REVIEW

CURRENT DEVELOPMENTS IN NUTRITION

Food and Nutrition Policy

A Global Analysis of National Dietary Guidelines on Plant-Based Diets and Substitutions for Animal-Based Foods

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ABSTRACT

Discussing plant-based diets and substitutions for animal-based foods in food-based dietary guidelines (FBDGs) can be a key step in making dietary recommendations more sustainable and healthy as well as more inclusive. The existing large-scale evaluations of FBDGs do not assess whether and to what extent countries cover the broad spectrum of plant-based diets and have policy positions on vegetarian diets, including vegan diets, and whether they mention specific plant-based alternatives to milk, dairy products, and meat. The main aim of this state-of-the-art review was to determine whether and how FBDGs provide such information. An overall 95 guidelines and 100 corresponding countries were assessed via an exploratory sequential mixed method. This involved qualitative explorative content analysis of the guidelines, followed by hierarchical cluster analysis. Furthermore, the Balanced Food Choice Index (BFCI) was constructed, which measures the extent to which FBDGs provide recommendations that cover the broad spectrum of plant-based diets, with some or no animal-based products. To explore the correlations between FBDGs' recommendations and ecological and economic country characteristics, ordinary least squares regression was used. It was found that most countries do not provide information to their citizens that cover the broad spectrum of plant-based diets, as indicated by the mean score of the BFCI (33.58 of 100 points). A total of 38 guidelines (40%) contain a position on vegetarian diets. Nearly half (45%) of all FBDGs already mention plant-based alternatives to meat or animal milk. The regressions showed that the BFCI correlates positively with countries' ecological efforts and negatively with the importance of animal-based products in their economies. This study demonstrates considerable information insufficiency in current FBDGs worldwide. FBDGs should provide recommendations for the broad spectrum of plant-based diets and balance the ethical, ecological, religious, and economic aspects that play a role in people's food choice. *Curr Dev Nutr* 2022;6:nzac144.

Keywords: dietary guidelines, nutrition policy, plant-based diet, vegan, vegetarian, sustainability

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Ethical statement: The current article involves a secondary status quo analysis of national food-based dietary guidelines. Our research used only information that is freely available in the public domain. Our research did not involve human participants or animals, human or animal material, or human or animal data in any direct way; therefore, an ethics committee approval was not required.

Supplemental Materials 1–10 are available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/cdn/.

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Abbreviations used: BFCI, Balanced Food Choice Index; EPI, Environmental Performance Index; FBDG, food-based dietary guideline; GDP, gross domestic product; HCA, hierarchical cluster analysis; NNR, Nordic Nutrition Recommendation; OLS, ordinary least squares.

Introduction

National dietary guidelines can be important instruments for establishing healthier and more sustainable diets. They provide dietary advice to citizens as well as to health and nutrition experts, and more important, they form the basis for the development of official health and nutrition policies (1–3). The UN FAO and WHO (4) highlight the need to shift to plant-based diets for environmental and health reasons. They argue that countries should promote this shift through food-based dietary guidelines (FBDGs), among other tools. However, in the past, dietary guidelines have been criticized for omitting or softening advice against certain reputedly unhealthy or unsustainable foods (1, 5–7).

Previous large-scale evaluations of FBDGs by Gonzalez Fischer and Garnett (1), van 't Erve et al. (8), and Herforth et al. (2) showed that governments are lagging in integrating health and sustainability goals into national nutritional guidelines. To achieve this, several strategies are proposed, such as rethinking the existing protein group recommendations to moderate the consumption of animal-based products (1, 2).

Herforth et al. conducted a global review of national dietary guidelines, summarizing the key messages and graphic information of 90 countries. An overall 74% of the guidelines contain key messages about protein-rich food, "which could include meat (53% of countries), poultry (29%), fish (58%), eggs (31%), legumes (41%), and sometimes dairy (9%), nuts/seeds (8%), and insects (only Kenya)." However, 54% refer only to animal-based foods in the protein group, whereas legumes, with or without nuts, are presented as a separate food group in some countries. Van 't Erve et al. agreed that most guidelines recommend mainly animal-based foods in the protein group. Seventy-five percent of the guidelines contain key messages and recommendations on milk and dairy products, which are classified as a separate food group in 64% of the cases and included in the protein category in 31% of the cases (8).

An analysis by Springmann et al. (9) showed the potential of more plant-based guidelines for 85 countries in terms of health and environmental goals. The authors estimated that if citizens followed their countries' FBDGs in their current forms, this would be associated with a reduction in premature mortality from diet-related noncommunicable diseases of ~15% on average and a reduction of food-related greenhouse gas emissions of 13%. Even so, the data show that plant-based diets with just a few or no animal-based products can have much greater potential. The exclusion of all animal-based products would be associated with a reduction in premature mortality of 22% on average and a reduction of food-related greenhouse gas emissions of 82%.

An analysis of 7 FBDGs from around the world argued that adding concrete recommendations for plant-based dairy alternatives to FBDGs could substantially lower greenhouse gas emissions from the dairy food group (10). Compared with dairy and meat, plant-based alternatives can have better ecological footprints and various health benefits (11–13). Such products are intended to replace animal-based products without adjustments to eating habits. However, studies have shown that attention must be paid to the degree of processing and the nutritional value, since animal-based products usually cannot be replaced one-to-one by plant-based substitutes (14–17).

Moreover, discussing plant-based diets in FBDGs can be a key step in making dietary recommendations more inclusive and taking economic and cultural circumstances into account. People need information about plant-based diets, as animal-based products are prohibitively expensive in most regions of the world, especially those with a lack of affordable healthy food (18).

Furthermore, lactose intolerance—which makes it difficult for people to digest cow's milk—affects 68% of the global population and is particularly prevalent in low- and middle-income countries as well as among Indigenous people (19). Regarding this, information is needed about which plant-based foods people with lactose intolerance can choose to meet their nutritional needs when lactose-free products are not available.

Information about the broad spectrum of plant-based diets is required for many people worldwide who follow vegetarian diets for various motivating reasons, such as ethical, social, health, and environmental concerns as well as religious reasons (20, 21). Although numerous studies confirmed that vegetarian diets, including vegan diets, are healthy and sustainable (22, 23), the evidence has also shown that deficiencies can occur when vegetarian diets are not well planned (20, 24). Therefore, relevant information is needed in the FBDGs. Even though FBDGs have a major impact on nutrition policies, very few citizens use or follow them (25, 26). This underlines the importance of enhancing recommendations to increase their relevance to a greater number of people.

Nevertheless, the existing analyses do not assess whether and to what extent different countries have a policy position on vegetarian diets and whether they mention specific plant-based alternatives to milk, dairy products, and meat. Of all the analyses, only Baroni (27) looked at vegetarianism in the dietary guidelines and just in the United States, Canada, Australia, and the United Kingdom. An international overview is therefore urgently needed. In this way, possible action areas and best practice examples can be identified, which can form the basis for enhanced FBDGs and for discussions about FBDG development. To this end, the extent to which FBDGs provide recommendations that cover the broad spectrum of plant-based diets was assessed. Another aim of the study was to examine if there are structural biases in dietary recommendations due to various country characteristics. Moreover, this study aimed to understand how ethnic differences in lactose tolerance and cultural preferences for certain foods are considered and taken care of.

The remainder of the article is structured as follows: the Methods section describes the mixed method approach of the status quo analysis of FBDGs and the guidance that they offer in terms of balanced food choices. This involves a qualitative explorative content analysis of the guidelines, followed by a quantitative global evaluation. The Results section discusses the status quo, covering individual aspects of guidance on plant-based diets and making overall assessments by introducing the Balanced Food Choice Index (BFCI). It also discusses statistical associations of the BFCI with country characteristics. In the final section, these results are discussed and conclusions are made with regard to further research and reaching out to multipliers, civil society, industry, and the political sphere.

Methods

An exploratory, sequential, mixed method design was used that started with the collection and analysis of qualitative data and then the collection and analysis of quantitative data (28).

Definitions

There are several definitions of plant-based diets (29). This study used the following definition to describe plant-based diets: "a wide spectrum of dietary patterns which emphasize plant products, such as fruits and vegetables, wholegrains, legumes, nuts and seeds and [plant-based] alternatives and limit or exclude animal-derived products" (29). The spectrum thus includes omnivorous diets that contain small amounts of animal-based products, such as meat, fish, dairy, and eggs, as well as vegetarian diets. Vegetarian diets can be further divided into the following types: a lacto-ovo-vegetarian diet, which includes dairy products and eggs; a lacto-vegetarian diet, which includes dairy products but is free from eggs; an ovo-vegetarian diet, which includes eggs but is free from dairy products; and a vegan diet, which is free from any animal-based products (20, 24, 30). When talking about sustainable healthy food choices, we refer to the 16 guiding principles of the WHO and FAO (4) for sustainable healthy diets. These principles comprise health aspects, environmental impact, and sociocultural aspects. In terms of

specific food choices, the recommended foods "include wholegrains, legumes, nuts and an abundance and variety of fruits and vegetables" and "can include moderate amounts of eggs, dairy, poultry and fish; and small amounts of red meat." Furthermore, plant-based substitutes to animal-based products, also called plant-based alternatives, were defined as products that are very similar to the respective animal-based products in terms of use—for instance, soy milk as an alternative to animal milk or textured vegetable protein as an alternative to meat products. By "plant-based foods," the wide spectrum of unprocessed and processed plant foods made from fruits, vegetables, grains, legumes, or nuts was meant.

Data set

The data set consists of 95 guidelines and 100 corresponding countries, including states and some subnational regions. As a starting point, an overview from the FAO was used, which listed 96 countries with dietary guidelines, linking to the corresponding documents and institutional websites. In some cases, the current guidelines were not linked on the FAO website. If a more recent guideline was found during the Google web search (data collection: June 1, 2020–March 31, 2021), the newer version was used for the evaluation. The search terms used were as follows: Dietary Guideline "country name." The literature review was conducted in English and, if necessary, in the official language of the country. Only guidelines and recommendations for the general population were evaluated, not those designed for specific target groups; this is why Cambodia (listed on the FAO website) was excluded, which has a dietary guideline just for schoolchildren.

Google Translate and DeepL were used for guidelines that were unavailable in English, Spanish, or German. Nevertheless, 8 FAO-listed guidelines were excluded from the evaluation due to language barriers: Bosnia and Herzegovina, Croatia, Estonia, Hungary, Iran, Lithuania, Romania, and Vietnam. In addition, 9 guidelines not listed by the FAO were evaluated: from the Nordic Council, which is an official interparliamentary body in the Nordic Region, and from Slovakia, Luxembourg, Pakistan, Qatar, Russia, China (Hong Kong), Saudi Arabia, and the Arab Food Dome, which applies to 11 countries. This resulted again in a collection of 95 guidelines in total. This process is shown as a flow diagram in **Figure 1**. A complete list of analyzed guidelines and their sources is presented in **Supplemental Materials 1 and 2**.

Qualitative analyses

To our knowledge, no global overview of the different countries' positions on vegetarian diets currently exists. To close this research gap and identify possible action areas, we started with a qualitative content analysis as described by Mayring (31), which is particularly suitable for exploring new phenomena. The analysis was conducted with 3 separate investigators: 2 of the authors and 1 additional researcher who analyzed the guidelines in Spanish (see Acknowledgments). The guidelines were reviewed in an open inductive manner, and the results were discussed among the 3 investigators to obtain a consensus. Thereafter, a category system was developed and discussed. A consensus was reached about the following 6 categories: none, neutral recommendations, health benefits, ecological sustainability, risks highlighted, and advise against (see **Table 1** for explanation). Since the positions on vegetarian diets were relatively brief in most FBDGs, the category system was not made more detailed. As such, commonalities and differences can be discussed among meaningful numbers of positions.

Quantitative analyses

The overall question that this study explores is whether national dietary guidelines provide recommendations for the broad spectrum of plant-based diets and information on plant-based alternatives (research objective 1). During the qualitative analysis, the question arose if there are structural biases in dietary recommendations due to country characteristics such as economic development level and particular economic interests (research objective 2). Furthermore, we asked whether environmental efforts influenced current recommendations in the dietary guidelines (research objective 3). Based on the results of the qualitative analysis, 3 hypotheses were formulated and tested via the quantitative analysis:

Hypothesis 1: FBDGs in their current form do not encourage sustainable healthy food choices.

Hypothesis 2: The economic importance of animal-based foods, measured by their share of the gross domestic product (GDP), correlates negatively with FBDGs providing guidance that covers the broad spectrum of plant-based diets.

Hypothesis 3: Ecological efforts are positively correlated with FBDGs providing guidance that covers the broad spectrum of plant-based diets.

Hierarchical cluster analysis.

Based on the categorizations obtained in the qualitative content analysis, a hierarchical cluster analysis (HCA) was conducted as inspired by Zhang et al. (32) and Zolfaghari et al. (33). This analysis was performed to identify systematic similarities and differences in countries' positions on vegetarian diets. A distinction is made between strategies in HCA: the agglomerative and the divisive. In this study, agglomerative hierarchical clustering was used, which is also called the "bottom-up" approach since each object starts as a single-element cluster. Step by step, the algorithm brings together pairs of clusters that are the most similar and combines them into a new, bigger cluster. The results can be visualized with a tree-based representation called a dendrogram (**Supplemental Material 8**).

For distance measurement, Euclidean distance combined with Ward's algorithm was used to create clusters with high homogeneity. This method, also known as the "minimum variance method," combines 2 clusters that produce a minimum increase in variance into the next new cluster and so on. It is determined by evaluating the sum of squared deviations from the mean of a cluster. This means a minimal increase in the error sum of squares due to the clustering. Ward's method is not only the most commonly used algorithm but is also considered very effective (33).

Each FBDG was counted as a country's position. When an FBDG was used by multiple countries, as with the Arab Food Dome, for example, it was used for each country unless a country had its own FBDG. This resulted in the addition of Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, and Yemen to our data set. The Nordic Nutrition Recommendations (NNRs) similarly apply to several countries. However, since every

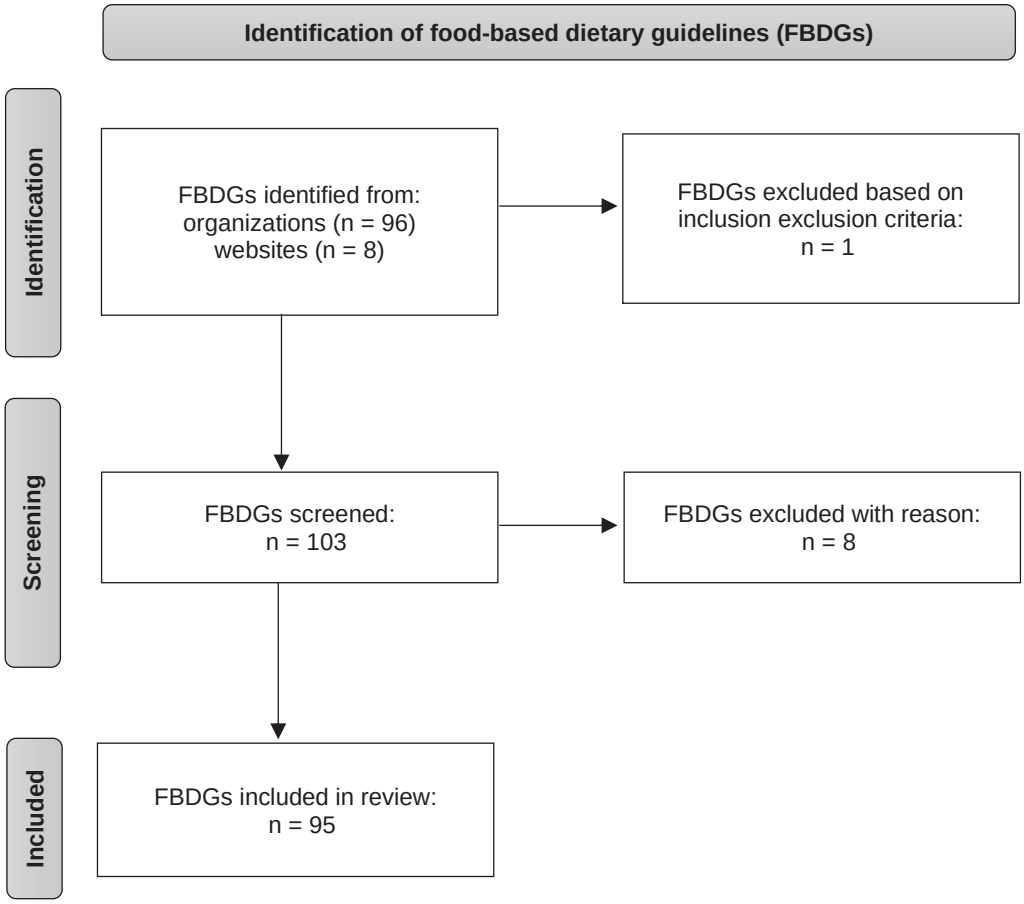

FIGURE 1 PRISMA flow diagram (75) of the process for selecting food-based dietary guidelines (FBDGs) for the analysis. The excluded FBDGs were Bosnia and Herzegovina, Cambodia, Croatia, Estonia, Hungary, Iran, Lithuania, Romania, and Vietnam.

Nordic country has its own FBDG, this FBDG was excluded from the HCA. This resulted in a sample of 100. Furthermore, the text passages that contain statements on vegetarian diets were analyzed in detail. For this step, the category system from the qualitative part of the study was used for the development of items. This resulted in 6 binary-coded variables that correlate with the categories of the qualitative content analysis (Table 1). The optimal number of clusters was set at 4 because, with this number, the clusters were the most homogeneous and could be distinguished the most clearly. For the HCA, the statistics software R (version 4.1.0) was used.

Plant-based alternatives.

Guidelines were analyzed that mentioned plant-based alternatives to meat, milk, and dairy products. Alternatives to meat include but are not limited to seitan, tempeh, tofu, textured vegetable protein, falafel, and processed veggie meat. Milk alternatives include all plant milks, such as soy and oat milk. Alternatives to dairy products include plant-based cheese and yogurt, such as nut cheese and soy yogurt, but also tofu, which is often mentioned as a dairy alternative. For these 3 categories of foods, a binary coding set was used: 1 when they were mentioned in the FBDGs or 0 when they were not.

Balanced Food Choice Index.

The BFCI was developed to measure the extent to which existing dietary guidelines encourage sustainable healthy food choices that can but do not have to include animal-based products. The word "balanced" was used not only to refer to varied food choices but also to indicate that FBDGs should balance the ethical, ecological, religious, and economic aspects that play a role in people's food choices. Therefore, FBDGs with balanced food choices were defined as FBDGs that provide nutrition information that covers the broad spectrum of plant-based diets. Indices can be a helpful tool for policy makers to identify best practices and learn from the experience of other countries. They are critical tools for data-driven policy making and help to prioritize reform areas and maximize impact (34).

The BFCI consists of 10 indicators and 17 variables based on their importance in promoting sustainable healthy food choices and providing nutrition information that covers the broad spectrum of plant-based diets (**Table 2**).

There were 2 central methodological selection criteria for the underlying indicators. First, all variables stem from existing recommendations of the 95 FBDGs that were analyzed. Second, international cross-country comparability must be possible. To increase construct validity, 5

TABLE 1 Operationalization–category system for countries' positions on vegetarian diets[1]

Category	Definition	Example
None	Guidelines do not deal with the topic of vegetarian diets at all	FBDG Mexico, 2015
Neutral recommendations	Text passages offer neutral recommendations for people who follow vegetarian diets—for example, advice on how to cover critical nutrients when consuming no or few animal-based products	"Those following a strict vegetarian or vegan diet can meet nutrient requirements as long as energy needs are met and an appropriate variety of plant foods are eaten throughout the day. Those following a vegan diet should choose foods to ensure adequate intake of iron and zinc and to optimise the absorption and bioavailability of iron, zinc and calcium. Supplementation of vitamin B12 may be required for people with strict vegan dietary patterns" (FBDG Australia, 2013)
Health benefits	Text passages point out the preventive potential of vegetarian diets in terms of noncommunicable diseases such as obesity, heart disease, and type 2 diabetes	"People choose to follow a vegetarian diet for a variety of reasons. Well-planned vegetarian diets can be both nutritious and healthy. These have been associated with a lower risk of heart disease, type 2 diabetes, obesity and certain types of cancer, and lower blood cholesterol levels." (FBDG South Africa, 2013)
Ecological sustainability	Text passages point out the lower resource usage and/or lower greenhouse gas emissions of vegetarian diets vs. animal-based diets	"Eating vegetarian or vegan is good for the environment. In the Netherlands, food is responsible for 20 to 35% of all greenhouse gas emissions. More than half of these emissions come from meat and dairy. If you stop eating meat and replace it with legumes, nuts and eggs, you will reduce your greenhouse gas emissions by approximately one third." (FBDG Netherlands, 2018, translated from Dutch)
Risks highlighted	Text passages highlight the risks of vegetarian diets	"Vegans eat a purely plant-based diet and abstain from all foods of animal origin. Such a diet lacks vitamin B12, which is exclusively contained in products of animal origin. Furthermore, in the long run, a lack of mineral salts such as calcium, zinc and iron, as well as essential fatty acids can occur if meals are not properly composed. Vegans only live healthy lives if they regularly take food supplements." (FBDG Luxembourg, 2016, translated from German)
Advise against	Guidelines advise against some forms of vegetarian diets	"Consumers can do a lot for their health and the environment through their food choices. In particular, preferring a diet with a strong plant-based component, but without giving up that small share of animal products to avoid specific deficiencies, is essential to protect health and the environment at the same time." (FBDG Italy, 2018, translated from Italian)

[1] FBDG, food-based dietary guideline.

individuals were consulted whose work relates to the spectrum of plant-based diets. They were from different academic disciplines and had different backgrounds, and they were asked to provide an assessment of the weighting and to confirm that the index measures what it is supposed to measure. To maintain objectivity, only individuals who were not otherwise involved in the research project were consulted. The specific backgrounds were as follows: 1 person from South America with an academic background in public health, 1 person from East Africa with an academic background in development studies, 1 person from Eastern Europe with an academic background in cultural studies, and 2 persons from Western Europe with academic backgrounds in nutrition and food science. The indicator weights were assigned through the analytic hierarchy process. In this process, researchers consult people who are very knowledgeable in a particular area to assign relative importance to indicators (35). To decide among the different opinions, the quality of the justifications for the relative importances was considered. A pairwise comparison was made between the criteria, with 7 levels "ranging from 'equally important' to 'much more important' representing how many times more important one criterion is than another" (36). Three of the 5 respondents viewed food groups as having the most relevance for the index, whereas 2 respondents viewed plant-based alternatives for meat, milk, and dairy products as being the most relevant. The researchers

TABLE 2 Indicators and their weights in the Balanced Food Choice Index[1]

Indicator	Coding Rule	Weight[2]
No food group that includes only meat, fish, and/or eggs	Do all food groups that include meat, fish, and/or eggs also include ≥1 plant-based foods?	18
No food group that contains only dairy	Do all food groups that include dairy foods (milk or milk products) also include ≥1 plant-based foods?	18
Plant-based food sources for critical nutrients of plant-based diets	Does the guideline mention ≥1 plant-based food as a source of protein, iron, calcium, zinc, or omega-3 fatty acids?	≤15 points, 3 for each nutrient
Recommendations on how to obtain vitamin B-12 without animal-based foods	Does the guideline say that diets without or low in animal-based products require B-12 supplementation?	5
Plant-based meat alternatives	Does the guideline text mention/do the guideline graphics (food pyramids, plates, etc.) display ≥1 plant-based meat alternative and present it as a possible alternative?	≤6 points, 3 each for inclusion in texts and graphics
Plant-based milk alternatives	Does the guideline text mention/do the guideline graphics (food pyramids, plates, etc.) display ≥1 plant-based milk alternative and present it as a possible alternative?	≤6 points, 3 each for inclusion in texts and graphics
Plant-based dairy alternatives	Does the guideline text mention/do the guideline graphics (food pyramids, plates, etc.) display ≥1 plant-based alternative to dairy products (e.g., yogurt and cheese) and present it as a possible alternative?	≤6 points, 3 each for inclusion in texts and graphics
Recommendations on vegetarian diets	Does the guideline mention a form of a vegetarian diet and give any nutritional guidance about it?	12
Health benefits of vegetarian diets	Does the guideline point out the preventive potential of vegetarian diets in terms of noncommunicable diseases such as obesity, heart disease, and type 2 diabetes?	9
Environmental sustainability benefits of vegetarian diets and/or plant-based foods	Does the guideline point out the lower resource usage and/or lower greenhouse gas emissions of vegetarian diets or plant-based foods vs. animal-based diets?	5
Potential sum		100

[1] "Guideline": any official document or web application that provides food-based dietary guidance for people in the general population (healthy adults who are not seniors, pregnant, or lactating). "Food group": the guidelines' largest unit of food grouping. "Plant-based alternatives": products that are very similar to their respective animal-based products in terms of use.
[2] Full points if *yes*, zero points if *no*.

were in agreement with the majority of respondents, as food groups are part of the basic structure of an FBDG and therefore have a much greater impact on food choices. For the remaining indicators, an average of the respondents' opinion with the researchers' assessment was attempted. The weightings were scaled so that the total BFCI takes values from 0 (least balanced) to 100 (most balanced). The final weightings are detailed in Table 2. Potential sources of uncertainty can be attributed to various procedures used in the development of the index, including the selection of individual indicators, normalization, and weighting. Any change in these processes affects the BFCI value. A number of weightings were tested to check the robustness of the results. It was found that although the calculated index values change, the key message of the index remains the same. Even with different weightings, on average the same countries were found in the upper, middle, and lower fields of the index. Thus, the BFCI appears to be robust with regard to measuring the extent to which existing dietary guidelines encourage sustainable healthy food choices and cover the broad spectrum of plant-based diets.

A detailed description of the BFCI development process and its theoretical framework and method is presented in the **Supplemental Material 10**, which uses the OECD checklist (36) for building composite indicators.

Regression analyses.

To explore the correlations between FBDGs' orientation on balanced food choices and several country characteristics, ordinary least squares (OLS) regression was used, a form of linear regression analysis (37). The previously developed BFCI was used as the response variable, with a total of 5 explanatory variables. Because there was often not enough data available for the 100 countries, as there were too many missing data points, the choice for explanatory variables was limited. For the regressions, all OLS inference assumptions (classical linear assumptions) were verified: linearity in parameters, random sampling, sample variation in the regressors, zero conditional mean, homoskedasticity, and normality of the residuals. All 6 assumptions in

all models were met, with the exception of model 3, which displayed some heteroskedasticity. Therefore, heteroskedasticity-robust (Huber-White) SEs were used for this model and regular SEs for the other models.

Explanatory variables.

EPI indicates healthy environments and thus provides a proxy variable for the extent to which governments prioritize environmental policy. The variable indicates a country's score on the Yale/Columbia 2020 Environmental Performance Index (EPI) (38).

Meat Production measures the importance of the meat industry for a country's economy. It is the monetary value of meat produced divided by the GDP, expressed as a percentage. Both values were taken from 2016 and expressed in contemporaneous US dollars. The data were obtained from the FAO (39) and the World Bank (40), respectively.

Dairy Production measures the importance of the milk and dairy industry for a country's economy. It is the value of milk produced divided by the GDP, expressed as a percentage. Both values were taken from 2016 and expressed in contemporaneous US dollars. The data were obtained from the FAO (39) and the World Bank (40), respectively.

Last Update FBDG indicates the year of the last update and thus how recent a guideline is. By extension, a lower Last Update FBDG value indicates a longer update cycle and thus perhaps smaller government budgets or lesser focus on nutrition. The years as whole numbers were taken from the documents. In most cases, the last update year was identical for all parts of a dietary guideline. If not, the years of the individual documents or web applications were averaged, which yielded decimal fractions in a handful of cases. For example, Brazil's guideline consisted of a 2014 and a 2019 document, yielding a value of 2016.5 (Supplemental Material 2).

Page Length FBDG is a proxy for how detailed a country's dietary guideline is. It measures the number of PDF pages (A4/letter size) of the dietary guideline or the approximate equivalent if the guideline was in a different format. Apart from the level of detail, the page length can vary due to different spacing and use of nontext pages (e.g., contents, editorials by ministries, appendices). Even so, it is the most straightforward way to measure the level of detail. The page length was transformed by taking the square root to meet the OLS inference assumption of normally distributed residuals. Prior to the square root transformation, model 2 failed this assumption, as indicated by Shapiro-Wilk and Kolmogorov-Smirnov tests. In this model, the Page Length variable had a positively skewed distribution. Normalizing Page Length by applying the square root was the simplest transformation possible that also gave us normality of residuals for all models (41).

Last Update FBDG and the square root of Page Length FBDG were used as control variables in all models. A lower and thus less recent Last Update indicates a longer update cycle and may imply less or outdated evidence in relation to plant-based diets. Cases that had $\geq$1 missing value were removed from the regressions. The significance level (alpha) was set to 0.05 for the statistical analyses. As mentioned, Kolmogorov-Smirnov and Shapiro-Wilk tests were performed for the normality of the residuals of all models. The tests all returned P values >0.05, indicating that all models met the normality assumption. IBM SPSS Statistics 26 and Stata/IC 16.1 were used.

Results

In this section, the quantitative and qualitative results of the study are presented. Most of the data are accessible via **Supplemental Materials 3 and 4**, which contain the data set of all 100 countries and the summary statistics of the data set, respectively.

Qualitative results

A total of 95 guidelines were analyzed, of which 38 (40%) contained a position on vegetarian diets. Within these positions, 6 main aspects were identified per Mayring's (31) category system for qualitative content analysis. These are presented in turn. For the description and interpretation of the data, additional literature was used, which is a common practice when using this analysis method.

None.

Most guidelines without a position on vegetarian diets (n = 57) came from countries in the FAO world region Latin America and the Caribbean (26 guidelines). Nevertheless, some of these guidelines contained recommendations on ensuring an adequate supply of certain nutrients even without animal-based products. Mexico, for example, explains how a combination of legumes and cereals can cover one's essential amino acids needs:

> "*Legumes are seeds that are part of the "animal and legume" food group. They are high in protein, carbohydrates, fiber, vitamins, and minerals such as iron, copper, calcium, carotenoids, vitamin B1, niacin and folates. They also have no fat, sugar or salt. Since they are usually low in an amino acid called methionine (essential amino acid), it is recommended to supplement them with cereals (eat them together) that are rich in lysine (another essential amino acid) to improve the protein consumed when eating them together (e.g. beans and corn, lentils and rice, etc.).*" (FBDG Mexico, 2015, translation from Spanish)

Canada is another example with no explicit position on vegetarian diets. However, the design makes it theoretically possible to follow the guideline with several dietary patterns, including vegetarian ones. In 2019, Canada (42) dropped the milk food group from its updated guidelines, moving cow's milk to the protein group, which includes fortified soy drinks, tofu, pulses, nuts and seeds, and other animal-based products such as meat and fish. Daily consumption of milk and meat is no longer recommended, and instead, an increased intake of plant proteins is suggested: "*Choose protein foods that come from plants more often. Plant-based protein foods can provide more fibre and less saturated fat than other types of protein foods. This can be beneficial for your heart health*" (FBDG Canada, 2019). Nevertheless, Canada lacks explicit recommendations for adequate vitamin B-12 supply without the consumption of animal-based products.

Most dietary guidelines in the African and Middle East regions lack recommendations on diets with few or no animal-based products, even though 16% of people in these regions are vegetarian and 6% are vegan (21). Sierra Leone's FBDG, for example, makes it impossible to follow vegetarian diets. Meats, fish, poultry, and eggs are grouped as a single food group, without a mention of plant-based food or plant-based alternatives. According to the guideline, this food group should be consumed daily: "*Key Message: Eat either fish, poultry, meat, milk or eggs every day*" (FBDG Sierra Leone, 2016).

Yet, it should be noted that only 9 of 54 African countries have a guideline at all, the lowest share of all FAO regions: 7 have a national guideline—Benin, Kenya, Namibia, Nigeria, Seychelles, Sierra Leone, and South Africa—whereas Algeria and Egypt use the supranational Arab Food Dome guideline.

Neutral recommendations.

Most of the guidelines that had a position on vegetarian diets contained neutral advice on covering certain nutrients with plant-based sources. Guidelines such as those from the United Kingdom, Australia, Belgium (Flemish), Lebanon, Malaysia, and Malta point out that all nutrients can be obtained from a vegetarian diet, including a vegan diet, by combining different foods and consuming sufficient calories.

> "*With good planning and an understanding of what makes up a healthy, balanced vegan diet, you can get all the nutrients your body needs. If you do not plan your diet properly, you could miss out on essential nutrients, such as calcium, iron and vitamin B12.*" (FBDG UK, 2018)

The literature mentioned several nutrients that need special attention in vegetarian diets, especially vitamin B-12, but also iron, zinc, calcium, vitamin D, omega-3 fatty acids, and protein (24). Some of these nutrients, but not all, are mentioned in the FBDGs. Malta and Luxembourg referred to only some of the relevant nutrients, whereas Belgium (Flemish), Iceland, the United Kingdom, Saudi Arabia, and Slovenia mentioned several relevant nutrients and explain how to cover nutrient requirements with plant-based foods. For example, they stated that calcium is found in green, leafy vegetables such as broccoli, cabbage, and okra.

> "*Even without the intake of milk and milk products, you can get enough calcium. Plant-based sources of calcium include certain vegetables, legumes, and whole grains. Drinking water can also contribute to calcium intake. Do you buy plant-based (milk) substitutes? Then choose the fortified varieties with calcium, vitamins B2, and B12.*" [FBDG Belgium (Flemish), 2017, translation from Flemish]

To obtain iron, these countries recommended eating pulses, wholemeal bread, and flour. For vitamin B-12, they recommended supplements, fortified breakfast cereals, and fortified soy drinks. Vitamin B-12 is the most frequently mentioned nutrient in the positions on vegetarian diets. Another nutrient often mentioned is protein, as is the case in Greece: "*If for any reason you do not consume meat, for example during fasting, or if you follow a vegetarian diet, as an alternative source of protein opt for a variety of legumes and nuts and combine them with cereals*" (FBDG Greece, 2014, translation from Greek).

Lebanon pointed to the combination of different plant-based protein sources, such as legumes and nuts, and gave recommendations on how to increase the bioavailability of iron: "*Vegetarians are advised to increase the bioavailability of iron from plant sources by adding vitamin C-rich food items (such as lemon or orange juice, kiwi, and green peppers) to meals*" (FBDG Lebanon, 2013).

Qatar explained what a healthy vegetarian diet should look like:

> "*One cannot be a healthy vegetarian by going to a fast food restaurant and ordering french fries and soda! Vegetarians can meet their nutrient needs by choosing a variety of meat alternatives such as beans, lentils, eggs, tofu, soy-based meat substitutes, nuts, nut butters and seeds.*" (FBDG Qatar, 2015)

In addition, Greece, Israel, Lebanon, and Brazil suggested seeking the advice of a dietician or medical staff when following a vegetarian diet, especially one that completely avoids animal-based products.

Health benefits.

Several FBDGs highlighted the health benefits of vegetarian diets. This includes countries from all regions of the world. Some of them—such as Australia, the Netherlands, the Nordic Council, Norway, Portugal, Saudi Arabia, South Africa, Sri Lanka, and the United States—stated that well-planned vegetarian diets are healthy and nutritionally adequate: "*A well-planned vegetarian diet is healthy, adequate, and may be beneficial for health, particularly in the prevention and treatment of some diseases*" (FBDG Portugal, 2003, translated from Portuguese).

> "*There are great health benefits from eating lots of vegetables, fruits, beans, lentils, whole grains, and other foods from the plant kingdom. A plant-based diet is associated with a lower risk of, among other things, high blood pressure, obesity, cardiovascular disease, diabetes, and cancer. With good knowledge and planning, both vegetarian and vegan diets can be suitable for people in all phases of life, including during pregnancy and breastfeeding, for infants, for children, and adolescents and for athletes.*" (FBDG Norway, 2020, translated from Norwegian)

The lower risk for noncommunicable diseases—mainly cardiovascular disease, type 2 diabetes, obesity, and cancer—compared with that of nonvegetarian diets is stated in most guidelines.

> "*In general, research indicates that vegetarian diets are associated with lower risk of chronic diseases such as CVD, type 2-diabetes, and obesity. In addition, vegetarians often have lower blood-lipid levels and lower blood pressure, and are likely to live longer.*" (FBDG Nordic Council, 2014)

The evidence showed that the health benefits of vegetarian diets are mainly driven by higher dietary fiber intake and lower fat intake when compared with nonvegetarian diets (24). These aspects are discussed in some guidelines:

> "*Plants are mostly rich in dietary fibre and low in fat and energy. None of them contains cholesterol. Thus they help prevent constipation and increase our sense of fullness without adding too much burden to our weight and cholesterol level. Fruit, vegetables and legumes are also excellent sources of antioxidants and phytochemicals which can strengthen the immunity and reduce risks of chronic diseases.*" [FBDG China (Hong Kong), 2018]

Besides the dietary influence, FBDGs from the Nordic Council, Saudi Arabia, Slovenia, Germany, Switzerland, the Netherlands, and Finland mentioned that the healthier lifestyle of many vegetarians is a factor in terms of better health status: "*The better health of vegetarians is partly explained by the fact that they move more and smoke less than the mixed-food population in general*" (FBDG Finland, 2014, translated from Finnish).

Ecological sustainability.

Eight guidelines highlighted the ecological sustainability of plant-based diets as compared with diets rich in animal-based products: Bolivia, Brazil, Denmark, Finland, the Netherlands, New Zealand, the Nordic

Council, and Sweden. They also pointed out that sustainability is an important aspect of nutrition generally.

> "*Food supplies and dietary patterns based on rice, beans, corn, cassava, potatoes, vegetables and fruits are socially beneficial. They encourage family farming and local economies, and living and producing in solidarity. They also promote biodiversity and reduce the environmental impact of food production and distribution. Reduced consumption and thus production of animal foods will reduce emissions of the greenhouse gases responsible for global warming, of deforestation caused by creation of new grazing areas for cattle, and of intensive use of water. It will also reduce the number of intensive animal production systems, which are particularly harmful to the environment.*" (FBDG Brazil, 2014)

In 1981, Brazil (43) had already legally recognized the importance of the environment as a basis for well-being in its National Environmental Policy. Gonzalez Fischer and Garnett (1) identified sustainability as a cross-cutting theme in the Brazilian FBDG. Brazil's guideline not only recommends a diet based on plants and minimally processed foods but also thoroughly explains the environmental and social impacts of animal-based foods.

FBDGs from the Netherlands, the Nordic Council, and Sweden pointed to the lower environmental impact of vegetarian diets, especially when all products of animal origin are excluded:

> "*Eating vegetarian or vegan is good for the environment.*" (FBDG Netherlands, 2018, translated from Dutch)

> "*Those who choose a diet with less meat and dairy products have even less of an impact on the climate than those eating the present average diet. With a general vegan diet, it is possible to halve the climate impact from what we eat.*" (FBDG Nordic Council, 2014)

> "*A vegan diet, where all foods of animal origin are excluded, has the lowest climate impact.*" (FBDG Sweden, 2015)

> "*Vegan and vegetarian diets have, among other things, significance for the climate impact of diet. Vegan diets generally provide the greatest reduction in climate footprint, followed by vegetarian diets and plant-rich diets with less meat and dairy products.*" (FBDG Denmark, 2021, translated from Danish)

It is notable that most Nordic countries mentioned ecological sustainability aspects when it comes to vegetarian diets. These countries have developed a common scientific basis for national nutrition recommendations, the NNRs, published by the Nordic Council. The Nordic Council (44), the official body for cooperation among the Nordic countries, states on its website, "Our vision is to make the Nordic region the most sustainable and integrated region in the world." Besides recommendations for a healthy diet, the NNRs (45) included a whole chapter on sustainable food consumption, which gave "a short overview of the major issues recognized in connection with food consumption and its environmental impact." The NNRs pointed to the fact "that no food group affects the environment as much as the production of meat and dairy products, and their effect on the climate contributes to almost half of the present climate impact from food consumption in the Nordic countries." All 5 Nordic Council member states (Denmark, Finland, Iceland, Norway, and Sweden) had individual guidelines but also referred to the NNRs. However, Norway and Iceland were exceptions. Norway's FBDG did not discuss the environmental sustainability of vegetarian diets, whereas Iceland (46) did but took an unusual approach: it did not describe vegetarian diets as sustainable but defined a sustainable diet as a diet "where a lot of plant-based foods are consumed but also something from the animal kingdom, meat, eggs, fish and dairy products, although this may not be classified as a plant-based diet" (translated from Icelandic).

Risks highlighted.

Many FBDGs described how to obtain critical nutrients on vegetarian diets without going into detail about possible risks. In contrast, the risks of vegetarian diets are highlighted in 8 guidelines (Argentina, Germany, Indonesia, Italy, Luxembourg, Paraguay, Slovenia, and Turkey), with vitamin B-12 deficiency being the most frequently mentioned risk: "*Vitamin B12 is important for blood formation, and its lack can also cause anemia. This can occur in people who are strict vegetarians, who do not consume meat, eggs, or milk*" (FBDG Paraguay, 2013, translated from Spanish).

Paraguay offered no information for people on vegetarian diets (e.g., that they should supplement vitamin B-12). Furthermore, Paraguay asserted that soy milk is not an adequate substitute for cow's milk:

> "*It is important to know that consuming a cup of soy juice, also misnamed as "soy milk," is not the same as drinking a cup of cow's milk because soy juice does not contain the necessary amounts of nutrients, mainly the amount of calcium, to cover the needs of the organism. Therefore, it is always better to consume cow's milk if it is available.*" (FBDG Paraguay, 2015, translated from Spanish)

Another example is Slovenia's FBDG. The authors discussed "normal" diets compared with vegetarian ones and warned of great dangers when following a vegetarian diet:

> "*It should be noted, however, that due to the specifics of the vegetarian diet, individuals must more carefully control the adequate intake of nutrients, as otherwise very serious diseases of deficiency can occur. There is a particularly great danger of this when an individual with a normal diet decides to make a change simply by completely removing foods of animal origin from their diet and only increasing the consumption of plant foods that they have been accustomed to previously. Such a reckless transition can lead to too low protein and micronutrient intake, especially in more severe forms of vegetarianism, and therefore poses a serious health risk.*" (FBDG Slovenia, 2015, translated from Slovene)

Italy presented vegetarian diets as risky and stated that health-motivated vegetarians misunderstand the scientific recommendations for increasing one's consumption of plant-based foods:

> "*The choice of this diet [vegetarian diet] is generally linked to ethical or environmental issues. It has become a fashion for alleged health reasons because the importance of a high quantity of plant-based foods is misunderstood with the need to exclude a part of animal-based foods.*" (FBDG Italy, 2018)

The Indonesian and Slovenian FBDGs presented a special case. They compared the risks and benefits of vegetarian diets and gave concrete recommendations on how to cover critical nutrients. Therefore, they were categorized as "risks highlighted" as well as "neutral recommendations" and "health benefits": "Note the advantages and disadvantages (of different vegetarian diets). Learn how to overcome the risk of nutritional deficiencies that might happen" (FBDG Indonesia, 2017, translated from Indonesian).

Advise against.

Only 4 guidelines worldwide advised against vegan diets, a form of vegetarian diet that excludes all animal-based products. These are the FBDGs from France, Germany, Italy, and Switzerland, which are neighboring countries in Europe. Their main point was that a healthy diet should consist of a variety of foods, which should always include animal-based foods.

Although all 4 countries rejected vegan diets, they did accept ovo-lacto-vegetarian diets. The positions on ovo-lacto-vegetarian diets are similar in France, Germany, and Switzerland:

> "*When you eliminate meat products and fish from your diet, you limit your protein intake. It is therefore important to replace these sources of protein, for example by eating eggs, dairy products and especially cheeses which are good supplements to vegetable proteins (provided in particular by the consumption of cereals, legumes, soy, etc.). In general, it is a good idea to combine foods of plant and animal origin."* (FBDG France, 2019, translated from French)

> "*Any diet that does not lead to the intake of adequate levels of essential nutrients and energy is unfavourable. The DGE (German Nutrition Society) recommends a diet that includes all groups of foods in the nutrition circle—including animal products.*" (FBDG Germany, 2016)

Italy described ovo-lacto-vegetarian diets as theoretically adequate for adults who are not pregnant or breastfeeding (the focus group in this article). Additionally, Italy described vegetarian diets as "a fashion" and suggested that those who follow such diets misunderstand the recommendation to follow a diet that is high in plant-based foods.

> "*The choice of this diet [the vegetarian diet] is generally linked to ethical or environmental issues. It has become a fashion for alleged health reasons because the importance of a high quantity of plant-based foods is misunderstood with the need to exclude a part of animal-based foods. In adults, it does not create particular problems, but in the individual in growth or in particular physiological conditions such as pregnancy and breastfeeding.*" (FBDG Italy, 2018, translated from Italian)

The 4 countries agreed in their rejection of vegan diets:

> "*On a vegan diet, it is difficult or impossible to ensure adequate supply of some nutrients. The most critical nutrient is vitamin B12. Other potentially critical nutrients on a vegan diet include protein resp. indispensable amino acids and long-chain n-3 fatty acids (EPA and DHA), other vitamins (riboflavin, vitamin D) and minerals (calcium, iron, iodine, zinc and selenium).*" (FBDG Germany, 2016)

> "*Vegan diets are extremely restricted due to the absence of all animal-based products (i.e. also eggs, milk and honey), which can lead to a risk of insufficient intake of various nutrients and protective substances. However, with a specific and careful choice of food, it is possible to achieve an intake that meets requirements. In certain phases of life (e.g. pregnancy, breastfeeding, childhood, growth, old age), however, complete coverage is more difficult. Therefore, the vegan diet is not suitable for the general population.*" (FBDG Switzerland, 2019, translated from German)

Quantitative results

Hierarchical cluster analysis.

The world map in **Figure 2** shows the results of the HCA, indicating the 100 countries' positions on vegetarian diets. The cluster analysis used the 6 binary-coded variables derived from the qualitative analysis as input (none, neutral recommendations, health benefits, ecological sustainability, risks highlighted, advise against). Four clusters were calculated as the ideal number and were distributed and named as follows.

Cluster A ($n = 63$) was the largest group. Countries in this cluster have no position on vegetarian diets and thus do not provide any information about this topic to their citizens. Accordingly, this cluster was labeled "the uninformed."

Cluster B ($n = 15$) was characterized by countries that emphasize the health and/or ecological sustainability benefits of vegetarian diets. They also make neutral recommendations on how to cover nutrient needs on vegetarian diets. Accordingly, this cluster was labeled "the supporters."

Cluster C ($n = 11$) was characterized by countries that emphasize the risks of vegetarian diets but often in combination with neutral recommendations. This cluster includes countries that advise against vegan diets, a form of vegetarian diet. As such, this cluster was labeled "the critics." Two countries (Indonesia, Slovenia) in this cluster showed the exceptional characteristic of providing neutral recommendations while highlighting the risks and health benefits of vegetarian diets.

Cluster D ($n = 11$) included all countries that give neutral recommendations for vegetarian diets without highlighting positive or negative aspects. Accordingly, this cluster was labeled "the informers."

Plant-based alternatives.

A total of 36 guidelines (37.9%) mentioned plant-based meat alternatives, 35 (36.8%) mentioned plant-based milk alternatives, and 12 (12.6%) mentioned plant-based alternatives to dairy products. Most FBDGs used visual elements such as pyramids or plates, which summarize the key messages. Some of these graphics included plant-based alternatives to meat, milk, and dairy products. However, they are cited less often in the graphics than they are mentioned in the text (**Table 3**). The guidelines that had a position on vegetarian diets are not automatically the ones that mentioned plant-based alternatives. The world map in **Figure 3** shows which countries' FBDGs mentioned plant-based alternatives.

Balanced Food Choice Index.

Table 4 shows the BFCI scores of the 100 countries in our data set as well as their rankings. With 94 points out of 100, the Netherlands had the most balanced guideline thus far, indicating strong support for sustainable healthy food choices and providing nutrition information that covers the broad spectrum of plant-based diets. Mongolia, though, shared the lowest rank with a group of Central American and Caribbean countries. The median BFCI score was 31 and the arithmetic mean was 33.58. **Supplemental Material 5** shows the details of each country's scores for the indicators that make up the BFCI.

Regression analyses

Before running the regressions, scatter plots were produced of the explanatory variables to determine the shape of their correlation with the BFCI (**Supplemental Material 9**). In these plots, OLS regression slopes

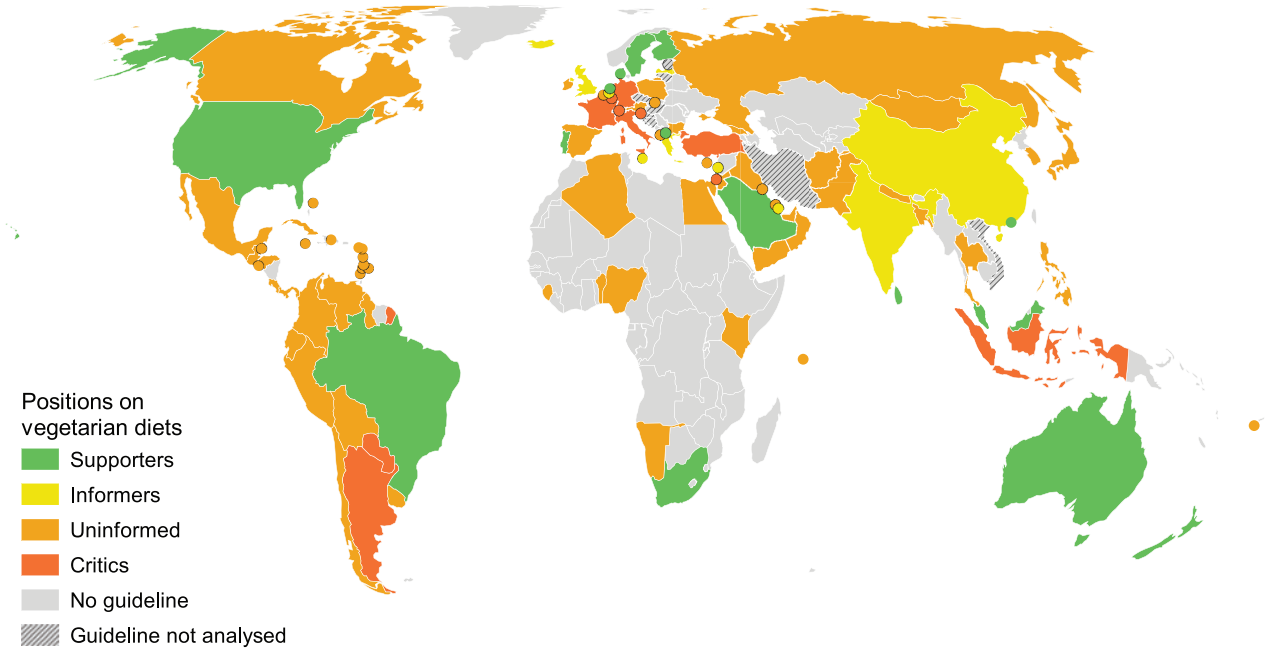

FIGURE 2 World map of 100 countries (states and subnational regions) and their positions on vegetarian diets in food-based dietary guidelines. The figure shows the results of the hierarchical cluster analysis.

TABLE 3 Plant-based alternatives in FBDGs[1]

Are Plant-Based Alternatives to the Following Products Mentioned?	Yes		No		Total	
	n	%	*n*	%	*n*	%
Guideline texts						
Meat	36	37.9	59	62.1	95	100
Milk	35	36.8	60	63.2	95	100
Dairy products	12	12.6	83	87.4	95	100
Meat or milk[2]	43	45.3	52	54.7	95	100
Guideline graphics (food pyramids, plates, etc.)						
Meat	14	15.7	75	84.3	89	100
Milk	10	11.2	79	88.8	89	100
Dairy products	3	3.4	86	96.6	89	100

[1] FBDG, food-based dietary guideline.
[2] FBDGs mention plant-based alternatives to meat, milk, or both.

with intercepts were included as well. The R^2 levels of these binary regressions were rather low, indicating that >1 variable explains the countries' BFCI scores.

The results of the multiple regression models are shown in Table 5. Model 1 regresses the BFCI on the economic importance of meat and dairy production, as well as on the year and length of the dietary guidelines. Meat production constituted between 0.03% and 8.11% of the GDP in our data set. It was hypothesized that dietary guidelines were influenced by economic interests. The estimated coefficient is consistent with this hypothesis. For every percentage point increase in the economic importance of meat production, there was a correlational decrease in the BFCI of 4.0 points. This correlation was highly statistically significant, with a 95% CI from −7.1 to −0.9 points and a *P* value of 0.013.

Model 2 inspects the possible effect of environmental sustainability on the BFCI. It revealed that countries with a 1-point cleaner environment on the EPI scored about half a point more on the BFCI. This result is also precisely estimated ($P < 0.001$).

Model 3 regresses the BFCI on all 5 independent variables together. Meat production is no longer statistically significant at the 5% level ($P = 0.089$) yet is still significant: a 1–percentage point higher economic share of meat is associated with a 3.7-point fall in the BFCI, a slightly weaker correlation than in model 1.

In all models, short guidelines tend to provide less information that covers the broad spectrum on plant-based diets and are more likely to be found in low- and middle-income countries. All models excluded some countries due to missing values. It is expected that this had little impact on our results, as the BFCI average in the smaller samples was

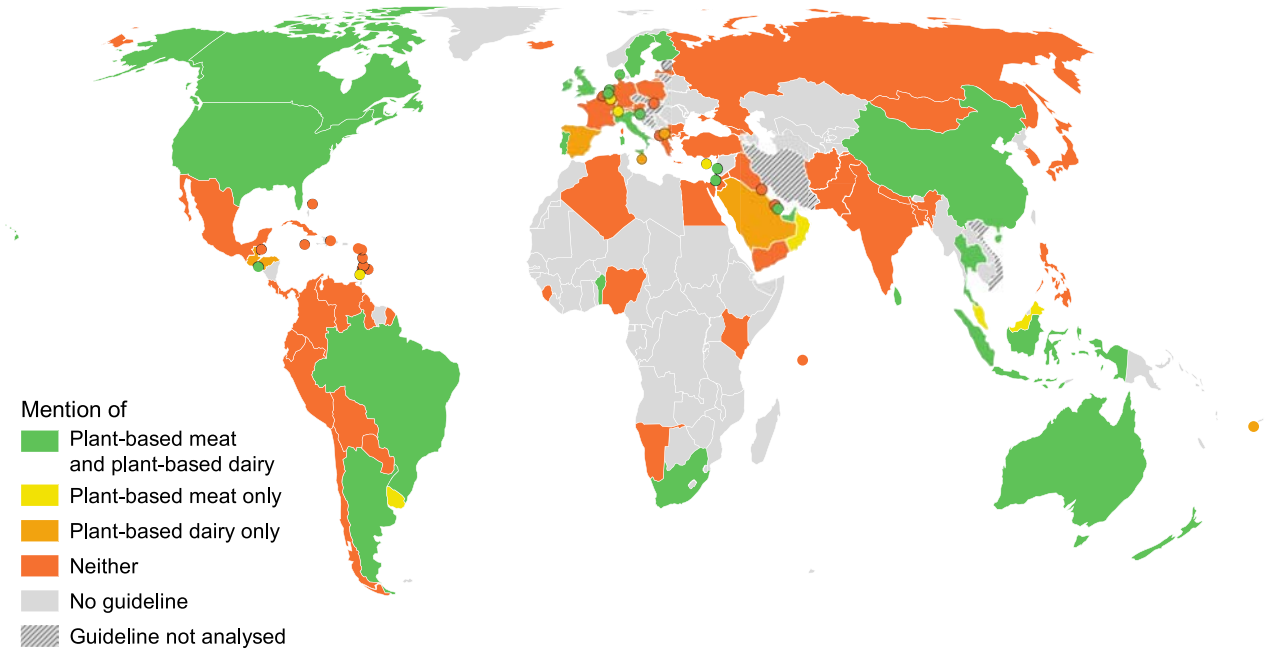

FIGURE 3 World map of 100 countries (states and subnational regions) and their mentions of plant-based alternatives in food-based dietary guidelines. "Plant-based dairy" in this figure means plant-based milk, plant-based dairy products, or both.

only slightly higher than the full sample average of 33.58, depending on the model (range: 33.96–37.84) (Supplemental Material 4). The regression was also run with egg production, fish production, and mortality rates of countries, but due to too much missing data, these variables were excluded from the analysis. Additionally, the BFCI was regressed on cereal production and vegetable production, excluding the share used for livestock feed. Here a small but nonsignificant negative correlation was found. Furthermore, the regression was run with GDP per capita, with a positive significant correlation noted, whereas with the percentage of vegetarian citizens, a slight negative correlation occurred (**Supplemental Materials 6 and 7**).

Statistical significance levels for all slope coefficients are indicated with asterisks. The underlying *P* values indicate the probability of obtaining the sample coefficient estimate or a more extreme one if the null hypothesis holds (2-sided *t* test). The null hypothesis is that the true population coefficient is 0. Heteroskedasticity was checked with the White test ($P < 0.05$), and regular SEs were used in all models except model 3, due to heteroskedasticity. In this model, heteroskedasticity-robust SEs were used (Huber-White).

Discussion

The overall question of this study was whether and how national dietary guidelines provide recommendations that cover the broad spectrum of plant-based diets and provide information on plant-based substitutes to animal-based products.

The study demonstrates a considerable information insufficiency in current FBDGs worldwide. The BFCI was constructed and measured to what extent dietary guidelines encourage sustainable healthy food choices and provide nutrition information that covers the broad spectrum of plant-based diets. The cluster analysis revealed that most countries do not provide information for well-planned vegetarian diets to their citizens, and the mean score of the BFCI was 33.58 out of 100 points.

The largest number of points in the BFCI were assigned to the use of inclusive food groups, giving no points for purely animal-based food groups (i.e., FBDGs that do not mention any plant-based foods or alternatives). Of 100 countries, 47 had a purely animal-based meat food group, which may include eggs. This gives meat a special status by implying that it should be an essential part of a healthy diet. But such a status is in conflict with the current evidence, which indicates that humans can obtain all necessary nutrients from entirely plant-based diets (22–24) and sometimes even contradicts guidance in the same FBDG. Purely animal-based meat groups also mean that the FBDGs miss an opportunity to promote the avoidance of potentially cancer-causing meat products as classified and recommended by the WHO (47). More explicit guidance to reduce meat consumption is needed due to its high environmental impact (1). Moreover, the EAT-Lancet Commission (48) came up with a similar recommendation in its Planetary Health Diet, including a substantial reduction of animal-based foods for human health and environmental sustainability. Despite such high-level guidance, the advice to reduce the consumption of some or all types of meat is not yet an internationally common standard. Removing the special status of meat as a single food group would send a powerful signal to citizens that we need to reduce meat consumption for our own health and the health of the planet.

The foods recommended in FBDGs should not only be healthy and sustainable but also affordable for all citizens. It is well documented that the consumption of meat and milk is low in low-income areas (49),

TABLE 4 Ranking of the 100 countries by BFCI score[1]

Rank	Country	BFCI	Rank	Country	BFCI
1	Netherlands	94	51	Bulgaria	30
2	Australia	89	51	Colombia	30
3	Switzerland	85	51	Cyprus	30
4	Qatar	83	51	Georgia	30
5	New Zealand	82	51	Ireland	30
6	United Kingdom	80	56	Poland	26
7	China (Hong Kong)	78	57	Greece	24
8	USA	75	57	India	24
9	Sweden	74	57	Japan	24
10	Belgium (Flemish)	64	57	Russia	24
11	Turkey	63	61	France	23
12	Malaysia	62	62	Republic of Korea	21
13	Italy	61	63	Algeria	18
14	Sri Lanka	60	63	Bahrain	18
15	Canada	59	63	Chile	18
15	Iceland	59	63	Egypt	18
17	Belgium (French)	57	63	Iraq	18
17	North Macedonia	57	63	Jordan	18
19	Israel	56	63	Kuwait	18
19	Lebanon	56	63	Philippines	18
21	Slovenia	55	63	Yemen	18
22	Malta	53	72	Afghanistan	15
22	South Africa	53	72	Honduras	15
24	Denmark	52	72	Oman	15
25	Indonesia	50	72	Uruguay	15
25	Portugal	50	76	Austria	12
27	Finland	49	76	Belize	12
27	Norway	49	76	Dominican Republic	12
29	Ecuador	48	76	Kenya	12
29	Thailand	48	76	Saint Kitts and Nevis	12
31	China	45	81	Bangladesh	9
31	Latvia	45	81	Costa Rica	9
31	Namibia	45	81	Nepal	9
31	Paraguay	45	84	Barbados	6
31	Spain	45	84	Cuba	6
31	United Arab Emirates	45	84	Grenada	6
37	Luxembourg	44	84	Sierra Leone	6
38	Brazil	43	84	Venezuela	6
39	Saudi Arabia	41	89	Guyana	3
40	Fiji	39	89	Jamaica	3
40	Nigeria	39	89	Peru	3
42	Argentina	38	89	Slovakia	3
42	Mexico	38	93	Antigua and Barbuda	0
44	El Salvador	36	93	Bahamas	0
44	Guatemala	36	93	Dominica	0
46	Pakistan	35	93	Mongolia	0
47	Albania	33	93	Panama	0
47	Benin	33	93	Saint Lucia	0
47	Bolivia (Plurinational State of)	33	93	Saint Vincent and the Grenadines	0
50	Germany	32	93	Seychelles	0

[1]Countries include states and subnational regions. Countries with the same score received the same rank. BFCI, Balanced Food Choice Index.

TABLE 5 Ordinary least squares regressions of the Balanced Food Choice Index on 5 explanatory variables[1]

Explanatory Variable	Unit	Model 1[2]			Model 2[2]			Model 3[3]		
		Coeff	95% CI	*P* Value	Coeff	95% CI	*P* Value	Coeff	95% CI	*P* Value
Meat production	GDP %	−4.0** (1.6)	−7.1, −0.9	0.013				−3.7* (2.1)	−7.9, 0.5	0.082
Dairy production	GDP %	−2.0 (2.4)	−6.7, 2.7	0.390				−1.0 (2.1)	−5.1, 3.1	0.634
EPI	0–100 scale				0.5*** (0.1)	0.3, 0.8	0.000	0.3 (80.2)	−0.2, 0.8	0.221
Last update FBDG	Years	0.6 (0.5)	−0.4, 1.5	0.244	0.4 (0.4)	−0.4, 1.2	0.309	0.1 (0.6)	−1.1, 1.4	0.811
Page length FBDG	Square root of pages	2.9*** (0.5)	1.9, 4.0	0.000	2.8*** (0.5)	1.9, 3.8	0.000	3.0*** (0.4)	2.1, 3.8	0.000
Constant		−1,094.6 (951.1)	−2988.2, 799.0	0.253	−824.2 (790.8)	−2394.4, 746.0	0.300	−293.7 (1235.4)	−2754.1, 2166.8	0.813
Observations, *n*			83			98			82	
R^2			0.4			0.4			0.4	

[1]Significance levels for the slope estimators for the 2-sided *t* test with null hypothesis = 0: $^{*}P < 0.1$. $^{**}P < 0.05$. $^{***}P < 0.01$. Coeff, regression coefficient; EPI, Environmental Performance Index; FBDG, food-based dietary guideline.
[2]Models 1 and 2: regular SE in parentheses.
[3]Model 3: White-Huber robust SE in parentheses.

which suggests that these animal-based products are too expensive for many people (18). Besides the need to lower the cost of nutrient-rich food, it seems likely that the more plant-based dietary recommendations are, the more affordable they are in most world regions. Existing studies indeed point in this direction (18, 50). Since many people struggle to afford animal-based foods (18), it is crucial that FBDGs inform citizens about how they can meet their nutritional needs with plant-based sources. In this sample of 100 countries, it was found that many dietary guidelines omit such information. For instance, 18% do not mention plant-based sources of protein, 30% do not mention plant-based iron, and 39% do not discuss plant-based calcium. Meat contains bivalent iron that is absorbed more efficiently than the trivalent form found in plant sources such as legumes, whole grains, or tofu, whereas cow's milk is a good source of calcium. Nevertheless, it seems negligent and divorced from the reality of many people's lives not to inform them that they can meet their iron needs with plant-based foods in combination with vitamin C, which promotes intake efficiency, or their calcium needs with calcium-rich mineral water, green leafy vegetables, or calcium-fortified plant milk (51, 52). Note that the calcium bioavailability of certain green leafy vegetables such as kale, broccoli, and turnip greens is even higher than cow's milk (>50%) and dairy products (∼30%) (51). Even so, FBDGs should point out that vegetables with low concentrations of oxalic acid are preferable, since oxalic acid reduces the bioavailability of calcium (51). Furthermore, the current evidence clearly indicates that people should obtain protein, carbohydrates, and fat predominantly from plant sources (48). Following a form of plant-based diet can also reduce the risk for obesity, type 2 diabetes, cardiovascular disease, and some forms of cancer (9, 24, 48). Yet, people who menstruate, as well as other specific groups that were not considered in this study, are at a higher risk of iron deficiency and need additional information about iron supplementation and iron-fortified foods (e.g., cereal flour) if they do not want to eat meat or other animal-based products or cannot afford them (48, 53). Another critical nutrient is vitamin B-12. In its guidelines on food fortification, the WHO (53) points out that vitamin B-12 "intakes are very low or close to zero in many population groups that are economically disadvantaged, or among those who avoid animal products for religious or other reasons. There is a high risk of deficiency in strict vegetarians and even lacto-ovo vegetarians (i.e., milk and egg consumers) have lower plasma concentrations of the vitamin compared with meat consumers." Therefore, FBDGs should urgently include recommendations on vitamin B-12 intake in the form of fortified foods and supplements for people who consume few or no animal products. Currently, only 22 countries out of 100 do so, including Australia, Brazil, and Indonesia.

One possible argument against discussing nutrients in FBDGs in more detail is that they should be kept simple. However, consumers can benefit from details such as sources of critical nutrients, especially since there are endemic nutritional deficiencies of nutrients such as iron and vitamin B-12 in many populations (53–55). Furthermore, such nutrient information can be made very short and simple to understand. A good example is the British FBDG (the Eatwell Guide), which briefly explains each nutrient and its sources and provides accompanying guidance for vegetarian and vegan diets, focusing on the critical nutrients for these diets (56). Even if most citizens do not read their FBDGs' nutrient section, many should still benefit from its content through government nutrition programs, medical staff, public canteens, or the media. FBDGs

should thus include detailed nutrient information, at least for use by these institutions and professionals.

Of the 100 countries that were analyzed, 75 had a purely animal-based dairy food group. Such guidelines did not mention any plant-based alternatives to cow's milk or dairy products in the respective food group. Although pure dairy groups are compatible with lacto-vegetarian and ovo-lacto-vegetarian diets, they fail to meet the informational needs of the large number of citizens with lactose intolerance as well as those who are vegan. Constituting 68% of the world's population, people with lactose intolerance are prone to diarrhea, gas, and bloating after eating or drinking dairy products. Especially in countries with a high estimated prevalence of lactose intolerance, such as Yemen (100%), Oman (96%), and Malaysia (87%) (19), it seems inappropriate for dairy to represent a single food group. Although lactose-free dairy products exist, it seems hard to justify dairy-only food groups in any country where lactose intolerance affects more than a third of the population. Yet, 80% of the countries in the data set with a high estimated prevalence of lactose intolerance also had a single dairy food group (Supplemental Material 3).

An example of inclusive food groups is in the Canadian FBDG. Since 2019, it has neither a single meat nor a single dairy food group but lists animal- and plant-based foods together under the name "protein group." The case of Canada illustrates how FBDGs can inspire and influence each other, even across different culinary cultures. For example, Saudi Arabia's 2012 guideline refers to an older Canadian guideline in its dairy section. It has not been updated since, so Saudi Arabia still reserves a single food group for animal-based dairy. All in all, a wide prevalence of purely animal-based food groups has been identified. When future FBDGs are being developed and revised, we recommend paying more attention to designing inclusive food groups.

Newer and longer guidelines in the data set provided more information that covers the broad spectrum of plant-based diets, as the regression results showed. In all models, the coefficient of the publication year had the expected magnitude and direction: younger guidelines were more balanced between animal- and plant-based foods, probably due to better study availability. Nevertheless, it was surprising that it was not statistically significant at the 5% level in any model. This underscores that just because a guideline is more up-to-date, it is not automatically more balanced in its recommendations, even though on average, this is true. The page length of FBDGs was also positively associated with the BFCI. In contrast to last update, page length had statistical significance in all regression models. The correlation may be due to 2 factors, which cannot be disentangled based on the results.

First, guidelines usually discussed omnivore diets first and got into more detail about the broad spectrum of plant-based diets the more pages that they had available. The BFCI rewarded the mention of plant-based sources of 5 critical nutrients. Short guidelines may lack space to mention any sources of these nutrients, be they plant or animal based. Second, a higher page length may indicate more careful guideline makers, who might write guidelines that are longer and more inclusive of various dietary patterns. Furthermore, GDP per capita has a significantly positively correlation with BFCI and the page length of FBDGs (Supplemental Material 7), which may indicate that countries with higher incomes have the capacity to develop more balanced guidelines. In addition, an extensive literature review was considered to be highly relevant for a balanced FBDG. Such deep reviews were conducted when developing the current FBDGs of the United States and the Netherlands, for example. Yet, very few countries are transparent with regard to their development and review process, so it was not possible to include this aspect in the analysis.

Another way to make FBDGs more inclusive is concrete recommendations for well-planned vegetarian diets. Currently, only 37 countries in the data set had a position on vegetarian diets. Most were rather brief, and some differed greatly from others. The cluster analysis was used to divide the countries' positions into 4 groups. Although the largest group was "the uninformed" (i.e., countries that had no position on vegetarian diets), the second-largest group was characterized by countries that emphasized the health and/or ecological sustainability benefits of vegetarian diets ("the supporters"). Furthermore, there was a difference in the provision of information about critical nutrients in vegetarian diets. Even though 11 countries provided information on how to plan vegetarian diets well in terms of critical nutrients ("the informers"), the group of so-called critics was characterized by 11 countries emphasizing the risks of vegetarian diets and/or advising against some forms of vegetarian diets (vegan diets). It is important to highlight critical nutrients in vegetarian diets and to give recommendations for good dietary planning. Even so, this should be done without making the risks the focus of the information. Nutrition and health experts might learn from UNESCO's (57) comprehensive sex education guidance when it comes to the development and revision of FBDGs—taking a positive approach that recognizes that nutrition education goes beyond teaching about risks and deficiencies and equips people with knowledge and skills to make responsible, empowered choices for healthy living.

Italy, as one of the countries in the group of "the critics," is perhaps a good example. According to Bettinelli et al. (58), the number of people following a form of vegetarian diet is constantly increasing, reaching levels in Italy that are higher than the estimated European average. At the same time, the researchers found insufficient knowledge among health professionals about vegetarian diets, so they cannot provide appropriate guidance to their patients. As well as education and training programs for health professionals, Bettinelli et al. emphasized the important role of FBDGs.

The authors hypothesized that there is a systematic bias in dietary recommendations. The regressions showed that the BFCI does indeed correlate negatively with the economic importance of meat and dairy production, measured as a share of the GDP. Yet, the correlation was statistically significant only for meat. For every percentage point increase in the economic importance of meat production, the guiding for balanced food choices decreased by 4.0 points (on a 0–100 scale). The smaller association of the BFCI with dairy, as compared with meat, could be explained by a combination of 2 facts. First, in the data set, fewer countries had high GDP percentages of dairy production when compared with meat (0.7% on average compared with 1.6% for meat). Second, if the marginal political impact of the meat and dairy sectors increase, so does their share of the GDP. Since dairy numbers are relatively low, the marginal effects would thus also be smaller.

Stakeholders may have influenced dietary guidelines through sociopolitical activities. For example, an Australian group of food industry, farming, and fishery interests successfully inhibited the inclusion of environmental information in the current FBDG, published in 2013 (1). Regardless, the majority of food-related emissions is caused by the livestock sector, along with the majority of land use and a major propor-

tion of freshwater extraction (12, 59, 60). According to the Intergovernmental Panel on Climate Change (61), vegan and vegetarian diets have the highest and second-highest greenhouse gas mitigation potential of 8 diets. Therefore, FBDGs can help to achieve ecological sustainability by providing healthy eating advice that covers the broad spectrum of plant-based diets, with some or no animal-based products (9). At the same time, FBDGs with such recommendations can represent a contribution to social sustainability, as they help to meet the basic needs of about 1.5 billion people worldwide who follow vegetarian diets, either out of economic necessity or by choice (62). Yet, guidelines that include more information on plant-based diets can combine these interests with a third, economic dimension of sustainability in a win-win-win situation. This was shown in a recently published report by the Inter-American Development Bank (63), which estimated that shifting toward a plant-based diet by 2030 will lead to 4.3 million fewer jobs in Latin American livestock herding, poultry, dairy, and fishing but will be more than outbalanced by 19 million new jobs in the production of more sustainable, plant-based foods.

Nevertheless, the authors of this study advise that industry interests should not influence the development and revision of FBDGs. Canada's evidence-based approach is a good example. Although food producers and the food industry were able to participate in the Canadian revision process through a public consultation, the responsible authority balanced upcoming interest conflicts (6). This resulted in a more inclusive "protein" food group, with the purely animal-based dairy food group losing its special status (6). All in all, the authors considered it important to get input from different stakeholders to ensure that FBDGs are evidence based as well as economically affordable and feasible.

Nevertheless, meat and dairy products remain culturally important foods representing wealth, status, and enjoyment. In more and more countries, incomes are growing and, with them, the demand for animal-based foods (64). FBDGs cannot stem this tide entirely, as the discrepancy between FBDG advice and actual consumption patterns shows (9). Yet, FBDGs can redirect the demand for meat and dairy by presenting more plant-based options, as the Dutch guideline already does, for example. Furthermore, a new cultural narrative for plant-based foods is needed, since for example, in many cultures, the idea exists that a meal without meat is not a "real" meal and plant-based meals are not considered tasty (65–68). Here, plant-based alternatives may be helpful. Nearly half (45%) of all FBDGs already mentioned plant-based alternatives to meat or animal milk. We see this as a positive development that should accelerate in future revisions of FBDGs, since public interest in plant-based alternatives has increased rapidly in the last few years, along with the number of scientific and technical journal articles about their benefits and limitations (11–17, 69). However, further research is needed to provide nutritional recommendations on plant-based alternatives, since the market is very fluid and animal-based products cannot generally be replaced one-to-one in terms of nutritional value. A diet based on wholegrains, legumes, nuts, and a variety of fruits and vegetables would be the most beneficial for the health of people and the planet. But FBDGs should also take into account cultural preferences. Sausages, meatballs, coffee lattes, and yogurt are all part of many people's everyday lives. Many of these products can be made from plant-based raw materials, offering alternatives that can help people preserve their taste and product preferences. Even if plant-based substitutes offer environmental benefits over some animal-based products, various aspects should be taken into account when including them in FBDGs, such as the raw materials used, the degree of processing, and geographic location. FBDGs should help identify which plant-based alternative products can and cannot be part of a sustainable healthy diet.

We recommend that guidelines differentiate between plant-based alternatives that can be consumed frequently and those that should be eaten in moderation or seen as merely for enjoyment. Like their animal-based counterparts, some plant-based alternatives include elevated amounts of salt, fat, or sugar, for instance. Many guidelines already recommend only low-fat dairy products, and they should apply similar nuances when discussing plant-based alternatives. A good example is the Netherlands' current FBDG (70), whose protein food group includes vegetarian burgers, pieces, or balls with "not too much salt," though it excludes the ones with "too much salt." It includes soy milk with added vitamin B-12 and calcium but not dairy and soy milk with "too much sugar." However, plant-based alternatives are quite heterogeneous beyond salt, fat, and sugar concentrations. More studies should investigate which of them can be part of a healthy diet. Moreover, in some world regions, some or all plant-based alternatives are more expensive than the originals, which poses an availability problem. Yet, this is not the case for all areas and products, especially where plant-based alternatives such as tofu and soy milk are part of the traditional cuisine. For example, Incaparina is a popular plant-based drink in Central and South America that is used as a cheap and nutritionally adequate alternative to cow's milk (71), and it is in Guatemala's FBDG. In areas with low availability or affordability of plant-based alternatives, governments can improve access, for example, via fiscal policies used to implement climate strategies (72).

To stop exceeding planetary boundaries, FBDGs should discuss sustainability aspects. This may be more politically feasible in some countries than others. The results of this study, specifically regression model 2, indicate that including guidance for balanced food choices in a country's FBDG correlates positively with its ecological efforts. On average, for every additional point on the EPI, the country's guideline has a 0.5-point higher BFCI, with high statistical significance. It was hypothesized that the correlation is driven by 2 factors. First, government commitment to environmental protection increases the EPI and leads to guidelines that cover the broad spectrum of plant-based diets because the government is aware of the livestock sector's deep and wide-ranging environmental impacts. Second, a big livestock sector might contribute to a low BFCI via economic influence and to a low EPI by degrading the environment. For instance, high livestock activity may lead to lower EPI scores on the indicators "Biodiversity and Habitat," "Tree Cover Loss," and "CH4 [methane] Growth Rate" (34). This possible link between the livestock sector and the EPI may also explain why the EPI coefficient becomes statistically insignificant when regressors for meat and dairy production are included (model 3). The 2 variables are too similar, making it hard for the regression algorithm to decide which one of them has a statistically significant effect on the BFCI (multicollinearity).

All in all, this study has several strengths and limitations. With 95 FBDGs (100 countries), almost all of the world's national guidelines were analyzed. This makes this article the most comprehensive cross-country FBDG analysis that we know of. Furthermore, it is the first global FBDG comparison focused on positions toward vegetarian diets.

An analysis was conducted to compare the FBDGs in their treatment of food groups, nutrients, vegetarian diets, plant-based alternatives, and

environmental aspects. The categorization allowed us to draw quantified comparisons of the FBDGs on a large number of characteristics. Additionally, this study reports many examples and a qualitative analysis of the contents of FBDGs. For the regressions, all OLS assumptions (classical linear assumptions) were verified and met.

Even though almost all of the world's national dietary guidelines were analyzed, the resulting sample size of 100 is low for statistical inference. Since cases with missing values were excluded, the regression models excluded ≤18 cases (model 3), reducing the sample size even further. As discussed in the Results section, the sample still showed several statistically significant results.

Statistically and materially significant relationships were found between the recommendations of a country's FBDG and *1*) its year of last update and *2*) the importance of meat production in the domestic economy. Yet, the exact causal process from these determinants to the outcomes in the dietary guidelines was not traced. The discussion pointed to some examples of authors who have done this. Nonetheless, this aspect is still underexplored and further research is needed.

There is most likely some degree of measurement error in the variables that measure meat and dairy production as a share of the GDP. Governments cannot assess their exact GDP due to capacity limitations and large informal sectors, including the meat and dairy sectors. Moreover, the FAO data that we used do not have the same quality for each country and are usually based on estimates. Overall, the magnitude of the correlations that we measured may be larger or, less likely, smaller in reality.

The BFCI was designed to make FBDGs comparable. To increase construct validity, the classification was discussed with 5 individuals whose work relates to the spectrum of plant-based diets. However, others could have selected different indicators or weights, which would have led to different results. The BFCI can be considered a tool to analyze the current state. Add-ons and further developments may bring other viewpoints. A quantitative coding method was used for the BFCI indicators. This does not capture the sizable qualitative variation among the countries.

In conclusion, with global planetary and human health goals and targets falling short, it is more important than ever to ensure that FBDGs promote sustainable healthy food choices. This includes recommendations to eat fewer animal products and fostering plant-based diets and plant-based alternatives as part of their positions and food groups. Policy makers, civil society actors, and economic agents have to use all available tools to promote more sustainable, healthy, and equitable consumption patterns. FBDGs that encourage balanced food choices are also more inclusive in that they consider ethical, ecological, religious, and economic aspects that play roles in people's everyday lives.

The same suggestions apply to countries that do not yet have an FBDG, which is mostly low- and middle-income countries. For them, it should be relatively easy to implement FBDGs that encourage balanced food choices, since the diets of their populations are usually less westernized (73, 74). In addition, FBDGs should be revised regularly (e.g., every 5 y) to take the latest research and evidence into account.

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The authors' responsibilities were as follows—all authors: designed the research; A-LK, NF: identified the latest versions of countries' FBDGs and analyzed them qualitatively and quantitatively; A-LK, NF: developed the BFCI, analyzed nonprimary data, and performed the statistical analysis; AR: reviewed the statistical analysis; all authors: wrote and revised the manuscript; A-LK: had primary responsibility for the final content; and all authors: read and approved the final manuscript.

Data Availability

Data described in the article, code book, and analytic code are publicly and freely available without restriction at https://github.com/aklapp/data-plant-based-diet-spectrum-in-dietary-guidelines.git.

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