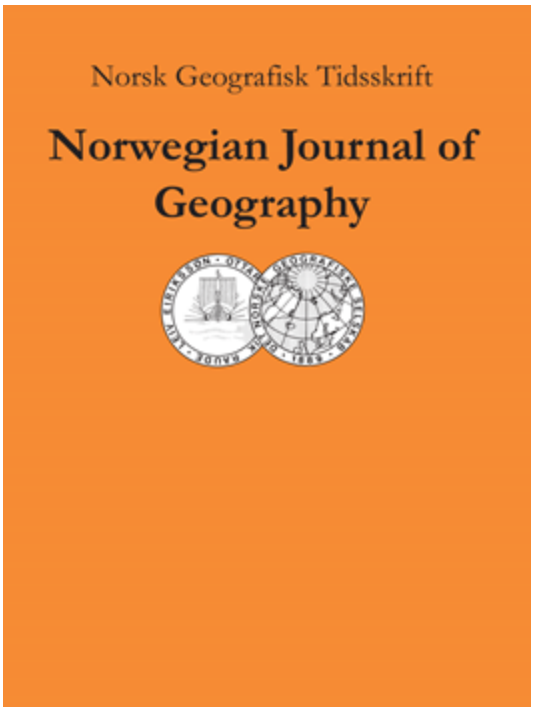
Going beyond hunger: Linking food supplies to global malnutrition

Journal Item



Going Beyond Hunger: Linking Food Supplies to Global Malnutrition

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SHORT ARTICLE

Going beyond hunger: Linking food supplies to global malnutrition

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Abstract

International food security and nutrition studies focus mainly on hunger rather than diertary diversity and the nutritional requirements essential for a productive life. The authors present a method that processes Food and Agriculture Organization food supply data into World Health Organization food groups to determine whether national food supply satisfies nutritional requirements for medium energy intake (i.e. c.2200 calories per day) rather than minimum energy intake. They employ a modified version of the International Food Policy Research Institute's 2013 Global Hunger Index to group nations for comparison. The results show that most nations have a deficit in at least one of four required food groups. However, many developed Mediterranean nations with low levels of hunger display an adequate supply of all food groups. The positioning represents a successful model for managing the nutrition transition from plant-

based diets to the consumption of animal protein, oils, fats, and sugars and other carbohydrates. Additionally, the results suggest that health risks associated with overweight and obesity may increase with societal development. Accordingly, the authors conclude that information on medium energy requirements should be combined with complementary socio-economic analysis to inform food and nutrition research and policy.

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Introduction

The world suffers from a triple burden of malnutrition, in that individuals can be *hungry*, *affected by micronutrient deficiency*, or *overweight or obese* (Gomez et al. 2013; Johnston et al. 2014). Although healthier diets are readily available to wealthy consumers, significant obstacles exist for many consumers in vulnerable, poor populations (Ronto 2018). Various health problems, such as obesity, are associated with the nutrition transition from plant-based diets to the consumption of animal protein, oils and fats, and sugars and other carbohydrates (Popkin et al. 2012). Research is necessary to create healthy food strategies that go beyond hunger. In this article, we apply a food group method to consider whether sufficient food supplies exist for citizens to live productive lives beyond basic sustenance.

There are challenges to understanding whether national agricultural and food systems provide the correct balance of nutritious foods, and whether populations consume recommended dietary requirements rather than simply an adequate number of calories (Dangour et al. 2012; Gustafson et al. 2016). Unfortunately, contemporary food security and nutrition studies do not address balanced diets in a robust way, since requirements are not homogeneous and the relationship between food intake and nutrition varies greatly depending on social and economic factors (Mayen et al. 2014). Dietary diversity information informs food availability rather than access, consumption, or stability because international food security metrics prioritize food supplies (Jones et al. 2013). For effective application, dietary diversity data should be contextualized alongside analysis of socio-economic inequalities. These can include but are not exclusive to: (1) unequal gender relations embedded within families that manifest in disparities in food consumption and nutritional outcomes between male and female household members (Agarwal 2014); (2) food deserts that create scenarios in which low-income

residents may not have access to affordable and healthy food (Donald 2013); and (3) the varying abilities of individuals and families to respond to shocks in labour markets, prices, and the loss of assets relating to livelihoods (Barrett 2010).

Approaches to measuring overall diet quality include those that focus on examining the intake of nutrients or food groups, or a combination of both (Kant 1996; Cafiero et al. 2014). There are significant constraints to measuring diets through micronutrients because many are essential to proper nutrition but only vitamin A, iron, and iodine are routinely and robustly monitored to allow for comparisons between nations (Gomez et al. 2013). Alternatively, the recommendation to consume diverse types of foodstuffs is an internationally accepted concept for achieving a healthy diet (Ruel 2003). A variety of approaches to dietary diversity exist, although none have been implemented with consistency. Some researchers count the food groups used to construct the food balance sheets produced by the Food and Agriculture Organization (FAO) (Hatloy & Oshaug 1998). The Dietary Quality Index– International (DQI–I) was developed at the University of North Carolina with support from the National Institutes of Health in the USA to compare the quality of diets in China and the USA. The index records five main food groups, noting variety within protein sources (Kim et al. 2003). The Healthy Eating Index was created by the Center of Nutrition Policy and Promotion within the Department of Agriculture, USA, to determine the extent to which people living in the USA were following dietary guidelines. The index is based on a system of five food groups, four nutrients, and a measure of variety in food intake (Kennedy et al. 1995). Another approach to measuring overall diet quality examines healthy food diversity through the quantity, distribution to all segments of society, and the health value of consumed foods (Drescher et al. 2007).

Dietary diversity is usually measured by counting foods or food groups consumed over a reference period. Examples of this include the Household Dietary Diversity Score (HDDS) used

by the FAO based on guidelines produced by the Food and Nutrition Technical Assistance Project (Kennedy et al. 2011), and the Food Consumption Score (FCS) used by the World Food Programme (WFP 2008). The FAO collects quantitative information, whereas the WFP incorporates both quantitative and qualitative information in its data (WFP 2008; Kennedy et al. 2011). Both approaches to quantifying food focus on the number of food groups consumed, rather than on portion size or the proportions of each food group consumed. In both cases, points are awarded for foods that are not required for a healthy diet (World Food Programme Vulnerability Analysis and Mapping Branch (ODAV) 2008; Kennedy et al. 2011).

Currently, international food security indicators focus mainly on the hunger component of the triple burden of malnutrition (Headey & Ecker 2012). For example, the FAO's prevalence of undernourishment indicator is based on the mean quantity of available calories, the inequality in access to those calories, and the mean minimum of required calories (de Haen et al. 2011). This approach is problematic because dietary energy needs are based on an aggregated value of the minimum dietary energy requirement (MDER). The MDER refers to the amount of food energy needed to maintain an acceptable minimum body weight, body composition, and level of minimum sedentary physical activity consistent with long-term good health (de Haen et al. 2011). The MDER monitors caloric minimums, rather than the ability of populations to live more active and dynamic lives.

A more detailed exploration of the connection between dietary diversity and the triple burden of malnutrition is desirable. In this respect, measurements that address overweight and obesity are of interest (Johnston et al. 2014). Efforts have been made to place overweight and obesity goals at the centre of food environment frameworks, but they are not yet broadly applied across nations (Vandevijvere et al. 2017). The efforts have been congruent with an international move to encourage regular monitoring of the prevalence of overweight and obesity in

populations (Ng et al. 2014). Food security and nutrition studies have largely focused on one aspect of the triple burden of malnutrition. A more complete understanding of food supply would assist policymakers in addressing the challenges presented by malnutrition.

Methodology

The International Food Policy Institute (IFPRI) produced the 2013 Global Hunger Index (International Food Policy Institute 2013), in which nations are ranked by their hunger levels. By contrast, the FAO's food balance sheets present a country's food supply during a specified reference period, showing food item information on availability for human consumption in grams per capita per day (Food and Agriculture Organization of the United Nations 2018). The FAO food balance sheets indicate shortages and surpluses for each food item. They are the sole source of data that facilitate cross-country comparisons (Food and Agriculture Organization of the United Nations 2001) and are referenced by authors when making consumption inferences (Popkin et al. 2012). For our research, we placed food balance sheet information into four food groups determined by the WHO as being essential for nutrition: 1. carbohydrates in the form of starches; 2. fruits and vegetables; 3. dairy; and 4. meat and alternatives (World Health Organization 2000, 5) (Supplementary Appendix 1).

We developed a model to examine the balance of food groups in a country's food supply. The model was combined with a modified version of the 2013 Global Hunger Index (by including industrialized nations and reclassifying others) to identify the availability of food groups essential to nutrition across nations. The availability of food groups was calculated for medium levels of physical activity (rather than minimum levels) based on the WHO's standards for recommended dietary consumption (Supplementary Appendix 2A–2E).

Development of the model

A total of 140 nations were selected for analysis based on available data available for 2013 in FAOSTAT, which is the Food and Agriculture Organization of the United Nations' statistical database (Food and Agriculture Organization of the United Nations 2018). Of these, 114 were taken from the IFPRI's 2013 Global Hunger Index (International Food Policy Research Institute 2013). The remaining were 26 industrialized nations. Five distinct hunger groups (hereafter abbreviated as HGs) were created, which modified the categorization of nations used in the2013 Global Hunger Index: (HG1): 26 Industrialized Nations; (HG2): 43 Upper Middle Nations; (HG3): 20 Lower Middle Nations; (HG4): 38 Upper Developing Nations; (HG5): 13 Lower Developing Nations.[1]

HG1 comprises the 26 industrialized nations not listed in the 2013 Global Hunger Index. HG5 combines the two lowest ranking groups in the IFPRI's index. Three Hunger Groups (HG2, HG3, and HG4) consist of nations that are placed in groups identical to IFPRI groups. All hunger groups are shown on a colour-coded world map in Fig. 1 (see Supplementary Appendix 2A–2E for food group data for all nations covered in our study and see Supplementary Appendix 3 for a list of specific nations in each of the five hunger groups).

FAOSTAT food balance sheets provide information on domestic supplies of food commodities measured in grams per capita per day. We used food balance sheets for the year 2013, the most recent year for which such information is available. We categorized FAOSTAT data into new WHO food groups for our computations (Supplementary Appendix 1).

Application of the Hunger Group Model

The food group computations were used to compare the gap between daily dietary needs and available food group supply. The average supply for all nations in each hunger group was subtracted from the WHO Countrywide Integrated Noncommunicable Diseases Intervention (CINDI) recommended dietary consumption totals for individuals with medium levels of activity (World Health Organization 2000). The unit of measurement was grams/capita/day. Computations produced results that showed surpluses and deficits in the food groups determined by national food supplies (Table 1). The data used to generate the computations are listed in Supplementary Appendix 2A–2E. Following computations for each food group, the number of surpluses and deficits per country were summarized (Table 2).

Results

The Hunger Group Model indicates that only 11 of 140 selected nations had adequate supplies of all essential food groups required for proper nutrition. HG1 nations Austria, Greece, Italy, Netherlands, and Portugal, and HG2 nations Cuba, Kazakhstan, Kuwait, Lebanon, and Montenegro, along with HG3 country Albania enjoy surpluses across all food groups (Supplementary Appendix 2A–2C). The numbers of deficits in food groups by country are summarized in Table 2, in which hunger group members are subdivided into meaningful clusters.

Discussion

Researchers who use dietary diversity indicators often struggle to make cross-country comparisons. There is a lack of coordination, dissemination of data is incomplete, and many inconsistencies exist between sundry food cultures (Jones et al. 2013). The model supports the

arguments for the use of more rigorous nutritional information to inform food policy (Dangour et al. 2012; Mayen et al. 2014; Gustafson et al. 2016). It illustrates that food balance sheets can be processed into food groups that provide insights into dietary energy supply at the national level. The groups reveal food supply deficits with respect to the medium dietary requirements determined by the World Health Organization (World Health Organization) (Table 2) (Supplementary Appendix 2A–2E). We suggest that food security and dietary diversity should be measured beyond the minimum standards currently used as food security indicators (de Haen et al. 2011).

By applying the standard of medium levels of activity across four key food groups required for nutrition (World Health Organization 2000), we identified large deficits of fruits and vegetables for all hunger groups. Conversely, there was a general abundance of carbohydrates in the form of starches. Dairy is marked by a transition from deficit to surplus in HG2 and similarly, adequate meat and alternatives availability begins in HG3 (Table 1) (Supplementary Appendix 2A–2E). Only 11 of 140 nations studied had sufficient supplies across all food groups essential for nutrition, and 6 of them were Mediterranean nations (Table 1) (Supplementary Appendix 2A–2E).

Although the supply of adequate nutrients is the central focus of this article, our results also provide insights into potential sources of overweight and obesity. HG3 and HG2 each recorded a surplus of carbohydrates in the form of starches along with one other food group. By contrast, HG1 had a surplus in dairy, in meat and alternatives, and carbohydrates in the form of starches (Table 1) (Supplementary Appendix 2A–2E). This indicates that the possibility of both general overconsumption and excessive meat consumption was greatest in HG1. Additionally, the results suggest that the risk of numerous types of cancer (Abid et al. 2014) and cardiovascular diseases (Etemadi et al. 2017) from meat is greatest when hunger is the lowest.

The global agricultural system produces enough calories to feed the planet (Herforth & Ahmed 2015), yet access to and consumption of sufficient amounts of nutritious food continues to be a challenge (Johnston et al. 2014; Herforth & Ahmed 2015). Furthermore, food balance sheets tend to overestimate food consumption (Kearney 2010). The findings in this article reveal that significant supply shortages of key food items make balanced and healthy meals difficult for many citizens of most nations.

Although information regarding food supplies for medium energy requirements is useful, there are limitations to our model. It is based on a Western standard of dietary requirements (World Health Organization 2000) and thus reflects the dominant global pattern of development and nutrition transition, for which there are alternatives (Popkin et al. 2012). Furthermore, the model does not capture socio-economic characteristics and inequalities that might impact the relationship between a nation's food supply and healthy diets. For example, an alternative diet might explain why Japan has a healthy population yet the model recorded three deficits for the country. The eating habits of Japan were acknowledged as being unique at the first World Food Summit held in Rome in 1996 (Gabriel et al. 2018). The traditional Japanese diet is based on a high consumption of fish and soybean (Gabriel et al. 2018). However, contemporary Japan is shifting to global trends, which are influencing the type and amount of food consumed in the country. It is undergoing a nutrition transition to unhealthy diets due to Western influence in urban areas (Smil & Kobayashi 2012). More food is required to accommodate increasingly active lives for greater numbers of people, as the ratio of women to men in the labour force is rising: in 2012 it was 68.3% (United Nations Development Programme n.d.). This was below the 75.8% average in 2012 for peer nations designated by the United Nations as

having very high human development and below the 88.5% recorded in 2012 for Norway the index leader (United Nations Development Programme n.d.).

Food balance sheet data on quantity in grams is imperfect. The precise nutrient content of consumed food is variable and subject to factors such as agricultural production methods (Augustin et al. 2016) and diverse food cultures and practices (Gatley 2016). Similarly, it cannot be concluded with precision that surpluses in food supply lead to increases in overweight and obesity in all cases. For example, in the developed world, considerable food waste occurs: 50% at the household level (Stancu et al. 2016). Lastly, a margin of error is likely when applying medium dietary requirements to food supplies, due to the possible influence of factors unique to individuals, such as age, gender, physical activity, health, absorption and utilization efficiency, and metabolism (British Nutrition Foundation n.d.).

The pursuit of a balanced diet in both the developed and developing world will have a direct positive effect on health. Ways forward include encouraging home production and promoting education regarding nutrition and health (World Bank 2011; Herforth & Dufour 2013). Urbanizing nations with deficits in food groups should explore peri-urban agricultural solutions that incorporate a mosaic of urban and rural worlds inspired by home gardens (Tornaghi 2014). These strategies are potentially beneficial, as the globalization of agrifood is marked by the growing role of large retail supermarkets in place of traditional markets. This in turn will bring changes in consumer preferences that will impact nutritional outcomes (Qaim 2017). While the modernization of the food system contributes to increased food security, critics note it does not always result in the production of more nutritious foods for all (Nugent 2011).

Conclusions

The findings from our study have the potential to influence methodological improvements, educational development, cultural change, and collaborative multinational actions. The application of dietary diversity is continually being amended and it is illuminating to consider dietary requirements in the context of medium dietary energy needs. There is potential for processing food balance sheet data into food groups, thus providing detailed information regarding national food supplies. This would enable targeted research and policy action to address individual deficits and surpluses in food groups, along with larger systemic weaknesses.

Our results indicate that almost every country in the world has a deficit in at least one major food group essential for proper nutrition. Also, there are insufficient fruits and vegetables to meet dietary energy needs for medium levels of activity in each global hunger group. Many developed Mediterranean nations demonstrate adequate levels of all required food groups. They stand as viable and successful models for rapidly urbanizing, developing nations. However, there are potential drawbacks. Societal development usually results in increases in food surpluses, which can lead to increased incidences of overweight and obesity as well as non-communicable diseases.

We hope this article will serve as a harbinger for further engagement within wider food and nutrition security research and policy. The development of more rigorous dietary diversity and nutritional information is essential to lighten the triple burden of malnutrition. However, for effective implementation, it will need to be contextualized within socio-economic realities.

Note

1. The elements ‘upper’, ‘lower’, and ‘middle’ in the names of the hunger groups refer to the modified positions of the nations relative to the 2013 Global Hunger Index.

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Figure caption

Fig. 1. Hunger groups of the World (modified from the 2013 Global Hunger Index (IFPRI 2013) and created with mapchart.net)

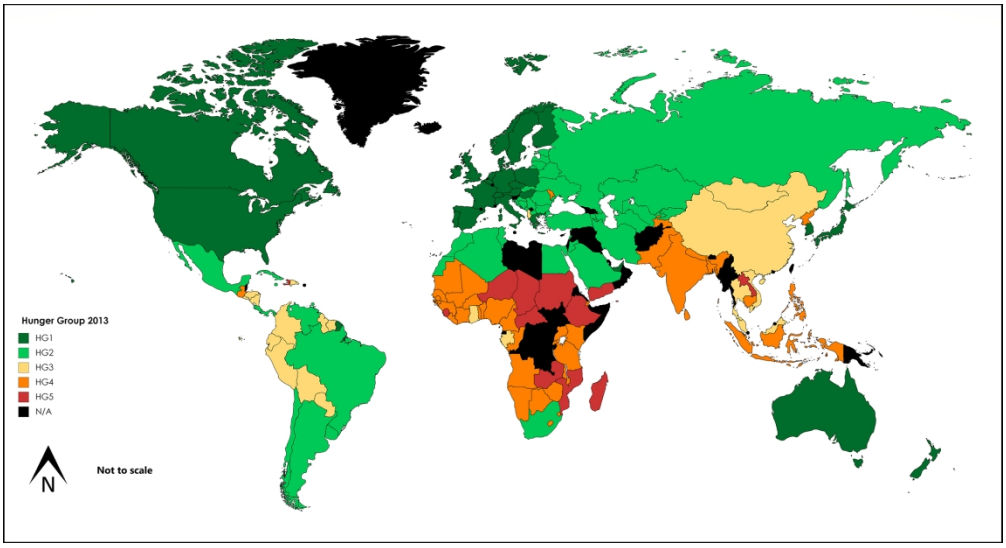

Fig. 1. Hunger groups of the World (modified from the 2013 Global Hunger Index (IFPRI 2013) and created with mapchart.net)

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Table 1. Essential food group supply: hunger group surplus and deficit averages (grams per capita per day) (Source: Food and Agriculture Organization of the United Nations 2018) (see Supplementary Appendix 2A–2E for country data)

Hunger Group	Carbohydrates in the form of starches	Fruits and vegetables	Dairy	Meat and alternatives	Deficit-free nations
HG1	49.14	-101.31	278.89	156.04	Austria Greece Italy Netherlands Portugal
HG2	153.12	-75.53	164.91	37.65	Cuba Kazakhstan Kuwait Lebanon Montenegro
HG3	91.86	-204.47	-16.92	26.41	Albania
HG4	216.53	-395.28	-135.93	-79.45	–
HG5	191.23	-466.99	-217.64	-93.08	–

Table 2. Hunger groups and food group deficit clusters (Supplementary Appendix 2A–2E)

	Deficit in 1 food group	Deficit in 2 food groups	Deficit in 3 food groups	Deficit in 4 food groups
HG1	Belgium; Canada; Czechia; Denmark; Finland; France; Germany; Ireland; Norway; Poland; South Korea; Spain; UAE; UK	Australia; Hungary; New Zealand; Sweden; Switzerland; USA	Japan	–
HG2	Algeria; Argentina; Armenia; Belarus; Bosnia; Brazil; Bulgaria; Chile; Estonia; Latvia; Lithuania; Macedonia; Mexico; Russia; Serbia; Slovakia; Trinidad and Tobago; Tunisia; Turkey; Ukraine; Uruguay; Uzbekistan; Venezuela	Azerbaijan; Costa Rica; Croatia; Egypt; Fiji; Iran; Jamaica; Kyrgyzstan; Romania; Saudi Arabia; South Africa; Turkmenistan	Jordan; Morocco; Panama	–
HG3	China; Colombia; Guyana; Mauritius; Mongolia	Bolivia; Dominican Republic; Gabon; Malaysia; Paraguay; Vietnam	Ecuador; El Salvador; Ghana; Honduras; Nicaragua; Peru; Suriname	Thailand
HG4	–	Botswana; Kenya; Mali; Mauritania; Moldova; Philippines; Rwanda	Angola; Bangladesh; Benin; Burkina Faso; Cambodia; Cameroon; Cote d'Ivoire; Djibouti; Gambia; Guinea; Lesotho; Liberia; Malawi; Namibia; Nepal; Nigeria; North Korea; Pakistan; Republic of Congo; Senegal; Sri Lanka; Swaziland; Tajikistan; Tanzania; Togo; Uganda	Guatemala; Guinea-Bissau; India; Indonesia; Zimbabwe
HG5	–	Laos	Central African Republic; Chad; Ethiopia; Haiti; Madagascar; Mozambique; Niger; Sierra Leone; Timor-Leste; Yemen; Zambia	Sudan

Supplementary Appendix 1. Essential food groups. Calculated using FAOSTAT Data. *Source:* Author calculations based on the World Health Organization's CINDI pyramid methodology (World Health Organization 2000*)

Nutritional Food Group Name	Components of Calculation using FAOSTAT data for 2013 (Food and Agriculture Organization of the United Nations 2018)**
Carbohydrates in the form of starches	Result derived by adding the categories of cereals and starchy roots.
Fruits and Vegetables	Calculated using data under the headings of fruits and vegetables, respectively.
Dairy	Result from the milk category in the database.
Meat and Alternatives	Calculated by adding the cumulative results for eggs, fish, meat, pulses, and treenuts.

*World Health Organization. 2000. *CINDI Dietary Guide.* http://www.euro.who.int/__data/assets/pdf_file/0010/119926/E70041.pdf (accessed 3 July 2018).

** Food and Agriculture Organization of the United Nations. 2018. *Food Balance Sheets*. http://www.fao.org/faostat/en/#data/FBS (accessed January 2019).

Supplementary Appendix 2A–E. Surplus/deficit of food group supply (grams/per capita/per day)

2A. Hunger Group 1

Nation	Starch Carbs	Fruits and Vegs	Dairy	Meat and Alternatives
Australia	-55.04109589	-176.739726	292.4383562	237.1780822
Austria	16.63013699	6.410958904	357.0958904	148.2739726
Belgium	145.4794521	-130.739726	297.0958904	120.8493151
Canada	78.38356164	-31.17808219	164.4383562	193.0410959
Czech Republic	65.34246575	-322.4657534	184.7945205	65.50684932
Denmark	81.20547945	-78.46575342	409.7260274	147.5068493
Finland	46.76712329	-195.8356164	830.1643836	148.0273973
France	46.4109589	-120.109589	311.1232877	182.3561644
Germany	22.79452055	-203.0958904	358.7671233	123.6164384
Greece	120	247.6986301	349.3424658	131.2328767
Hungary	-8.602739726	-324.0273973	85.75342466	35.80821918
Italy	88.63013699	36.05479452	326.3835616	170.7123288
Ireland	152.6575342	-8.301369863	449.6164384	140
Japan	-54.84931507	-274.9589041	-152.5753425	130.4931507
Netherlands	45.28767123	18.79452055	585.5342466	167.4246575
New Zealand	-19.64383562	-73.91780822	26.02739726	199.8356164
Norway	24.24657534	-102.4657534	366	195.890411
Poland	252.9041096	-240	212.7123288	68.46575342
Portugal	110.1643836	59.75342466	211.7534247	234.6027397
South Korea	15.53424658	47.26027397	-270.4109589	164.5753425
Spain	4.821917808	-174.3013699	100.109589	242.5479452
Sweden	-7.835616438	-99.04109589	584.8767123	166.4109589
Switzerland	-67.26027397	-118.3287671	523.1232877	104.9041096
UAE	28.10958904	-189.5890411	13.45205479	172.1643836
UK	152.4657534	-85.20547945	286.1643836	126.630137
USA	-6.767123288	-101.3972603	347.7808219	239.0136986
HG1 Averages	49.14752371	-101.3150685	278.8956797	156.0410959

2B. Hunger Group 2

Nation	Starch Carbs	Fruits and Vegs	Dairy	Meat and Alternatives
Algeria	323.8356164	66.82191781	137.7534247	-81.69863014
Argentina	7.97260274	-301.6986301	284.4657534	147.8630137
Armenia	46.87671233	559.6164384	322.6849315	-24.84931507
Azerbaijan	406.7945205	-38.73972603	166.630137	-75.47945205
Belarus	356.3835616	-90.2739726	116.3835616	140.4383562
Bosnia	245.3972603	142.9041096	226.7945205	-63.69863014
Brazil	21.23287671	-303.5068493	158.9863014	168.5479452
Bulgaria	40.49315068	-322.4657534	176.6027397	0.712328767
Chile	106.4109589	-328.3835616	68.10958904	111.8082192
Costa Rica	-106.3287671	-198.5205479	252.1369863	32.4109589
Croatia	-1.397260274	-182.9315068	382.9315068	67.45205479
Cuba	234.8767123	77.67123288	23.80821918	48.1369863
Egypt	352.739726	111.6438356	-87.09589041	-27.69863014
Estonia	151.5616438	-162.1369863	530.4109589	70.08219178
Fiji	269.5890411	-466.6849315	-139.8630137	56.19178082
Iran	198.6575342	358.9589041	-122.0821918	-1.561643836
Jamaica	46.93150685	-135.0136986	-0.328767123	51.78082192
Jordan	44.21917808	-223.2054795	-37.17808219	-24.32876712
Kazakhstan	167.6438356	88.68493151	539.369863	60.21917808
Kuwait	132.4657534	209.9726027	181.9452055	136.3561644
Kyrgyzstan	274.3835616	-205.9178082	327.8630137	-72.84931507
Latvia	204.9863014	-258.8219178	227.0136986	79.50684932
Lebanon	34.82191781	118	63.75342466	9.863013699
Lithuania	226.0547945	-266.9315068	559.4794521	181.8082192
Macedonia	74.54794521	125.4246575	182.6849315	-38.10958904
Mexico	31.97260274	-252.5753425	56.49315068	86.76712329
Montenegro	234.0821918	329.8630137	706.739726	123.6986301
Morocco	390.9863014	-104.3561644	-100.1917808	-10.57534247
Panama	-18.82191781	-375.369863	-57.42465753	46.05479452
Romania	320.5205479	-0.383561644	402.9589041	-2.931506849
Russia	265.8356164	-192.630137	198.1369863	117.7260274
Saudi Arabia	36.46575342	-160.5205479	-20.82191781	50.68493151
Serbia	28.24657534	-106.0821918	156.9315068	9.479452055
Slovakia	71.61643836	-375.3150685	142.1643836	26.1369863
South Africa	130.3561644	-477.9726027	-97.26027397	21.97260274
Trinidad and Tobago	-2.849315068	125.4246575	34.38356164	118.3835616
Tunisia	198.4109589	236.630137	63.61643836	-21.09589041
Turkey	229.7260274	309.369863	281.3424658	-10.52054795
Turkmenistan	187.3150685	-136.0547945	125.5890411	-10.90410959
Ukraine	301.6164384	-82.76712329	147.3424658	55.75342466
Uruguay	102.739726	-341.0958904	326.8219178	90.73972603
Uzbekistan (+1)	191.6438356	315.0136986	108.3835616	-82.98630137
Venezuela	23.26027397	-333.4794521	72.71232877	57.69863014
HG2 Averages	153.1226505	-75.53106085	164.9111182	37.65084422

2C. Hunger Group 3

Nation	Starch Carbs	Fruits and Vegs	Dairy	Meat and Alternatives
Albania	72.90410959	360.5205479	582.109589	43.50684932
Bolivia (+1)	106.6575342	-423.5890411	-123.8630137	38.21917808
China	145.890411	511.0136986	-159.0958904	126.4383562
Colombia	11.8630137	-185.5068493	47.17808219	3.726027397
Dominican Republic	-132.3013699	150.630137	-47.94520548	3.123287671
Ecuador	-126.6027397	-355.7808219	132.4657534	-1.808219178
El Salvador	-31.94520548	-382.0273973	90.65753425	-26.2739726
Gabon	349.5068493	-161.2876712	-167.369863	95.80821918
Ghana	913.4520548	-45.7260274	-225.1232877	-50.02739726
Guyana	27.53424658	-311.1232877	138.1643836	25.31506849
Honduras	-60.76712329	-336.1369863	0.219178082	-47.06849315
Malaysia	2.136986301	-382.9589041	-180.739726	174.8219178
Mauritius	58.08219178	-319.6986301	71.28767123	57.94520548
Mongolia (+1)	61.09589041	-468.7123288	133.0684932	35.89041096
Nicaragua	2.849315068	-553.7808219	-16.68493151	-32.90410959
Paraguay (+1)	175.7260274	-380.6575342	-42.54794521	30.21917808
Peru	249.890411	-194.9041096	-79.7260274	-29.39726027
Suriname	-21.69863014	-224.109589	-115.8356164	17.53424658
Thailand	-14.68493151	-276.2191781	-169.5890411	-5.945205479
Vietnam	47.78082192	-109.5068493	-205.1780822	69.20547945
HG3 Averages	91.86849315	**-204.4780822**	**-16.92739726**	26.41643836

Appendix 2D. Hunger Group 4

Nation	Starch Carbs	Fruits and Vegs	Dairy	Meat and Alternatives
Angola	526.7945205	-267.1232877	-216.3013699	-31.15068493
Bangladesh	202.3835616	-561.1780822	-189.9726027	-110.5205479
Benin	624	-407.0684932	-226.9863014	-48.10958904
Botswana	13.39726027	-412.6027397	72.57534247	-87.26027397
Burkina Faso	186.0821918	-636.2739726	-168.3835616	-98.60273973
Cambodia	113.890411	-525.7260274	-240.4931507	-32.46575342
Cameroon	310.2191781	-99.20547945	-208.1643836	-55.80821918
Cote D'Ivoire	675.369863	-379.8356164	-232.5753425	-89.20547945
Djibouti	54.46575342	-390.4931507	-86.1369863	-102.4931507
Gambia	66.43835616	-618.0273973	-124.7671233	-107.5342466
Guatemala	-59.04109589	-379.9726027	-122.3287671	-36.16438356
Guinea	281.8082192	-327.260274	-193.5068493	-25.80821918
Guinea-Bisseau	61.45205479	-503.4520548	-195.5342466	-132.3287671
India	41.06849315	-302.5753425	-18.49315068	-125.2876712
Indonesia	250.4931507	-429.5068493	-209.3972603	-67.67123288
Kenya	147.1506849	-412.3835616	9.890410959	-99.12328767
Lesotho	324.0821918	-571.9178082	-180.5479452	-106.8493151
Liberia	214.4657534	-506.739726	-241.6712329	-133.0136986
Malawi	532.3287671	-469.369863	-228.1369863	-104.7671233
Mali	219.0410959	-466.3287671	20.35616438	-56.90410959
Mauritania	43.7260274	-575.6438356	190.6027397	-48.2739726
Moldova	103.369863	-302.2739726	175.1506849	-22.95890411
Namibia	214.3835616	-406.1917808	-49.8630137	-73.28767123
Nepal	313.369863	-219.8356164	-107.260274	-115.369863
Nigeria	614.9041096	-369.890411	-228.3287671	-76.1369863
North Korea	129.2328767	-201.0684932	-239.6164384	-91.89041096
Pakistan	-11.83561644	-547.4246575	251.7260274	-121.5068493
Philippines	83.06849315	-235.9726027	-207.0958904	2.164383562
Republic of Congo	454.3561644	-418.7671233	-220.7123288	-36.21917808
Rwanda	481.5616438	308.6849315	-230.1917808	-67.67123288
Senegal	75.69863014	-491.6712329	-203.8082192	-75.42465753
Sri Lanka	21.5890411	-474.2739726	-154.1643836	-71.15068493
Swaziland	59.67123288	-400.7945205	-94.93150685	-101.1506849
Tajikistan	62.49315068	-140.5479452	-100.5753425	-90.46575342
Tanzania	229.7534247	-363.3972603	-139.6164384	-96.95890411
Togo	482.4931507	-597.7534247	-228.1917808	-90.4109589
Uganda	90.54794521	-302.9863014	-147.890411	-65.34246575
Zimbabwe	-6.082191781	-614.0821918	-162.6027397	-126.1643836
HG4 Averages	216.5313627	**-395.2876712**	**-128.3669791**	**-79.45493872**

2E. Hunger Group 5

Nation	Starch Carbs	Fruits and Vegs	Dairy	Meat and Alternatives
Central African Republic	312.109589	-521.7808219	-236.47	-73.8630137
Chad	147.5616438	-655.5068493	-229.37	-129.4520548
Ethiopia	183.8630137	-631.1506849	-205.86	-133.8356164
Haiti	103.2876712	-467.0136986	-231.02	-80.84931507
Laos	150.9315068	102.1369863	-242	-74.19178082
Madagascar	334.7123288	-528.9315068	-225.16	-134.9041096
Mozambique	566.3287671	-577.7260274	-245.21	-106.4931507
Niger	174.0821918	-462.5753425	-191.08	-43.69863014
Sierra Leone	297.1780822	-440.2739726	-243	-43.39726027
Sudan	-103.9452055	-254	-94.8	-89.04109589
Timor-Leste	146.1917808	-562.1917808	-239.04	-53.7260274
Yemen	23.36986301	-470.4657534	-206.03	-113.5068493
Zambia	150.3835616	-601.3972603	-240.29	-133.0958904
HG5 Averages	191.2349842	**-466.9905163**	**-217.6407692**	**-93.08113804**

Supplementary Appendix 3. Hunger group membership (see Fig. 1. Hunger groups of the world)

Hunger Group 1 of Industrialized Nations (26 members): Australia; Austria; Belgium; Canada; Czechia; Denmark; Finland; France; Germany; Greece; Hungary; Italy; Ireland; Japan; Netherlands; New Zealand; Norway; Poland; Portugal; South Korea; Spain; Sweden; Switzerland; UAE; UK; USA.

Hunger Group 2 of Upper Middle Nations (43 members): Algeria; Argentina; Armenia; Azerbaijan; Belarus; Bosnia; Brazil; Bulgaria; Chile; Costa Rica; Croatia; Cuba; Egypt; Estonia; Fiji; Iran; Jamaica; Jordan; Kazakhstan; Kuwait; Kyrgyzstan; Latvia; Lebanon; Lithuania; Macedonia; Mexico; Montenegro; Morocco; Panama; Romania; Russia; Saudi Arabia; Serbia; Slovakia; South Africa; Trinidad and Tobago; Tunisia; Turkey; Turkmenistan; Ukraine; Uruguay; Uzbekistan; Venezuela.

Hunger Group 3 of Lower Middle Nations (20 members): Albania; Bolivia; China; Colombia; Dominican Republic; Ecuador; El Salvador; Gabon; Ghana; Guyana; Honduras; Malaysia; Mauritius; Mongolia; Nicaragua; Paraguay; Peru; Suriname; Thailand; Vietnam.

Hunger Group 4 of Upper Developing Nations (38 members): Angola; Bangladesh; Benin; Botswana; Burkina Faso; Cambodia; Cameroon; Republic of Congo; Cote D'Ivoire; Djibouti; Gambia; Guatemala; Guinea; Guinea-Bissau; Indonesia; India; Kenya; Lesotho; Liberia; Malawi; Mali; Mauritania; Moldova; Namibia; Nepal; Nigeria; North Korea; Pakistan; Philippines; Rwanda; Senegal; Sri Lanka; Swaziland; Tajikistan; Tanzania; Togo; Uganda; Zimbabwe.

Hunger Group 5 of Lower Developing Nations (13 members): Central African Republic; Chad; Ethiopia; Haiti; Laos; Madagascar; Mozambique; Niger; Sierra Leone; Sudan; Timor-Leste; Yemen; Zambia.