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Higher adherence to the EAT-Lancet reference diet is associated with higher nutrient adequacy in the NutriNet-Santé cohort : a cross-sectional study

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Running Head: Nutritional quality assessment of the EAT-Lancet reference diet

Abbreviations:

AI: Adequate Intake

ANSES: Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail

BMI: Body Mass Index

CU: consumption unit

EAR: Estimated Average Requirements

EI: Energy Intake

EIWA: Energy Intake Without Alcohol

ELD-I: EAT-Lancet Diet Index

IPAQ: International Physical Activity Questionnaire

NCI: National Cancer Institute

PANDiet: diet quality index based on the probability of adequacy of nutrient intake

PNNS : Programme National Nutrition Santé

PNNS-GS2: PNNS Guidelines Score 2

Q: Quintile

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Abstract

Background: In 2019, the EAT-Lancet Commission proposed a planetary and healthy reference diet; however, its nutritional quality has been rarely evaluated.

Objective: Across different adherence levels to the EAT-Lancet reference diet, the following were our objectives: 1) describe the food and nutritional intakes of the French population, 2) to evaluate the nutrient quality and, 3) investigate the consistency between the French national recommendations and the EAT-Lancet reference diet.

Design: This cross-sectional study was conducted among participants of the NutriNet-Santé cohort and the sample was weighted on the characteristics of the general French population. Adherence to the EAT-Lancet reference diet was estimated using the EAT-Lancet Diet Index (ELD-I). Usual nutrient intakes were obtained using the variance reduction method. We used the estimated average requirements cut-point method to estimate the proportion of participants who meet their respective nutritional requirements. Furthermore, the adequacy of the French food-based dietary recommendations (*Programme National Nutrition Santé [PNNS]*) according to adherence to the EAT-Lancet reference diet was studied.

Results: The weighted sample was composed of 98,465 participants. Except for bioavailable zinc and vitamin B12, we observed a decrease in the nutrient inadequacy prevalence when the adherence to the EAT-Lancet reference diet increased, particularly for vitamin B9 (Q1=37.8% vs. Q5=5.5%, $p<0.0001$) and vitamin C (Q1=59.0% vs. Q5=10.8%, $p<0.0001$). However, inadequacy prevalence remained high in all ELD-I quintiles, particularly for fiber (95.9%), vitamin B1 (70.8%), iodine (48.4%), and magnesium (76.8%). Higher ELD-I score was associated with higher adherence for most components of the PNNS, except for food groups that are not specifically included in the EAT-Lancet reference diet and are typical of the French diet, including alcohol, processed meat, and salt.

25 **Conclusion:** In the French context, although issues with the intake of certain nutrients may
26 occur, a diet that remains within the planetary limits as the EAT-Lancet reference diet allows
27 a favorable nutritional quality.

28 **Keywords:** sustainable diet, nutritional quality assessment, healthy eating, food system.

Trial registration number: NCT03335644

29

Introduction

Currently, the greatest challenge facing food systems is providing an affordable and nutritionally adequate diet for a growing population while preserving the integrity of the planet (1–3). The current food production is one of the main factors of environmental degradation, whereas, in 2022, numerous planetary boundaries have already been transgressed, threatening humanity's viability on Earth (4–6). Several studies have shown that diets based on high intakes of plant-based products, and low intakes of meat and dairy products have lower environmental impacts (7–9).

Moreover, it is now established that modern diets, low in fiber and based on unhealthy energy-dense foods, animal and processed foods, that is, rich in salt, sugars and saturated fats (10), have harmful effects on health (2). Suboptimal diets, including Western diets, are therefore the third leading risk factor for mortality among adults worldwide (11) and contribute to the development of morbidity (12–14). In contrast, diets containing low to moderate amounts of animal products and rich in plant-based foods can help lower the prevalence of these chronic diseases (2,15–17). However, these diets cover various eating practices, both healthy and unhealthy (18–21). Despite not being well planned, vegetarian diets may be associated with nutritional inadequacy and an increased risk of micronutrient deficiencies (22–25).

In 2019, the EAT-Lancet Commission developed a universal planetary healthy reference diet, which is an evidence-based diet considering the multiple links between nutrition, health and the environment (2). Overall, the EAT-Lancet reference diet is a 2,500 kcal per day-diet, mainly characterized by vegetables, fruits, whole grain products, legumes, oleaginous, dairy products, and unsaturated oils. It consists of very moderate amounts of seafood, eggs, and poultry and considerably low amounts of products rich in added fats and sugars as well as animal-based products, including beef, pork and lamb.

Whether the EAT-Lancet reference diet, which is developed for global targets and setting very low or no intake values for several nutrient-rich food groups, is adequate to satisfy the nutritional needs of different populations remains debated. The EAT-Lancet reference diet has been applied, compared with various dietary guidelines, and studied in different socioeconomic and nutritional contexts; the results are inconsistent (26–33). For example, Blackstone and Conrad observed marked differences between the EAT-Lancet reference diet and the dietary guidelines for Americans for whole grains, fruits, starches, red meat, nuts, and discretionary foods, which are mostly key components of the EAT-Lancet reference diet (28). Overall, these studies documented that, depending on the country and culture, compliance with the EAT-Lancet reference diet may require strong changes in an individual's dietary habits and that the nutritional quality does not frequently seem to be guaranteed.

However, the nutritional adequacy of the EAT-Lancet reference diet, favoring plant-based products and greatly limiting the consumption of animal products, has not yet been studied in the French context.

Therefore, this study aimed to investigate the nutritional quality of the diets of participants of the NutriNet-Santé cohort according to the level of adherence to the EAT-Lancet reference diet. Across various levels of adherence to the EAT-Lancet reference diet, the following were the specific objectives: 1) describe the food and nutritional intakes of the French population, 2) evaluate the nutrient quality, and 3) study the consistency between the French national recommendations and the EAT-Lancet reference diet.

Methods

Data were collected from the NutriNet-Santé study, a French web-based prospective cohort launched in 2009. Adult volunteers aged 18 years old or older were recruited from the general population through a large multimedia campaign. Registration and follow-up are made online

on a dedicated website (www.etude-nutrinet-sante.fr). The NutriNet-Santé study's design and methods are described elsewhere (34). The NutriNet-Santé study is conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the French Institute of Health and Medical Research (IRB Inserm Research n° 0000388FWA00005831) and by the National Commission on Informatics and Liberty (CNIL n° 908450 and n°909216). This cohort is registered in ClinicalTrials.gov (NCT03335644). At inclusion, all participants signed an electronic informed consent via the online platform. This procedure is appropriate for web-based cohorts and has been validated by the abovementioned ethical and regulatory authorities.

Data collection

Sociodemographic and lifestyle factors

Participants completed a set of validated self-administered questionnaires (34) at baseline, in the same period during which they completed the first 24-h dietary records, and their sociodemographic and lifestyle characteristics as well as health status information were collected. Data collected included sex, age, education level, monthly household income, occupation, and marital status. Monthly household income was calculated per consumption unit (c.u.) according to a weighting system, where 1, 0.5, and 0.3 are attributed to the first adult in the household, each person aged 14 years or older, and all children under 14 years old, respectively (35). Lifestyle and anthropometric characteristics were self-reported using validated questionnaires (36,37) and body mass index (BMI) was calculated from the formula weight (kg)/height in meter squared (m^2). Three levels of physical activity were defined based on the metabolic equivalent of task (MET) minutes per week (MET-min/week): low (<600 MET-min/week), moderate (600-1500 MET-min/week), and high (>1,500 MET-min/week). For females, menopausal status was also collected.

Dietary data

Dietary intakes were assessed at enrollment and twice a year thereafter using a series of three non-consecutive 24-h dietary records, randomized over a 2-week period (two weekdays and one weekend day). Participants reported all food and beverages (type and quantity) consumed during a 24-h period: three main meals (breakfast, lunch, and dinner) and all other eating occasions. Supplements were not considered in nutrition intakes. Portion sizes were estimated according to standard measurements or using photographs from a previously validated photo booklet (38). Collection methods were validated against biomarkers of nutritional status and conventional data collection methods (39–41). Daily energy, macronutrient and micronutrient intakes were calculated using a published food composition table (42). Intake from composite dishes was calculated using reference recipes validated by nutrition professionals. Energy under-reporters were identified following Black's method (43) using Goldberg's cut-offs (44), and the basal metabolic rate was determined based on Schofield's equations (45) according to sex, weight, and height collected upon study enrollment.

Computation of nutritional scores

EAT-Lancet Diet Index (ELD-I)

Adherence to the EAT-Lancet reference diet was estimated using the ELD-I. This dietary score has been described elsewhere (46).

The ELD-I for an individual j can be written as follows, equation (1):

$$(1) \text{ ELD-I } j = \frac{100 \times \left\{ \sum_{\text{component } i=1}^{14} \frac{a_i \times \left(\text{cut-off}_i - \frac{\text{consumption}_{ij} \times 2500}{\text{Energy intake } j} \right)}{\text{cut-off}_i} \right\}}{14}$$

where i refers to the 14 EAT-Lancet food groups and j is the individual. $a_i = 1$ for component to limit and $a_i = -1$ for component to promote.

Computing of the ELD-I leads to a continuous variable (positive or negative). The higher the score, the higher the adherence to the EAT-Lancet reference diet. In the present study, the ELD-I was estimated for each participant using the average of all 24-h dietary records during the first 2 years following inclusion in the NutriNet-Santé cohort. All mixed dishes have been decomposed into ingredients, which were subsequently allocated to the ELD-I food groups.

Cut-offs values are presented in **Supplementary Table 1**.

French nutritional recommendation scores

As complementary approaches in the study of the quality of the EAT-Lancet scheme in the French context, we calculated the following two scores: the *Programme National Nutrition Santé* -Guidelines Score 2 (PNNS-GS2) and the PANDiet score.

The PNNS-GS2, which reflects adherence to current French food-based dietary guidelines (47), includes 13 dietary components, which are divided into six adequacy components and seven moderation components.

The PANDiet is a diet quality whose objective is to estimate the probability of adequacy of nutrient intakes (48). This score is decomposed into the following two sub-scores: an adequacy score based on the probabilities of the adequacy of 27 nutrients and a sub-score including 6 nutrients and 12 penalty values referring to the probabilities of exceeding the upper limits of intakes. We presented the complement to 100 of the PANDiet score ($100 - [\text{PANDiet} \times 100]$) to be consistent with estimates of the prevalence of nutritional inadequacy.

Statistical analyses

This study included participants registered in the NutriNet-Santé cohort between 2009 and 2015, and who validated at least three 24-h dietary records during the first 2 years following

enrollment into the cohort. Owing to dietary intakes potentially not representative of the usual diet, female participants who were pregnant during the dietary data collection period were excluded as well as those who had missing sociodemographic or socioeconomic data and resided in overseas territories (**Supplementary Figure 1**).

Our sample was weighted to improve its representativeness in relation to the French population. Individual weights were calculated, by sex, according to the 2009 national census on age, presence of children aged <18 years in the household, education level, occupation status, marital status, and area of residence using the iterative proportional fitting procedure, to adjust the percentage of individuals in each stratum to the actual percentage in the French population (49). In case of rare presence of certain socio-demographic profiles, this method can lead to very high weights. Participants with extreme weights were excluded from the analyses.

Baseline characteristics were described across weighted sex-specific quintiles (Q) of the ELD-I using mean and standard deviation or percentage. Food intakes were adjusted for total energy intake (EI) and usual nutrient intakes for usual EI without alcohol (EIWA) using the residual method (50). Food and nutrients data were presented as means with their standard errors (SEM). P-values were estimated using the Mantel–Haenszel χ^2 test for dichotomized or ordinal variables, χ^2 for other categorical variables, and generalized linear models with linear contrast for continuous variables.

To estimate the proportion of participants meeting each specific item of the EAT-Lancet reference diet in our sample, we estimated the mean intakes for each food group considered in the EAT-Lancet reference diet for the total sample and by ELD-I quintiles and subsequently calculated the proportion of participants reaching these recommendations. For this, we used the reference values proposed by Willett et al (2).

Nutrient inadequacy was defined as the prevalence of individuals whose usual intakes were below their individual nutrient requirements. For the estimation of inadequacy prevalence, the effects of day-to-day intake variability were removed to estimate a long-term mean nutrients intake, that is, the usual nutrient intake. We performed variance reduction using the National Cancer Institute method (51–53). The usual intake modeling was performed from MIXTRAN macro followed by INDIVINT macro, using a one-part model, with age at inclusion and sex as variable parameters. Nutrient inadequacy was assessed using the estimated average requirement (EAR) cut-point method (54); for each nutrient, the threshold value considered was the estimated average requirement declined according to age and sex. The proportion of participants whose usual intake was below the EAR was estimated for each nutrient across sex and ELD-I quintiles. At the population level, this proportion represents an unbiased estimate of the proportion of participants with inadequate intakes relative to their individual requirements (54). When the EAR was not available for a nutrient, we considered the proportion of participants with a low intake, using the adequate intake (AI). For zinc and iron, the threshold values considered were those of the estimated average physiological requirements. Therefore for each participant the bioavailable zinc and iron were computed using the published formula (55,56). Of note, because the nutritional requirement for iron in menstruating females is not symmetrical around the population mean (57,58), the EAR-cut point method could not be used for this subgroup (54). Therefore, for menstruating females we performed out the probabilistic approach based on the distribution of the physiological requirement for iron, as modelled for females of reproductive age (59) . The EAR and AI used were those proposed by the French Agency for Food, Environmental and Occupational Health Safety (ANSES) (60) (**Supplementary Table 2**). Furthermore, we calculated the PANDiet complementary across the ELD-I quintiles.

Finally, sensitivity analyses were performed. First analyses were performed after removing prevalent cancer, cardiovascular diseases, and types 1 and 2 diabetes. Subsequently, we estimated the proportion of participants meeting the recommendation for each component of the PNNS-GS2, by the adherence level to the ELD-I to investigate the coherence between the EAT-Lancet reference diet and the official French dietary guidelines.

All tests were two-sided, and $P < 0.05$ was considered statistically significant. Statistical analyses were performed using SAS[®] version 8.3 (SAS Institute) and R[®] version 4.0.4 (R Foundation).

Results

Sociodemographic and lifestyle characteristics

The final study sample included 98,465 participants followed between 2009 and 2015. (Flowchart in **Supplementary Figure 1**). Participant characteristics in the overall sample and across quintiles of the ELD-I are presented in **Table 1**. The sample was 78% female, and the average ELD-I score was 41.2 (range, -161.5 to 428.6) points (**Supplementary Table 3**). Better adherence to the EAT-Lancet reference diet was more frequently associated with older age and lower physical activity.

Food consumption and usual nutrient intakes according to the ELD-I

By construction, higher consumption of fruits, vegetables, legumes, nuts, and seafood was associated with higher ELD-I scores. Conversely, a higher score was associated with lower consumption of meat, eggs, tubers, fat, fatty and/or sweetened products, and sweetened soft drinks (**Table 2**).

Participants with high adherence to the EAT-Lancet reference diet had, on average, lower EI than those with low adherence (**Table 3**). We observed a minimal decrease in the overall

protein intake as the ELD-I increases; however, across ELD-I sex-specific quintiles, the percentage of animal protein decreased in favor of plant proteins. Compared with the participants with the lowest ELD-I, those with the highest had slightly increased carbohydrate consumption, whereas fat intake decreased. Moreover, as the score increased, so did the fiber intake. Across ELD-I quintiles, an increase in the intake of beta-carotene, calcium, copper, total iron, iodine, potassium, magnesium, manganese, phosphorus, vitamin A and vitamin B9 and vitamin C was observed while intake of cholesterol, vitamin B12 and heme-iron intake decreased. The polyunsaturated fatty-acid, zinc, retinol, sodium, selenium, vitamins B1, B2, B3, B5, B6 and vitamin E intake was similar across quintiles.

The proportion of individuals meeting the different EAT-Lancet reference diet components widely varied across food groups (**Figure 1 and Supplementary Table 4**). The components for which the proportions of participants meeting the recommendations varied the most across quintiles were fruits, vegetables, and red meat. However, it was observed that for legumes, nuts, and whole grains as well as unsaturated oils, the recommendations were overall very poorly met regardless of the ELD-I.

Nutrient quality

The complement to 100 of the PANDiet score and mean values of prevalence inadequacy for main macronutrients and micronutrients are shown in **Table 4**.

PANDiet complement gradually decreased across the ELD-I. Inadequacy prevalence for vitamins B9 and C gradually decreased across the ELD-I quintiles. This was also the case for vitamin A and calcium; however, this decrease stagnates between the fourth and fifth quintiles. Conversely, zinc was the only nutrient for which the inadequacy prevalence was the highest in quintile 5 (42.9 %) and the lowest in quintile 1 (38.6 %). In our sample, inadequacy intakes for protein (1.8 %), copper (1.9 %), vitamin B3 (3.6 %) and iron in males and

menopausal females (1.4 %) were small. In non-menopausal females, the prevalence of bioavailable iron inadequacy of approximately 35% equal in all quintiles. Regarding fiber intake, although the inadequacy prevalence decreased with increasing ELD-I, the intake was by far insufficient whatever the quintile. The results of the sensitivity analysis after removing participants with prevalent chronic diseases were unchanged (**Supplementary Table 5**).

Sex differences in the prevalence of nutrient inadequacy are presented in **Supplementary Table 6**

As shown in **supplementary table 7**, the average proportion of participants with an intake is considered low (i.g. below the AI for the French population); however, in some cases, these intakes may potentially meet their individual micronutrient requirements. For vitamins B1, B6, E, magnesium, and manganese, this proportion gradually decreased across the ELD-I quintiles. Moreover, for selenium, vitamin B1 and magnesium a high prevalence of participants had intakes that were considered low. Regarding phosphorus, < 1% of our sample had intakes that were considered low.

Consistency between the EAT-Lancet reference diet and the French dietary recommendations

The PNNS-GS diet quality score gradually increased across ELD-I quintiles (**Table 5**). Regarding adherence to individual components of the PNNS-GS2 across ELD-I quintiles (**Supplementary Figure 2 and Table 5**), we observed similar trends for the components common to the EAT-Lancet reference diet. That is, across ELD-I quintiles, we observed a marked increase in the proportion of participants following the recommendations for fruits, vegetables and red meat as well as moderate-to-low proportions in whatever quintiles for nuts, legumes, fish, and dairy products. Regarding the groups of foods specific to the PNNS, including processed meats, alcohol, and salt, the proportion of participants respecting the

recommendations decreased in the first quintile and subsequently increased in the other quintiles. The proportion of participants following the recommendations for salt was equal in quintiles 1 and 5 and lower in the fifth quintile for alcohol consumption.

Discussion

In the present study, we investigated the dietary and usual nutrient quality of French adults across adherence levels to the EAT-Lancet reference diet. Attention is needed regarding fiber, calcium, vitamin C, bioavailable zinc, and bioavailable iron (in non-menopausal females) intakes. Nutrient inadequacy regarding macronutrient as protein and fiber decreased across ELD-I. For micronutrients, the lowest prevalence of inadequacy was observed for the participants with the highest adherence to the EAT-Lancet reference diet. Differences in food consumption according to ELD-I levels were substantial for only a few foods, with plant-based consumption being too low for any adherence level to the EAT-Lancet reference diet. Therefore, participants in the highest ELD-I score quintile remain far from meeting the recommendations of the EAT-Lancet reference diet. Additionally, the specific components of the French PNNS recommendations (salt, alcohol, and processed meat) were not better followed for higher adherence to the EAT-Lancet reference diet.

First, as noted in other studies (29,32), animal protein intake decreased across ELD-I quintiles. Although this decrease was largely offset by an increase in plant protein intake, as Hanley–Cook and Vallejo (30,32), we observed, a decrease in the proportion of energy provided by protein with increasing adherence to the EAT-Lancet reference diet.

Nevertheless, current evidence shows that, in high-income countries, plant-based diets can provide sufficient protein and essential amino acid intakes (25,61); therefore, more attention should be focused on fiber-related issues. The increase in plant-based foods promoted by the EAT-Lancet reference diet unequivocally allowed for an increase in fiber intake whatever the context (26,29,32). In our sample, the participants, whatever their ELD-I quintile, were very

far from the cut-off point provided by the PNNS. Higher adherence to plant-based components, including fruits, vegetables, legumes, and whole grains, would also lead to better adherence to the French reference values (30 g/day). Contrary to other studies (26,29,32), in the French context, we noted a decrease in the total fat intake across ELD-I quintiles. This should be ascribed to the fact that higher scores are mainly related to higher fruit and vegetable consumption and the decrease in meat, with lower increases in other products, such as nuts, which therefore cannot contribute to limiting the decrease in fat intake.

In our study, except for bioavailable zinc, the prevalence of nutrient inadequacy decreased with increasing adherence to the EAT-Lancet reference diet, particularly for vitamins C and B9, wherein the inadequacy prevalence was greatly reduced between the least and most adherent to the reference diet. In the study by Tucci et al. (29), zinc and vitamin B12 intakes were lower in participants who followed the EAT-Lancet reference diet; however, in these participants, intakes of these nutrients both met the national reference values, whereas calcium intakes were inadequate. A study conducted in the Danish population reported similar results for vitamin B12 and calcium (26). In these two populations, the insufficient intakes among participants who followed better the EAT-Lancet reference diet were explained by the low consumption of animal-based foods and more particularly of dairy products for calcium; however, dairy products are encouraged in the EAT-Lancet reference diet. However, in our study, the participants with higher adherence to the EAT-Lancet reference diet showed some intakes of these products, and in particular a higher consumption of dairy products than those in the first quintiles, which may explain that a high prevalence of inadequate intakes of calcium, zinc and vitamin B12 was not observed. Our results were consistent with the results of an observational study conducted on a sample of French adults, simulating a total or partial replacement of meat by plant-based substitutes, resulting in a decrease in the adequacy of vitamin B12 and bioavailable zinc and iron (62). Nutritional references for bioavailable iron

and zinc often appear to be the primary limiting factors in a transition to a plant-based diet; however, official thresholds lower than current values, not jeopardizing overall health, would allow for the identification of healthier diets (63,64). Furthermore, among non-menopausal females, although the prevalence of inadequacy was high, they were not reduced in the quintiles where meat consumption was the highest.

Overall, nutritional quality was better in the highest ELD-I quintiles. However, a study by Hanley–Cook (30) showed that in some populations, it is essential that the diet still include some nutrient-dense foods for nutritional adequacy to be improved by the EAT-Lancet reference diet. In our study the participants with the highest adherence to the EAT-Lancet reference diet did not attain the consumption target for all 14 components. In our study, participants with high adherence to the EAT-Lancet reference diet had a suboptimal and improvable diet. For example, on average they had a very high tuber and starchy vegetable consumption and a very low legume, whole grain, and nut consumption. However, dietary intakes remained sufficiently varied to cover most nutritional needs. However, other studies that have developed a plant-based diet that meets the EAT-Lancet targets adapted to Italian (29) and Danish (26) intakes showed that these highly strict targets can be challenging in achieving certain national references values.

Dietary recommendations varied from country to country and were nearly consistent with the EAT-Lancet reference diet. The PNNS-GS2 was consistent with the EAT-Lancet reference diet for fruits and vegetables, dairy products, and unsaturated fats (65); components for which (except for fruits) the Dietary Guidelines for Americans recommendations were also consistent with those of the EAT-Lancet Commission (28). However, the two national recommendations differed from the EAT-Lancet reference diet in several aspects, including the recommended serving sizes of whole grains, red meat and poultry, nuts, and legumes, which were essential components of this reference diet. These facts show the significance of

344 adapting dietary recommendations to the habits and cultures of each country, to account for
345 the variability in the food offered and cultural specificities (66). Processed meat, alcohol, or
346 salt, which are typical components of the French diet and therefore are to be limited according
347 to the PNNS (65), are not specifically considered in the EAT-Lancet reference diet and that
348 higher adherence to this reference diet tended to result in lower compliance with
349 recommendations related to these components. These disparities in components between the
350 EAT-Lancet reference diet and the French PNNS recommendations partly explain the lower
351 associations previously observed between the ELD-I score and the occurrence of cancers and
352 the nonsignificant associations with cardiovascular diseases (67) compared with those with
353 the PNNS-GS2 score (68), wherein the inverse associations were highly significant. These
354 two studies focused on existing dietary recommendations, defined differently (EAT-Lancet
355 and Official French dietary guidelines), and the risk of chronic diseases. Additionally, it is
356 observed that intakes were similar between quintiles, for some food groups and nutrients,
357 suggesting that the differences observed in terms of health impact were more related to those
358 components for which large differences were observed such as fruits, vegetables, red meat,
359 sweet products, and whole grains for foods, and vitamins C, B9, and magnesium for nutrients.

360 Moreover, adherence to the EAT-Lancet reference diet has been studied in other settings,
361 particularly in Gambia (69). In this population, as in our study, the intake of unhealthy plant-
362 based foods, including sugars and refined cereals, was excessively high and that of healthy
363 plant-based foods was excessively low. However, in the Gambian context, the consumption of
364 red and white meat and dairy products was below the EAT-Lancet reference diet range in
365 most households. In this country, beyond the financial barrier, the production and supply of
366 these food groups are challenging. Furthermore, consistent with our study, Bäck et al (31)
367 estimated the proportion of participants meeting each of the EAT-Lancet reference diet target
368 in Finnish children. In both populations, very low proportions (<10%) of participants met the

EAT-Lancet reference diet target for whole grains, legumes, nuts, saturated oils, and sugars, which are key components of the reference diet. These different comparisons confirm the need for not only adapting dietary recommendations to cultural habits (70,71) and the capacities of each country in terms of production and provisioning but also for specifically adapting them to individual preferences since a remarkable change from their usual food consumption could make several individuals reluctant to adhere to these new reference diet (72). In our study, we observe that the recommendations were followed differently according to participants profiles and that the EAT-Lancet reference diet was more followed by older and higher income participants. Therefore, it is also significant to adapt the messages related to the dietary recommendations to less-adherent individuals.

This study had some limitations. First, there is a lack of official values for the EAR of certain nutrients. When these values were unavailable although the AI was, we used the AI, which provides an indication of the proportion of participants with low intakes compared with an arbitrary threshold; however, for some participants, this intake may be sufficient as regards their individual physiology. Furthermore, some limitations inherent to the NutriNet-Santé cohort should be acknowledged. Indeed, owing to the voluntary-basis recruitment, the participants of the NutriNet-Santé cohort may be more health conscious and therefore exhibit healthier dietary habits (73,74) that may differ from those of the general population in particular regarding health and risk factors including diet. However, the large sample includes usually inaccessible individuals, including young adults, older or jobless population (73). However, this limited representativeness is minimized herein by weighting on a number of socioeconomic characteristics to best mimic the national population. Moreover, the small number of studies on the topic and the disparities in dietary habits between countries make comparisons challenging.

However, our study also exhibited significant strengths. First, we have used very detailed and high-quality nutritional data, with an average number of 5.9 24-h dietary records per participant. Additionally, the dietary assessment method used in the NutriNet-Santé cohort was validated by comparing with urinary and blood biomarkers (39,40) as well as supervised assessment performed by dietitians (41). Furthermore, the nutritional adequacy study was performed on usual consumption data, which allows limiting the intra-individual variation. Additionally, to better consider the ingredients of different foods, complex recipes were disaggregated into individual ingredients. Lastly, the very large sample of participants allows assessing a wide range of dietary profiles.

Conclusion

In French context, overall, although some key nutrient intakes remain challenging, including fibers, calcium, bioavailable zinc and vitamin C, a higher adherence to the global EAT-Lancet reference diet is associated with higher nutritional adequacy. In the context of environmental emergency, the inadequacy prevalence in certain nutrients should not be a barrier to a transition to a higher proportion of plant-based foods in the diet, especially since, overall, these diets present better nutritional profiles. However, the acceptability of this type of recommendation is a major issue of this diet as well as accessibility and cost, which must be studied to determine if they are fully compatible with a sustainable diet.

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Authors' contributions:

The authors' contributions were as follows: EKG and FB designed the study. FB performed statistical analyses and wrote the manuscript; EKG supervised statistical analysis and paper writing. All authors: contributed to the data interpretation and revised each draft for important intellectual content. All authors read and approved the final manuscript. FB and EKG had full access to all the data in the study, EKG takes responsibility for the integrity of the data and the accuracy of the data analysis, she is the guarantor. The corresponding author (FB) attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Transparency statement

Dr Emmanuelle Kesse-Guyot (the guarantor) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

Conflict of Interest

The authors declare no conflict of interest.

Data sharing statement

Analytic code will be made available upon request pending. Researchers from public institutions can submit a collaboration request including information on the institution and a brief description of the project to collaboration@etude-nutrinet-sante.fr. All requests will be reviewed by the steering committee of the NutriNet-Santé study. If the collaboration is accepted, a data access agreement will be necessary and appropriate authorizations from the competent administrative authorities may be needed. In accordance with existing regulations, no personal data will be accessible.

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Table 1. Description of socio-demographic and lifestyle characteristics at inclusion, by weighted sex-specific quintiles of EAT-Lancet Diet Index. NutriNet-Santé study, 2009-2015, France (n=98,465)

	Weighted sex-specific quintiles of ELD-I ¹						p-value ²
	All	Q1	Q2	Q3	Q4	Q5	
n	98,465	16,758	19,805	20,609	20,704	20,589	
Weighted n	98,465	19,673.1	19,696.7	19,704.6	19,692.7	19,698.9	
ELD-I	41.2 (27.5)	4.3 (18.6)	28.8 (4.4)	41.1 (3.8)	53.3 (4.6)	78.4 (14.4)	<0.0001
Sex %							1.00
Females	78.0	78.0	78.0	78.0	78.0	78.0	
Age (y)	47.4 (16.1)	40.8 (15.8)	44.1 (15.4)	47.7 (15.7)	51.2 (15.2)	53.3 (15.0)	<0.0001
Age category (y)							<0.0001
< 25	11.1	17.5	14.3	10.6	7.2	6.1	
25 - 40	25.2	34.9	29.5	25.3	20.0	16.5	
40 - 55	27.2	28.9	28.5	27.5	25.8	25.0	
55- 65	17.1	10.8	14.9	16.7	21.4	21.9	
≥ 65	19.4	7.9	12.8	19.9	25.6	30.5	
Education level, %							<0.0001
< High-school degree	53.8	58.4	52.4	52.1	53.6	52.9	
≥ High-school degree to < 2 y after high-school degree	17.4	19.2	18.5	17.2	15.6	16.3	
≥ 2 y after high-school degree	28.8	22.5	29.1	30.7	30.8	30.8	
Occupational category, %							<0.0001
Unemployed	4.3	6.0	5.1	4.0	3.4	3.0	
Farmer. merchant. artisan. company director	6.0	5.6	6.1	5.7	5.9	6.8	
Employees, manual workers	49.0	59.1	50.8	46.5	43.4	40.1	
Intermediate profession	25.1	19.4	24.1	26.3	27.6	28.3	
Managerial staff	16.6	9.9	13.9	17.5	19.7	21.8	
Monthly household income³, %							<0.0001
No communicated	13.0	14.4	12.7	12.9	12.2	13.0	
<1.200 €	22.6	34.3	26.1	20.5	17.7	14.3	
1.200 – 1.800 €	27.8	27.8	29.0	29.0	27.7	25.7	
1.800 – 2.700 €	21.6	14.7	20.0	22.3	24.6	26.3	
≥ 2.700 €	15.0	8.8	12.2	15.3	17.8	20.7	
Marital status, %							<0.0001
Single	9.9	9.5	9.4	9.3	10.0	11.5	
Married. civil union. cohabiting	75.9	76.7	77.9	77.5	75.3	72.2	
Separated. divorced. widowed	14.2	13.8	12.7	13.2	14.7	16.3	
Smoking status, %							<0.0001
Never smoker	47.8	42.9	48.1	48.6	50.2	49.4	
Former smoker	35.3	30.5	32.6	35.7	37.5	40.4	
Current smoker	16.8	26.5	19.4	15.7	12.4	10.2	
Level of physical activity⁴, %							<0.0001
Missing	17.2	21.1	18.3	16.0	16.0	14.7	
Low	32.5	28.6	29.6	31.7	33.6	39.0	
Moderate	31.2	28.3	30.1	31.8	33.7	32.0	
High	19.1	22.0	22.0	20.5	16.7	14.3	
Body Mass Index (kg/m²)	24.7 (5.1)	25.3 (6.3)	24.9 (5.2)	24.7 (4.8)	24.6 (4.6)	24.0 (4.0)	
Prevalent chronic disease⁵, %	10.3	7.7	9.0	10.5	11.9	12.4	<0.0001
Food supplementation⁶, %	35.4	26.4	30.6	35.0	38.6	44.3	<0.0001

Abbreviations: Q: quintiles; ELD-I: EAT-Lancet Diet Index.

Mean (standard deviation) for quantitative variables and percentages for qualitative variables.

¹ Sex-specific cut-offs for quintiles of ELD-I were -140.1/23.8/36.3/46.5/59.2/332.2 for females and -161.5/27.8/40.7/51.7/65.2/323.9 for males.

² P-value for comparison across weighted quintiles of ELD-I estimated by test from Mantel-Haenszel χ^2 for binary or ordinals variables, χ^2 for others categorical variables and generalized linear models with linear contrast for numeric variables.

³ Per consumption unit.

⁴ Physical activity: low (< 600 MET-min/week), moderate (600-1,500 MET-min/week) and high (> 1,500 MET-min/week).

⁵ The following are considered: prevalent cases of type 1 and type 2 diabetes, cancers excluding basal cell cancer and cardiovascular diseases.

⁶ Among 75,890 participants.

Table 2. Daily food consumption¹ according to weighted sex-specific quintiles of the EAT-Lancet Diet Index. NutriNet-Santé**study, 2009 – 2015, France**

	Target ¹ (g/day)	All	Weighted sex-specific quintiles ³					P-trend ⁴
			Q1	Q2	Q3	Q4	Q5	
Whole grains	≥ 232	45.4 (60.1)	26.2 (47.7)	35.2 (50.7)	42.8 (54.3)	52.3 (59.2)	70.3 (73.2)	<.0001
Tubers and starchy vegetables	≤ 50	65.0 (60.4)	82.0 (80.4)	68.5 (58.9)	63.7 (54.7)	59.8 (51.5)	51.2 (51.8)	<.0001
Vegetables	≥ 300	309.6 (185.3)	212.1 (152.0)	249.7 (142.9)	291.2 (140.8)	342.9 (148.5)	452.0 (224.4)	<.0001
Fruits	≥ 200	263.8 (211.5)	107.6 (116.1)	160.4 (112.7)	221.0 (121.9)	308.4 (132.7)	521.3 (240.0)	<.0001
Dairy foods	≤ 250	225.9 (210.3)	238.0 (219.4)	229.1 (205.7)	227.4 (196.0)	239.1 (201.5)	258.0 (232.2)	<.0001
Protein sources								<.0001
Beef and lamb	≤ 7	30.6 (46.7)	70.3 (78.2)	32.0 (36.6)	22.0 (29.5)	16.9 (25.5)	11.9 (23.5)	<.0001
Pork	≤ 7	17.5 (30.0)	32.6 (50.7)	19.1 (26.9)	15.4 (22.9)	12.4 (19.7)	8.1 (16.4)	<.0001
Poultry	≤ 29	37.8 (45.3)	48.6 (64.8)	40.8 (43.1)	35.4 (38.4)	33.9 (38.5)	30.3 (38.2)	<.0001
Eggs	≤ 13	20.5 (27.9)	31.4 (44.4)	21.3 (25.6)	18.3 (22.6)	16.7 (19.9)	14.8 (20.2)	<.0001
Fish	≥ 28	43.8 (49.9)	37.9 (59.0)	40.7 (48.3)	42.4 (44.8)	45.8 (44.2)	51.9 (52.6)	<.0001
Legumes	≥ 75	15.8 (32.1)	12.8 (30.4)	14.2 (29.2)	15.9 (31.9)	16.3 (29.2)	19.7 (38.3)	<.0001
<i>Dry beans, lentils and peas</i>	≥ 50	14.3 (32.3)	12.6 (30.5)	13.7 (29.4)	15.0 (31.3)	14.6 (29.9)	15.5 (39.1)	<.0001
<i>Soy foods</i>	≥ 25	1.5 (13.8)	0.2 (5.2)	0.5 (7.2)	0.9 (8.9)	1.7 (13.7)	4.2 (23.8)	<.0001
All nuts	≥ 50	5.7 (17.7)	1.4 (7.0)	2.6 (9.5)	4.2 (11.4)	6.9 (16.1)	13.4 (29.9)	<.0001
<i>Peanuts</i>	≥ 25	1.8 (7.4)	0.3 (2.7)	0.7 (3.8)	1.2 (4.4)	2.2 (6.7)	4.6 (13.0)	<.0001
<i>Tree nuts</i>	≥ 25	3.9 (11.3)	1.1 (5.1)	1.9 (6.6)	3.0 (8.2)	4.7 (10.5)	8.8 (18.4)	<.0001
Added fats								<.0001
Unsaturated oils	≤ 40	7.0 (9.4)	5.3 (9.1)	6.1 (8.4)	6.9 (8.7)	7.9 (9.5)	9.0 (10.5)	<.0001
Saturated oils	≤ 11.8	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.2)	0.0 (0.0)	0.0 (0.1)	0.13
Added sugars	≤ 31	44.5 (25.8)	54.7 (35.7)	50.5 (25.8)	45.1 (21.7)	39.9 (19.4)	32.1 (18.7)	<.0001

¹ Food consumption (g/d) standardized about 2,500 kcal/day.² Dietary targets of the EAT-Lancet reference diet.³ Sex-specific cut-offs for quintiles of EAT-Lancet Diet Index (ELD-I) were -161.5/22.2/36.5/48.1/62.4/428.6 for females and -148.7/18.2/31.8/42.5/55.7/332.2 for males.⁴ P-value for comparison across quintiles of ELD-I estimated by linear contrast models.

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Table 3. Daily usual nutrient intakes according to weighted sex-specific quintiles of the EAT-Lancet Diet Index¹. NutriNet-Santé study, 2009 – 2015, France (n=98,465)

	Weighted sex-specific quintiles of ELD-I ²				
	Q1	Q2	Q3	Q4	Q5
Energy intake (kcal)³	1,829.2 (424.9)	1,897.9 (385.1)	1,888.7 (366.5)	1,865.5 (357.2)	1,791.7 (357.1)
Energy intake without alcohol (kcal)²	1,766.5 (403.1)	1,820.2 (358.4)	1,808.2 (338.3)	1,786.0 (330.2)	1,724.2 (331.1)
Macronutrients					
Proteins (% of EIWA)	18.6 (3.6)	17.7 (2.7)	17.5 (2.4)	17.5 (2.4)	17.5 (2.7)
<i>Animal protein (g)</i>	60.3 (14.1)	56.2 (11.1)	54.1 (10.8)	52.8 (11.2)	49.8 (13.3)
<i>Plant protein (g)</i>	22.0 (3.9)	23.3 (3.7)	24.3 (3.8)	25.6 (4.1)	27.6 (5.3)
Carbohydrates (% of EIWA)	40.8 (5.6)	42.0 (4.7)	42.3 (4.4)	42.9 (4.5)	44.3 (5.1)
<i>Simple carbohydrates (g)</i>	84.8 (21.1)	86.7 (18.0)	88.1 (16.5)	91.3 (15.8)	99.8 (18.2)
<i>Added simple sugars (g)</i>	42.1 (18.5)	39.9 (14.9)	37.2 (13.1)	34.4 (12.2)	30.4 (12.2)
Lipids (% of EIWA)	40.6 (4.6)	40.3 (4.1)	40.2 (4.0)	39.5 (4.1)	38.2 (4.8)
<i>MUFA (g)</i>	30.6 (4.1)	30.3 (3.9)	30.3 (3.9)	30.0 (4.1)	29.2 (4.8)
<i>PUFA (g)</i>	11.2 (2.0)	11.1 (1.9)	11.2 (1.9)	11.4 (2.1)	11.7 (2.6)
PUFA n3 (g)	0.8 (0.2)	0.9 (0.2)	0.9 (0.2)	1.0 (0.3)	1.1 (0.3)
PUFA n6 (g)	0.2 (0.0)	0.2 (0.0)	0.1 (0.0)	0.1 (0.0)	0.1 (0.0)
<i>SFA (g)</i>	33.5 (5.0)	33.6 (4.8)	33.3 (4.6)	32.3 (4.8)	30.0 (5.2)
<i>Cholesterol (mg)</i>	340.5 (63.9)	326.0 (51.7)	315.8 (49.8)	305.2 (50.1)	280.6 (58.5)
Fibers	15.6 (3.6)	17.0 (3.4)	18.6 (3.5)	20.4 (3.7)	24.1 (5.1)
Alcohol (g)	9.0 (13.0)	11.1 (13.9)	11.5 (13.6)	11.4 (13.2)	9.7 (11.6)
Micronutrients⁴					
Calcium (mg)	857.4 (189.2)	889.3 (168.3)	910.3 (164.4)	930.7 (160.3)	954.5 (178.9)
Copper (mg)	1.4 (0.3)	1.5 (0.3)	1.5 (0.3)	1.6 (0.3)	1.8 (0.4)
Iron (mg)	12.5 (2.4)	12.6 (2.3)	13.0 (2.3)	13.4 (2.4)	14.1 (2.6)
Non-heme iron (mg)	1.5 (0.5)	1.3 (0.5)	1.2 (0.5)	1.2 (0.5)	1.0 (0.5)
Iodine (µg)	151.3 (36.6)	154.7 (33.5)	159.9 (37.0)	164.5 (40.4)	166.5 (44.9)
Zinc (mg)	10.8 (2.1)	10.6 (2.0)	10.6 (2.0)	10.6 (2.0)	10.4 (2.0)
Magnesium (mg)	297.1 (65.5)	308.8 (62.2)	321.7 (61.5)	341.5 (66.7)	372.9 (78.2)
Manganese (mg)	3.2 (1.1)	3.5 (1.2)	3.9 (1.2)	4.2 (1.3)	4.9 (1.6)
Phosphorus (mg)	1,249.7 (200.9)	1,240.7 (166.8)	1,244.0 (162.5)	1,262.0 (168.0)	1,290.6 (182.1)
Potassium (mg)	2,724.6 (462.6)	2,786.1 (420.9)	2,888.3 (411.3)	3,051.2 (426.4)	3,348.8 (536.0)
Selenium (µg)	68.5 (13.5)	67.5 (11.9)	67.6 (11.4)	68.6 (12.0)	69.1 (12.4)
Sodium (mg)	2,643.0 (463.8)	2,692.0 (417.8)	2,748.1 (419.4)	2,751.7 (413.5)	2,692.7 (452.8)
Retinol (µg)	445.1 (114.4)	458.3 (109.1)	459.0 (108.0)	454.2 (112.3)	415.9 (117.6)
Beta-carotene (µg)	2,599.1 (1,012.4)	2,925.1 (948.3)	3,234.6 (976.7)	3,629.8 (1,083.7)	4,180.0 (1,419.8)
Vitamin A (µg)	914.6 (198.1)	971.8 (183.7)	1,015.7 (189.5)	1,070.6 (202.9)	1,122.5 (240.6)
Vitamin B1 (mg)	1.1 (0.2)	1.1 (0.2)	1.1 (0.2)	1.2 (0.2)	1.2 (0.3)
Vitamin B2 (mg)	1.7 (0.4)	1.7 (0.3)	1.7 (0.3)	1.7 (0.3)	1.8 (0.4)
Vitamin B3 (mg)	18.6 (4.0)	18.3 (3.5)	18.2 (3.3)	18.6 (3.4)	19.1 (3.6)
Vitamin B5 (mg)	5.2 (0.9)	5.1 (0.8)	5.2 (0.8)	5.3 (0.8)	5.4 (0.8)
Vitamin B6 (mg)	1.7 (0.3)	1.6 (0.3)	1.7 (0.3)	1.7 (0.3)	1.9 (0.4)
Vitamin B9 (µg)	278.5 (57.9)	295.5 (52.9)	313.7 (53.5)	337.8 (55.2)	376.0 (70.8)
Vitamin B12 (µg)	5.1 (1.2)	5.0 (1.1)	4.9 (1.1)	4.9 (1.2)	4.8 (1.4)
Vitamin C (mg)	89.4 (37.0)	98.8 (34.9)	107.4 (33.5)	120.8 (35.5)	143.6 (44.1)
Vitamin E (mg)	10.8 (2.2)	11.1 (2.0)	11.3 (2.0)	11.8 (2.1)	12.5 (2.3)

Abbreviations: Q: Quintile; ELD-I: EAT-Lancet Diet Index; EIWA: Energy intake without alcohol; PUFA: Poly unsaturated fatty acids; MUFA: mono unsaturated fatty acids; SFS: saturated fatty acids.

¹ P-value for comparison between quintiles of ELD-I estimated by linear contrast models. All p-values were significant, except added carbohydrates (p=0.1087).

² Sex-specific cut-offs for quintiles of EAT-Lancet Diet Index (ELD-I) were -161.5/22.2/36.5/48.1/62.4/428.6 for females and -148.7/18.2/31.8/42.5/55.7/332.2 for males.

³ Values are means (SD).

⁴ Means (standard errors) adjusted for energy intake without alcohol using the residual method, except for alcohol.

Table 4. Prevalence of nutrient inadequacy¹, full sample, and by weighted sex-specific quintiles of the EAT-Lancet Diet Index. NutriNet-Santé study, France, 2009 – 2015 (n=98,465)

	All	Weighted sex-specific quintiles of ELD-I					P-value ³
		Q1	Q2	Q3	Q4	Q5	
PANDiet complement to 100⁴	36.6 (8.7)	41.3 (8.2)	39.3 (7.5)	37.4 (7.5)	34.5 (7.5)	30.2 (8.1)	<.0001
Proteins	1.8	3.1	1.5	1.5	1.1	2.0	<.0001
Fibers	95.9	99.5	98.9	98.3	95.9	86.7	<.0001
Vitamin A	6.4	11.9	6.5	5.2	3.9	4.7	<.0001
Vitamin B3	3.6	4.0	3.4	3.4	3.5	3.5	0.01
Vitamin B9	18.4	37.8	23.7	15.7	9.6	5.5	<.0001
Vitamin C	34.6	59.0	45.7	34.7	22.8	10.8	<.0001
Calcium	27.9	39.0	29.4	24.6	23.2	23.3	<.0001
Copper	1.9	4.7	2.1	1.4	0.9	0.6	<.0001
Bioavailable iron							
Males and menopausal females	1.4	2.9	1.2	0.7	0.9	1.6	<.0001
Non-menopausal females ⁵	35.0 (23.7)	33.7 (26.2)	35.9 (23.6)	35.7 (22.7)	34.7 (22.5)	35.4 (23.6)	0.0026
Bioavailable zinc	40.8	38.6	40.3	40.8	41.2	42.9	<.0001

Mean (standard deviation) for quantitative variables and percentages for qualitative variables.

¹ The probability of nutrient intakes below the estimated average requirements for the French population, %. Probability estimated only for nutrients for which ANSES has proposed an EAR.

² Sex-specific cut-offs for quintiles of EAT-Lancet Diet Index (ELD-I) were -161.5/22.2/36.5/48.1/62.4/428.6 for females and -148.7/18.2/31.8/42.5/55.7/332.2 for males.

³ P-value for comparison across weighted quintiles of ELD-I estimated by test from generalized linear models with linear contrast for numeric variables and Mantel-Haenszel χ^2 for binary variables.

⁴ Complementary to 100 of the diet quality index based on probability of adequate nutrient intake ($100 - [\text{PANDiet} \times 100]$) (n=98,120).

⁵ Due to the non-symmetry distribution around the iron requirements average in non-menopausal females, the EAR-cut method is not applicable in this sub-population. Bioavailable iron was obtained using complementary to 100 of the probability of adequate nutrient intake as calculated in the PANDiet.

Table 5. Proportion (%) of participants meeting each PNNS recommendation¹ according to weighted sex-specific quintiles of the EAT-Lancet Diet Index. NutriNet-Santé study, 2009 – 2015, France

Dietary components	Recommendation	All	Weighted sex-specific quintiles of ELD-I ²					p-value ³
			Q1	Q2	Q3	Q4	Q5	
PNNS-GS2		1.4 (3.5)	-0.5 (3.6)	0.3 (3.2)	1.1 (3.1)	2.1 (3.0)	3.7 (3.0)	<0.0001
Simplified PNNS-GS2		1.6 (3.5)	-0.4 (3.7)	0.4 (3.3)	1.2 (3.1)	2.3 (3.0)	4.0 (3.0)	<0.0001
Fruits and vegetables	≥ 5 servings/ d	51.4	11.9	27.7	47.2	73.3	93.4	<0.0001
Organic fruits and vegetables ⁴	Most of the time	11.1	5.5	8.0	10.2	12.8	17.9	<0.0001
Nuts	≥ 1 serving/ d	5.1	1.0	2.1	4.0	6.9	10.9	<0.0001
Legumes	≥ 1 servings / week	4.7	3.8	4.9	4.7	4.3	6.0	<0.0001
Organic legumes ⁴	Most of the time	10.1	3.6	6.2	9.0	12.4	18.0	<0.0001
Whole grain food	1-2 servings/ d	22.3	11.4	16.5	20.4	27.3	34.8	<0.0001

(n=92,770)

Organic legumes ⁴	Most of the time	8.6	2.8	4.6	7.3	10.5	16.5	<0.0001
Milk and dairy products	1.5-2.5 servings/ d	31.9	30.3	33.2	33.5	32.1	30.1	0.15
Red meat	< 500 g/ week	76.7	54.3	73.4	80.7	84.5	89.1	<0.0001
Processed meat	< 150 g/ week	42.3	39.0	36.9	38.6	43.3	53.1	<0.0001
White ham ⁴	> 50 %	32.2	29.1	28.3	29.6	34.1	43.8	<0.0001
Fish and seafood	1.5-2.5 servings/	16.7	14.6	17.5	18.1	17.1	16.0	0.01
Fat fish ⁴	0.5-1.5 servings/ week	24.3	19.0	23.7	25.7	26.7	25.6	<0.0001
Added fat	≤ 16 % of EIWA	81.2	80.4	82.0	81.1	80.2	82.1	0.07
ALA-rich and olive oil ⁶	≥ 50 %	37.9	23.5	30.5	38.3	44.1	50.4	<0.0001
Plant fat ⁴	>50 %	76.2	77.6	74.1	74.8	76.0	78.4	0.0003
Sugary foods	< 10 % of EIWA	78.1	63.6	69.2	77.8	85.8	92.7	<0.0001
Sweet-tasting beverages	0 ml/ d	24.8	23.3	22.5	22.2	24.2	31.5	<0.0001
Alcoholic beverages	0 g/ week	33.5	43.7	32.4	28.1	27.4	36.5	<0.0001
Salt	≤ 6 g/ d	18.1	22.9	16.1	14.0	15.3	22.4	0.17

Abbreviations: PNNS: Programme National Nutrition Santé; Q: Quintile; EIWA: Energy intake without alcohol.

Mean (standard deviation) for quantitative variables and percentages for qualitative variables.

¹ Recommendations of the fourth Programme National Nutrition Santé 2017-2021.

² Cut-offs for quintiles of ELD-I were -161.5/22.2/36.5/48.1/62.4/428.6 for females and -148.7/18.2/31.8/42.5/55.7/332.2 for males.

³ P-value for comparison across weighted quintiles of ELD-I estimated by test from generalized linear models with linear contrast for numeric variables and Mantel-Haenszel χ^2 for binary variables.

⁴ Dietary index reflecting the adherence to the 2017 French food-based dietary guidelines, penalized on energy intake (n=76,252).

⁵ Dietary index reflecting the adherence to the 2017 French food-based dietary guidelines, penalized on energy intake and simplified (n=92,770).

⁶ Among 76,252 participants.

Figure 1. Proportion of participants meeting each EAT-Lancet reference diet item according to weighted sex-specific quintiles of the EAT-Lancet Diet Index. NutriNet-Santé study, 2009 – 2015, France (n=98,465)