements, health status, or dietary preferences. Scientific development with regard to the data needed as well

as the development in communication technology (134) in recent years have led to the idea that dietary guidelines should accommodate individual requirements.

Strategies to derive individualized recommendations should be based on an individual's status and preferences (67), such as, for example, the desired abstinence from animal products. Furthermore, individual living conditions (e.g., working conditions or physical limitations) should be taken into account when formulating FBDGs for individuals.

In addition, individuals differ in their response to adherence to these recommendations due to different metabolic reactions or genetic make-up (11, 133). The further development of dietary guidelines should consider specific advances such as personalized nutrition (11). The concept of personalized nutrition was developed based on emerging understanding of the interactions between diet, phenotype, and genes on health (135, 136). Combining data on the genome, metabolome, and microbiota is likely to open possibilities for personalized nutrition planning (137). However, the implementation of this concept into practical recommendations still appears complex and is not yet possible (11, 137). A consortium of nutrigenetics experts pointed out that genotype is one class of information that can be used to personalize dietary advice and should be used in combination with the above-mentioned relevant individual variables and conditions (138). van Ommen et al. (133) stated that, on the basis of knowledge of individual conditions and phenotypic and/or genotypic information, experts can design (multiple) decision trees that define which recommendations to follow in specific subsets or in a given personal situation.

Requirements and data sources with regard to identified aspects

In order to be able to consider the aspects identified in parts I and II in the derivation of future FBDGs, the existence of corresponding background data is a basic prerequisite. Examples of available data sources and highlights of research gaps are provided in **Table 4**. Although national data are required for some aspects (e.g., national dietary survey to capture dietary habits), other aspects can be based on internationally available work. For example, evidence on diet-health relations is regularly reviewed in a systematic way by expert groups at an international level. The resulting reports may be used and completed at a country level, avoiding too much duplication of effort (3). Although it is required that data on some aspects, such as diet-health relations, are based on systematically generated meta-evidence, other data such as EFSA's DRVs are generated in a more narrative way. Building and constantly updating a solid scientific evidence base as well as overall database will inform the integration of diet, health, and societal and sustainability issues in FBDGs.

Discussion and Outlook

The evaluation of the scientific background of European FBDGs shows that over the past decade there has been a rapid progression in published concepts for the development of the present FBDGs, whereby the perspective on the underlying aspects has been expanded. However, we found that English publications on the background of most national FBDGs are not available. English information on the scientific basis for FBDGs was found to be available for 15 European countries. The available information shows that the more traditional aspects—diet-health relations, nutrient supply, energy supply, and dietary habits—were considered in the majority of the FBDG concepts. Thus, they also meet EFSA's recommendations (3). The more modern aspects of sustainability, contaminants, target group segmentation, and individualization were not (yet) considered in almost all concepts of European FBDGs. The concept of the recently published Flemish FBDGs, which are not included in the current analysis because they were published after our search period, points to the broader view of healthy and sustainable eating that is necessary for future FBDGs (106, 107).

To develop FBDGs based on scientific evidence for diet-health relations, existing meta-evidence on dietary patterns, food groups, and nutrients could be used, but it is important to evaluate the quality of the evidence. Densities of nutrients of public health importance should be used to optimize the nutrient supply while covering energy requirements and minimizing contaminants with a health-promoting food selection that is as close as possible to the existing dietary habits and preferences of the population. This implies that food processing and ultraprocessed products should be considered by future research efforts and FBDGs. Evidence is available to support target group–specific FBDGs—for example, to take physiologic needs and preferences of different population groups into account. There are also emerging indications to support individualized dietary guidelines. For example, it is possible to consider individual living conditions and lifestyles using existing technologies, but the implementation of personalized nutrition into practical recommendations warrants further research.

National governments have been called to revise current nutrition policy advice and to develop and disseminate FBDGs that also reflect sustainability objectives (111, 150–152, 154). Despite the growing evidence on the need for dietary approaches to integrate health and sustainability objectives, the current work shows that Sweden (17) was the only European country that included environmental sustainability in their FBDG derivation. In addition, sustainability aspects were also considered by the Flemish FBDGs that were published after the current analysis (107). The Health Council of the Netherlands (62) recommended that broad European support should be sought to clear approaches to measure sustainable diets and to develop guidelines for a healthy and ecofriendly diet. Social and ethical dimensions should also be considered. The European Public Health Association has recently suggested that international actors such as WHO should incorporate sustainability into FBDGs and develop accountability mechanisms (156).

A reasonable concept, on which FBDGs are based, strengthens the argument for implementing FBDGs by policy and facilitates the evaluation of the effects of FBDGs, as well as necessary adjustments. Future challenges are to

TABLE 4 Requirements and data sources (examples) for scientific derivation of European FBDGs based on aspects identified in recent concepts and literature[1]

Aspects	Data needed	Data sources (examples, no claim for completeness)			Research gaps, questions
		National	European/regional	Worldwide/international	
Diet-health relations	Evidence assembled in systematic review and meta-analyses; reports of expert groups	• DGE: methodology to systematically evaluate the evidence for prevention of chronic diseases and intake of nutrients (42, 43) • Health Council of the Netherlands (139) • USDA's NEL (140) • 2015–2020 Dietary Guidelines for Americans (141) • Institute of Medicine of the National Academies (142) • Australian Dietary Guidelines—providing the scientific evidence for healthier Australian diets (96)	• Nordic Nutrition Recommendations 2012 (15) and underlying systematic reviews (48–60)	• WHO (143) • WHO eLENA (144) • World Cancer Research Fund (145) • World Obesity Federation (146) • Cochrane Nutrition (74) • Meta-analyses on food groups and risk of chronic diseases (68–72)	• Quality/judgment of meta-evidence (77)
	Health statistics	• Country-specific health statistics		• Global Burden of Disease Study (81)	• Availability for all European countries?
Nutrient supply	Food-consumption data	• National food-consumption surveys • Food-composition tables	• EFSA: comprehensive European food-consumption database and EU menu project (147)	Not relevant	• Availability for all European countries? • Modern technologies such as digital photography to improve accuracy of assessment (137)
	DRVs	Not necessary	• EFSA: DRVs for nutrients (82)	Not relevant	
Energy supply	DRVs/energy requirement on a population level	Not necessary	• EFSA: scientific opinion on DRVs for energy (91)	Not relevant	• Consideration/integration of discretionary foods • Modern technologies such as wearable activity tracker to measure energy expenditure
Dietary habits/ sociocultural preferences	Food-consumption data	• National food-consumption surveys	• EFSA: comprehensive European food-consumption database and EU menu project (147)	Not relevant	• Consideration/integration of ultraprocessed foods
	Budget pattern	• Household budget survey	• European Commission: income support—reference budgets (148)	Not relevant	

(*Continued*)

TABLE 4 (*Continued*)

Aspects	Data needed	Data sources (examples, no claim for completeness)			Research gaps, questions
		National	European/regional	Worldwide/international	
Contaminants	Dietary exposure data	• Total Diet Studies (129)	• EFSA (149)		
Sustainability	Environmental impacts of diet	Initiatives on interrelations between health and sustainability in relation to the diet: overviews can be found in references 150 and 151, a report of the Green Food Project (61), the Food Climate Research Network (152), a project on Metrics, Models, and Foresight For European Sustainable Food and Nutrition Security (SUSFANS) (153), and the final report of the LiveWell for Life project (154) (e.g., the LiveWell for Life project, funded by the European Comission, developed demonstration diets—LiveWell Plates—for France, Spain, and Sweden) (154).			• Harmonizing methodologies applied for measurement and calculations • Identification/determination of key variables used as basis for derivation of FBDGs
	Social and ethical dimensions of diet	• Not available			• Warrants further research
Target group segmentation	Target group–specific (sex, age) DRVs	• Not necessary	• EFSA (82)	• Not relevant	• Applying metabolomics, genomics
	Health problems (e.g., allergies)	• Country-specific health statistics			
	Preferences in food selection (vegetarian, vegan)	• National food consumption surveys	• EFSA: comprehensive European food-consumption database and EU menu project (147)		
Individualization	Individual nutrient/energy requirement, preferences, health problems, metabolic responses	• Applying questionnaires or measurements on individual level	• Food4Me project (155)		• Modern technologies such as wearable tracker to measure individual behavior • Applying metabolomics, genomics

[1] DGE, German Nutrition Society; DRV, Dietary Reference Value; EFSA, European Food Safety Authority; eLENA, electronic Library of Evidence for Nutrition Actions; EU, European Union; FBDG, food-based dietary guideline; NEL, Nutrition Evidence Library.

(re)conceptionalize FBDGs in Europe, to operationalize the aspects to be incorporated in their derivation, and to convert the concepts subsequently into transparent, systematic approaches. In order to operationalize the various aspects to be incorporated in the development of FBDGs, mathematical optimization methods are the preferred approach, because they capture the complexity of the diet as a whole. There are some up-to-date scientific concepts in individual European countries, which can serve as examples and as a basis to derive national FBDGs. For example, the French approach (18) is very recent and comprehensive. It combines various aspects that were also included in other FBDGs, although it lacks sustainability aspects and specific target group segmentation.

FBDGs are important tools to inform policies and promote public health. To facilitate and improve the adherence to FBDGs and to have a real effect on food consumption, FBDGs need to have clear links to food policies that are actually implemented—for example, school and hospital meals, public procurement, advertising regulations, industry standards, etc. Health-promoting structures and living conditions have to be created to change nutrional behavior.

This is the first study, to our knowledge, that provides an overview of the official national FBDGs in Europe and focuses on the underlying scientific concepts in their derivation. The main limitation of this study is that the search was confined to information available in English. Thus, it remains possible that there is additional background information on national FBDGs that was not taken into account.

We hope that this overview and analysis will stimulate the discussion leading to a consensus to conceptualize and operationalize the aspects for the derivation of next-generation FBDGs in Europe. Harmonizing the concepts for scientific derivation would assist regional and national groups in developing FBDGs in a systematic manner, avoiding duplication of effort, and reducing their development costs. Further development of an overall concept of the European FBDGs for the population, certain population groups, and individuals is possible but requires considerable investment in development and implementation. Thereby, the interaction of scientific disciplines and professions is a cornerstone for the development of the FBDGs in order to integrate knowledge from the fields of nutritional and natural sciences, medicine, psychology, sociology, behavioral, and educational sciences. With regard to systematic reviews and meta-analyses, there is scope for more international collaboration on the scientific basis. Given the current experience and requirements for the evaluation of evidence, it would be useful to conduct scientific evaluations centrally, thereby allowing local expert groups to focus on the integration of national data and considerations (Table 4).

Our analysis has identified 8 aspects that are relevant for the derivation of future FBDGs. Mainly, the scientific advancements and the current trend of a more holistic approach have led to the number of aspects to be included in future concepts for the derivation of FBDGs. The different aspects of an optimized concept of FBDGs show that the attainment of an average "optimal diet" can be achieved in different ways. There is a vision that target group–specific and even individualized FBDGs will be able to be produced by using computer programs (modeling methods), which achieve a relative optimum of NCD risk reduction, nutrient supply, energy supply, and sustainability variables while limiting contaminant intakes and deviations from usual dietary habits under the premises of the particular aspects for a specific target group or individual. The aspects that should be considered in the derivation of future FBGDs are complex and it would therefore be useful to concentrate efforts and to have a common concept for the future derivation of European FBDGs. A common concept could serve as a starting point for the derivation of the national FBDGs and be adapted to the specific local circumstances.

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