Estimated micronutrient shortfalls of the EAT–*Lancet* planetary health diet

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Unhealthy diets are a major contributor to the global burden of disease, and food systems cause substantial environmental destruction. To lay out how to achieve healthy diets for all, within planetary boundaries, the landmark EAT–*Lancet* Commission proposed the planetary health diet, which includes a range of possible intakes by food group and substantially restricts the intake of highly processed foods and animal source foods globally. However, concerns have been raised about the extent to which the diet provides adequate essential micronutrients, particularly those generally found in higher quantities and in more bioavailable forms in animal source foods. To address these concerns, we matched each food group point estimate within the respective range with globally representative food composition data. We then compared the resulting dietary nutrient intakes with globally harmonised recommended nutrient intakes for adults and women of reproductive age for six micronutrients that are globally scarce. To fill the dietary gaps that were estimated for vitamin B12, calcium, iron, and zinc, we suggest modifications to the original planetary health diet to achieve micronutrient adequacy (without fortification or supplementation) for adults, which included increasing the proportion of animal source foods and reducing foods high in phytate.

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Introduction

To support optimal health and wellbeing, the world's food systems need to produce nourishing diets for nearly 8·0 billion people globally and an expected 9·7 billion people by 2064.[1] Human nourishment requires adequate essential nutrients to support healthy bodily functioning and development and to protect against communicable and non-communicable diseases (NCDs). At the same time, food systems must function within planetary boundaries.[2] Despite being a global priority, the important aims of simultaneously achieving adequate nutrition for all, while protecting our planet, are far from being realised. In fact, unhealthy diets are a major contributor to the global burden of disease,[3] and food systems cause substantial environmental destruction.[4] Worldwide, 39% of adults are overweight or obese,[5] 31% of adults are affected by hypertension,[6] and 69% of women of reproductive age (aged 15–49 years) are affected by one or more micronutrient deficiencies.[7] At the same time, food systems cause 34% of anthropogenic greenhouse emissions,[8] cause 70% of fresh water withdrawals,[9] and the conversion of natural ecosystems to agricultural land is the largest threat to species extinction.[10]

To lay out how to achieve healthy diets for all, within planetary boundaries, the landmark EAT–*Lancet* Commission proposed the planetary health diet, which includes a range of possible intakes by food group and substantially restricts the intake of highly processed foods and animal source foods globally.[4] The planetary health diet is rich in minimally processed, plant source foods and is low in saturated fat and high in fibre. Therefore, this diet is likely to be protective against NCDs compared with a diet high in ultra-processed foods that is low in healthy fats and dietary fibre. However, concerns have been raised about the extent to which the diet provides adequate essential micronutrients, particularly those that are generally found in higher quantities and in more bioavailable forms in animal source foods.[11] To address concerns about the micronutrient adequacy of the planetary health diet, we matched each food group point estimate within the respective range with globally representative food composition data,[12] and compared the resulting dietary nutrient intakes with globally harmonised recommended nutrient intakes[13] for folate, vitamin A, vitamin B12, calcium, iron, and zinc, which are commonly insufficient globally.[7,14] To fill dietary gaps that were found for several micronutrients, we modified the original planetary health diet to achieve adequacy of all six micronutrients for adult men and women (25 years or older).

Limitations of the EAT–*Lancet* Commission report's nutrient adequacy assessment

A limitation of the EAT–*Lancet* report's adequacy assessment was its exclusive use of the US Department of Agriculture FoodData Central,[15] a database that is not necessarily representative of global diets. Moreover, each analysed food group (eg, dark green leafy vegetables) included very few—sometimes just one—individual foods (eg, spinach), which is not representative of the nutrient density variance across foods within each food group. In most cases, nutrient values for raw foods were used without retention factors, despite many foods being inedible when raw or being mostly consumed in their cooked form. Additionally, recommended nutrient intakes used for the nutrient adequacy assessment were not based on the latest dietary reference intakes by the European Food Safety Authority (for Europe) or the Institute of Medicine (for the USA and Canada) and were calculated without accounting for the bioavailability of iron and zinc, two nutrients that are commonly insufficient among populations consuming few animal source foods.[7,14] Further, dietary energy requirements were calculated assuming individuals were moderately active or highly active, which could be an unrealistic assumption.[16] Finally,

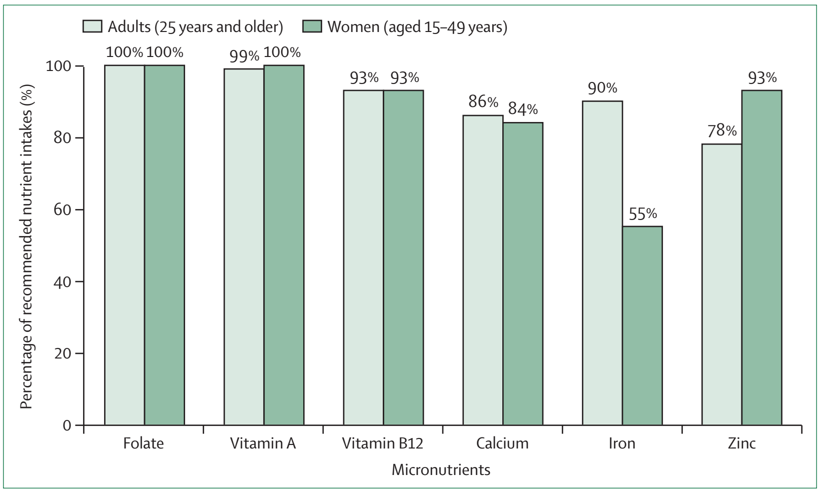

***Figure:* Percentage of recommended nutrient intakes for six micronutrients in the EAT–*Lancet* healthy reference diet**
Estimates are based on target values (within a possible range) that were adjusted for the energy requirements of a moderately active individual.

nutrient adequacy was not assessed for women of reproductive age, for whom increased iron requirements due to menstruation could be difficult to meet on the planetary health diet. For example, recommended iron intakes in the USA for women aged 19–50 years are more than double the recommended iron intakes for men of the same age.[17]

A new approach to assessing micronutrient adequacy

Given the harmonised nutrient reference values proposed in 2020[13] and the limitations of the original adequacy assessment of the EAT–*Lancet* planetary health diet, we conducted a new assessment for six key micronutrients that are commonly insufficient globally, four of which can be challenging to consume in adequate quantities when reducing the consumption of animal source foods. These four key micronutrients are vitamin B12, calcium, iron, and zinc.[7,14] We improved on the initial adequacy assessment in important ways. We built a globally aggregated food composition database following Beal and Ortenzi[12] from existing national and regional sources, with each included food group consisting of multiple individual foods in commonly consumed forms (ie, cooked, raw, or both). We added three new food groups that were not specifically included in the EAT–*Lancet* planetary health diet (ie, seeds, organs, and refined grains), and six specific foods that could be considered subcomponents of broader food groups included in the planetary health diet (ie, beef and five different categories of fish or shellfish).

We used harmonised nutrient reference values[13] and accounted for the bioavailability of iron and zinc, given the low amounts of animal source foods and high amounts of phytate on the planetary health diet. On the basis of existing guidelines, we estimated iron was 10% bioavailable and zinc 26% bioavailable in the planetary health diet.[13] Differences in bioavailability for vitamin A are already accounted for in the recommended intakes indicator (retinol activity equivalent).[17] Retinol activity equivalents assume that vitamin A from animal sources, which contain retinol, is on average 12 times more bioavailable than vitamin A from plant sources, which contain carotenoids.[17] Importantly, there is high uncertainty in the evidence used to set recommended nutrient intakes and estimates of bioavailability. Furthermore, although we agree that encouraging higher levels of physical activity is important from a public health perspective for many populations, we used global average energy requirements[18] for moderately active individuals, which are more in line with the current prevalence of physical activity worldwide.[16]

Micronutrient inadequacies of the EAT–*Lancet* planetary health diet

The EAT–*Lancet* planetary health diet was said to provide adequate nutrients for the average adult aged 30 years. Although the diet was not recommended for children aged 0–2 years due to their unique requirements, it did not recognise women of reproductive age separately as a population with increased needs. We assessed the adequacy of the planetary health diet for adults (25 years and older) and women of reproductive age (aged 15–49 years) because women of reproductive age represent a large share of the global population and have increased iron requirements. Pregnant and lactating women, adolescent girls aged 10–14 years, and adolescent boys aged 10–19 years also have increased micronutrient requirements.[12] However, we did not include these groups in our analysis because they represent a smaller share of the total population. Given the large quantities of whole plant foods such as pulses, dark green leafy vegetables, and vitamin A-rich fruits and vegetables in the EAT–*Lancet* planetary health diet, the estimated intakes of folate and vitamin A were essentially adequate for adults and women of reproductive age when using the energy-adjusted target values for each food group (figure). However, for adults and women of reproductive age, when using the energy-adjusted target values for each food group, estimated intakes of vitamin B12, calcium, iron, and zinc were below recommended nutrient intakes. For adults, estimated zinc intake was 78% of the recommended nutrient intake, calcium intake was 86% of the recommended nutrient intake, iron intake was 90% of the recommended nutrient intake, and vitamin B12 intake was 93% of the recommended nutrient intake. For women of reproductive age, estimated iron intake was 55% of the recommended nutrient intake, calcium intake was 84% of the recommended nutrient intake, and zinc and vitamin B12 intake were 93% of the recommended nutrient intakes.

	EAT–*Lancet* healthy reference diet*		Adequate diet for adults (25 years and older)†		
	Macronutrient intake (possible range), g per day	Caloric intake, kcal per day	Macronutrient intake, g per day	Caloric intake, kcal per day	Difference, kcal per day (g per day)
EAT–*Lancet* planetary health diet food groups					
Whole grains	232 (0–60%‡)	811	171	300	–511 (–291)
Tubers or starchy vegetables	50 (0–100)	39	181	200	+161 (+146)
Dark green leafy vegetables	100§	23	77	23	..
Red and orange vegetables	100§	30	89	30	..
Other vegetables	100§	25	85	25	..
All fruit	200 (100–300)	126	222	126	..
Whole milk or derivative equivalents (eg, cheese)	250 (0–500)	153	239	153	..
Beef and lamb	7 (0–14)	15	7	15	..
Pork	7 (0–14)	15	12	30	+15 (+6)
Chicken and other poultry	29 (0–58)	62	40	92	+30 (+13)
Eggs	13 (0–25)	19	50	79	+60 (+38)
Fish	28 (0–100)	40	39	40	..
Dry beans, lentils, and peas	50 (0–100)	172	27	36	–136 (–102)
Soy foods	25 (0–50)	112	61	100	–12 (–7)
Peanuts	25 (0–75)	142	4	25	–117 (–19)
Tree nuts	25§	149	4	25	–124 (–20)
Palm oil	7 (0–7)	60	7	60	..
Unsaturated oils	40 (20–80)	354	40	354	..
Dairy fats (included in milk)	0	0	0	0	..
Lard or tallow	5 (0–5)	36	4	36	..
All sweeteners	31 (0–31)	120	30	120	..
Additional food groups					
Refined grains	..	..	68	100	+100 (+68)
Seeds	..	..	17	100	+100 (+17)
Beef	..	..	19	45	+45 (+19)
Organs (eg, liver, spleen, kidney, and heart)	..	..	6	8	+8 (+6)
Fresh fish	..	..	16	20	+20 (+16)
Small dried fish	..	..	3	10	+10 (+3)
Canned fish with bones	..	..	15	30	+30 (+15)
Crustaceans	..	..	34	30	+30 (+34)
Bivalves	..	..	17	15	+15 (+17)
Total	..	2503	..	2227	–276

*Details on the food composition data are available in the appendix (p 2). †Details on the food composition data are available in the appendix (p 3). ‡Of total dietary energy. §No range recommended in the EAT–*Lancet* planetary health diet.

***Table:* EAT–*Lancet* healthy reference diet and hypothetical micronutrient adequate diet for adults (25 years and older) for EAT–*Lancet* planetary health diet food groups and additional food groups**

Potential strategies for filling micronutrient gaps

From a nutritional perspective, the preferred way to fill micronutrient gaps is primarily through minimally processed, intrinsically nutrient-dense foods. This is the preferred approach because foods are more than the sum of a handful of well known nutrients. In fact, foods contain thousands of compounds bound in a food matrix, which together can positively influence metabolism and health (eg, through nutrient absorption, satiety, and the immune system).[19–22] Given the potential micronutrient shortfalls of the EAT–*Lancet* planetary health diet, important changes might be required to achieve dietary micronutrient adequacy for adults without relying on fortification and supplementation. Most importantly, we found that to achieve a micronutrient adequate diet that is also more feasible at the population level would probably require increasing animal source foods from 14% of total kcal to 27% of total kcal, reducing dietary phytate from 1985 mg to 1021 mg to improve iron and zinc absorption, and allowing a 3:1 ratio of whole to refined grains (table; appendix pp 2–3). This modified diet would increase daily intake of tubers and starchy vegetables by 161 kcal,

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increase daily intake of fish and shellfish (including bivalves and crustaceans) by 105 kcal, increase daily intake of eggs by 60 kcal, increase daily intake of beef by 45 kcal, increase daily intake of chicken and other poultry by 30 kcal, and increase daily intake of pork by 15 kcal. Furthermore, the modified diet would add an average daily intake of refined grains of 100 kcal, add a daily intake of seeds of 100 kcal, and add a daily intake of organ meats of 8 kcal (table). To make room for these increases and enable an isocaloric diet, the modified diet would reduce daily intake of whole grains by 511 kcal, reduce daily intake of pulses by 136 kcal, reduce daily intake of tree nuts by 124 kcal, reduce daily intake of peanuts by 117 kcal, and reduce daily intake of soy foods by 12 kcal (table). These modifications are intended to illustrate relatively feasible dietary shifts that help achieve nutrient adequacy but are not intended to optimally minimis risk of NCDs, environmental effects, or unaffordability. For women of reproductive age, achieving adequate iron intakes without fortified foods or supplements can be particularly challenging and would require adherence to very high intakes of iron-rich foods and few, if any, junk foods.

Although it is possible for individuals on a variety of dietary patterns to meet micronutrient requirements through the consumption of foods that are intrinsically dense in micronutrients, factors in the food environment, including personal preferences, nutritional knowledge, socioeconomic status, convenience, access, and affordability might hinder diet quality to varying degrees globally depending on the context and population.[23] Therefore, fortification, including biofortification (ie, breeding crops to increase their nutrient value), and supplementation is seen by many as an important way to fill key nutrient gaps and prevent micronutrient deficiencies at the population level, especially for groups with increased needs. Indeed, even in high-income countries, micronutrient deficiencies among women of reproductive age are common,[7] highlighting a role for improved fortification and supplementation practices. However, while seeking to improve fortification and supplementation, it is important to simultaneously restrict the intake of energy-dense, ultra-processed foods (even if fortified), which have been linked to numerous NCDs and premature mortality.[24] Ultra-processed foods are currently the primary source of calories in many high-income countries,[24] and the consumption of these foods is increasing rapidly in low-income and middle-income countries.[24] Although the underlying mechanisms explaining the link between ultra-processed foods and disease are poorly understood,[25,26] ultra-processed foods are typically energy-dense and hyper-palatable and disrupt gut–brain signalling, which can lead to overconsumption and weight gain when they are a predominant component of the food environment.[27]

Conclusions

We find that the EAT–*Lancet* planetary health diet could fall short in multiple micronutrients. Deficiencies in these micronutrients would contribute to substantial public health burdens compared with what would be achievable for a fully nourished population. This new evidence suggests a planetary health diet consisting mostly of minimally processed, healthy plant source foods that is low in animal source foods should not necessarily be assumed to provide adequate nutrients, particularly for minerals such as iron (especially for women of reproductive age), calcium, and zinc. We estimate that to achieve dietary nutrient adequacy (without relying on supplementation or fortification) at the population level requires increased quantities (from the baseline planetary health diet) of nutrient-dense foods such as fish, shellfish, seeds, eggs, and beef; and reduced quantities (from the baseline planetary health diet) of foods high in phytate such as whole grains, pulses, and nuts. Compared with estimated average intakes of animal source foods globally,[28] a transition to this hypothetical diet would imply a decrease in red meat and increase in eggs, fish, shellfish, and dairy products on average globally.

Further analysis and consideration should be conducted to establish to what extent it is possible to sustainably achieve dietary nutrient adequacy for the global population and where environmental or other trade-offs might exist. For example, similar to modelling healthy diets that meet nutrient requirements at the lowest possible cost,[29] dietary optimisation modelling could be done to analyse available healthy diets that meet nutrient requirements with the lowest environmental effects, using lifecycle assessments.[30] However, it could be that meeting micronutrient requirements through intrinsically nutrient-dense foods alone is not feasible while minimising risk of NCDs or risk of environmental harm. If this were to be the case, the trade-offs to consider would change. First, should intrinsically nutrient-dense foods be prioritised at the expense of the environment? Second, should fortification and supplementation be prioritised at the expense of a diet containing primarily intrinsically nutrient-dense foods? Third, is environmental preservation prioritised at the expense of nutrient adequacy? Finally, is minimising risk of NCDs prioritised at the expense of optimising nutrient adequacy, or vice versa?

Undoubtedly, we need to sustainably and regeneratively produce all food of both animal and plant origin in alignment with local ecosystems and within planetary boundaries. The example of the EAT–*Lancet* planetary health diet can be useful for advocacy, but future efforts should consider context-specific guidelines using local data when possible to inform relevant policy making and programme planning. Rather than a planetary health diet, it might be better to suggest locally appropriate diets that meet nutrient needs and local dietary guidelines within different types of cultural contexts and environmental conditions. Although the EAT–*Lancet* planetary health diet provides possible intake ranges for each food group to account for flexibility in different contexts, the overall approach of prescribing a planetary health diet on the basis of the expert opinion of a team of scientists could be problematic if it does not equitably involve all of the local stakeholders affected by such dietary changes. We are hopeful that healthy and sustainable diets for all are possible; however, given the complexity and increasingly global nature of our food systems, it will require incredible effort and unification across society, governments, academia, and civil society. Human health and environmental preservation are two of the greatest challenges of our time, and they are integrally linked. We must leave no one behind, and we must neglect no environmental challenge.

Contributors

TB contributed to conceptualisation, methodology, formal analysis, visualisation, and writing of the original draft. FO contributed to data curation and formal analysis. FO and JF contributed to writing, reviewing, and editing.

Declaration of interests

JF declares grants from Rockefeller Foundation and the Swiss Development Cooperation and is the Editor-in-Chief of *Global Food Security* and Associate Editor of *The American Journal of Clinical Nutrition*. TB and FO declare no competing interests.

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