



**HAL**  
open science

## **A population-based study of macronutrient intake according to mental health status with a focus on pure and comorbid anxiety and eating disorders**

Junko Kose, Indira Paz Graniel, Sandrine Péneau, Chantal Julia, Serge Hercberg, Pilar Galan, Mathilde Touvier, Valentina Andreeva

### ► **To cite this version:**

Junko Kose, Indira Paz Graniel, Sandrine Péneau, Chantal Julia, Serge Hercberg, et al.. A population-based study of macronutrient intake according to mental health status with a focus on pure and comorbid anxiety and eating disorders. *European Journal of Nutrition*, 2022, 61 (7), pp.3685-3696. <10.1007/s00394-022-02923-x>. <hal-03812082>

**HAL Id: hal-03812082**

**<https://hal.science/hal-03812082v1>**

Submitted on 19 Sep 2025

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

**Title:** A population-based study of macronutrient intake according to mental health status with a focus on pure and comorbid anxiety and eating disorders

Junko Kose<sup>1</sup> (ORCID: 0000-0002-2971-5304),

Indira Paz Graniel<sup>2,3,4</sup> (ORCID: 0000-0002-3204-6877),

Sandrine Péneau<sup>1</sup> (ORCID: 0000-0002-3463-0989),

Chantal Julia<sup>1,5</sup> (ORCID: 0000-0003-2006-5269),

Serge Hercberg<sup>1,5</sup> (ORCID: 0000-0002-3168-1350),

Pilar Galan<sup>1</sup> (ORCID: 0000-0003-1706-3107),

Mathilde Touvier<sup>1</sup> (ORCID: 0000-0002-8322-8857),

Valentina A. Andreeva<sup>1</sup> (ORCID: 0000-0001-9480-5210)

**Author affiliations:**

<sup>1</sup> Nutritional Epidemiology Research Unit (EREN), Sorbonne Paris Nord University, INSERM U1153/INRAE U1125/CNAM, Epidemiology and Statistics Research Center (CRESS) – University of Paris, Bobigny, France;

<sup>2</sup> Rovira i Virgili University, Department of Biochemistry and Biotechnology, Human Nutrition Unit, Reus, Spain;

<sup>3</sup> Pere Virgili Institute for Health Research (IISPV), Reus, Spain;

<sup>4</sup> CIBER Physiology of Obesity and Nutrition (CIBEROBN), Carlos III Health Institute, Madrid, Spain;

<sup>5</sup> Department of Public Health, AP-HP Paris Seine-Saint-Denis Hospital System, Bobigny, France.

**Corresponding author:**

Valentina A. Andreeva, Ph.D. (ORCID: 0000-0001-9480-5210)

Équipe de Recherche en Épidémiologie Nutritionnelle (EREN)

Université Sorbonne Paris Nord

SMBH, 74 rue Marcel Cachin, 93017 Bobigny, France

Tel: +33 1 48 38 89 30

Email: [v.andreeva@eren.smbh.univ-paris13.fr](mailto:v.andreeva@eren.smbh.univ-paris13.fr)

1 **Abstract**

2 **Purpose:** Eating disorders (ED) and anxiety impact food choices. In addition, comorbid anxiety seems to  
3 increase ED symptoms and severity. However, the association between such comorbidity and dietary intake is  
4 unknown. This population-based, cross-sectional study aimed to assess macronutrient intake according to mental  
5 health status (i.e., no disorder, pure and comorbid anxiety and ED).

6 **Methods:** The study included N= 24,771 participants (74% female, mean age=53.2 ± 13.7 years) in the  
7 NutriNet-Santé cohort, who completed once the trait subscale of the State-Trait Anxiety Inventory (STAI-T;  
8 high anxiety: ≥40 points) between 2013 and 2016 and the SCOFF questionnaire screening for ED in 2014. The  
9 Expati algorithm was applied to categorize ED (no ED; restrictive: RS; bulimic: BL; hyperphagic: HP; other ED).  
10 Participants were divided into 10 groups by crossing their anxiety status (2 groups: low or high) and their ED  
11 status (5 groups). Macronutrient intakes were evaluated from ≥3 24-h dietary records. Analyses of covariance  
12 (ANCOVA) and Dunnett-Hsu tests (reference = no disorder) were performed.

13 **Results:** Significant differences in macronutrient intake were seen between the pure and comorbid forms,  
14 especially for RS and HP. Compared with the “no disorder” group, a significantly higher percentage of energy  
15 from carbohydrates, higher intakes of total carbohydrates, simple sugars, and plant-based protein, lower intakes  
16 of total fat, saturated and monounsaturated fatty acids, and cholesterol were observed in the comorbid anxiety +  
17 RS group, but not in the pure RS group. In contrast, significantly lower intakes of added sugar and plant-based  
18 protein, and a higher intake of cholesterol were observed in the pure HP group, but not in the comorbid anxiety +  
19 HP group. For BL and other ED, similar results were observed between the pure and comorbid forms.

20 **Conclusion:** This large epidemiological study provided some support for differences in macronutrient intake  
21 between individuals with pure or comorbid anxiety and ED. Differences in intake were largely dependent on ED  
22 type. Future prospective studies and studies using clinically-defined anxiety and ED are needed to elucidate  
23 causality as well as potential effect modification of the observed associations.

24 **Keywords:** comorbidity, trait anxiety, eating disorders, dietary intake, macronutrients, population-based study

25

26 **Author's contributions:** SH, PG, and MT designed and implemented the NutriNet-Santé cohort study; PG and  
27 VAA implemented the STAI questionnaire and coordinated anxiety data collection; SP and VAA implemented  
28 the SCOFF questionnaire and coordinated eating disorder data collection; VAA conceptualized the study,  
29 designed the analytic strategy, and provided theoretical and empirical guidance; JK performed the literature  
30 review, statistical analyses and led the writing; all authors assisted with interpretation of the data, critically  
31 revised the manuscript for important intellectual content. All authors approved the final version of the  
32 manuscript and its submission.

33 **Acknowledgements:** The authors thank Prof. Pierre Déchelotte and Dr. Françoise Radat for their respective  
34 involvement in the assessment of eating disorders and general anxiety in the NutriNet-Santé cohort, and Dr.  
35 Marie-Pierre Tavolacci for providing the *Expali* algorithmic tool. The authors also thank Cédric Agaesse (dietary  
36 data manager), Alexandre De-Sa and Rebecca Lutchia (dietitians); Younes Esseddik (IT manager), Thi Hong  
37 Van Duong, Régis Gatibelza, Jagatjit Mohinder and Aladi Timera (computer scientists); Julien Allegre, Nathalie  
38 Arnault, Laurent Bourhis, Nicolas Dechamp (biostatisticians), and Fabien Szabo de Edelenyi, Ph.D. (biostatistics  
39 team manager); Maria Gomes (NutriNet-Santé participant support) and Nathalie Druesne-Pecollo, Ph.D.  
40 (operations coordinator) for their technical contribution to the cohort. Finally, the authors thank all the volunteers  
41 of the NutriNet-Santé cohort.

42 **Funding:** The NutriNet-Santé study is supported by the French Ministry of Solidarity and Health, the National  
43 Agency for Public Health (Santé Publique France), the National Institute for Health and Medical Research  
44 (INSERM), the National Research Institute for Agriculture, Food and Environment (INRAE), the National  
45 Conservatory of Arts and Crafts (CNAM), the Center for Epidemiological Research and Statistics (CRESS) and  
46 Sorbonne Paris Nord University. Junko Kose is funded by a doctoral fellowship provided by the French Ministry  
47 of Education via Sorbonne Paris Nord University. Indira Paz Graniel is supported by a doctoral grant from the  
48 Spanish Ministry of Universities (# EST19/00261). The funders had no role in the design of the study; in the  
49 collection, analysis, or interpretation of data; in the writing of the manuscript, or in the decision to publish the  
50 results.

51 **Conflict of interest:** The authors declare that they have no conflict of interest.

52 **Ethical Standards:** The NutriNet-Santé study is conducted according to the Declaration of Helsinki guidelines.  
53 It was approved by the Institutional Review Board of the French Institute for Health and Medical Research  
54 (INSERM # 00000388FWA00005831) and by the National Commission on Informatics and Liberty (CNIL #

55 908450 and # 909216). NutriNet-Santé is registered (# NCT03335644) at <http://www.ClinicalTrials.gov>.  
56 Electronic informed consent was obtained from all individuals prior to inclusion in the study.

57 **Abbreviations:**

58 AN: Anorexia nervosa

59 ANCOVA: Analysis of covariance

60 BED: Binge-eating disorders

61 BL: Bulimic eating disorders

62 BMI: Body mass index

63 ED: Eating disorders

64 HP: Hyperphagic eating disorders

65 LS mean: Least-squares mean value

66 MUFA: Monounsaturated fatty acids

67 PUFA: Polyunsaturated fatty acids

68 RS: Restrictive eating disorders

69 SFA: Saturated fatty acids

70 STAI-T: Trait subscale of the State-Trait Anxiety Inventory

71        **1. Introduction**

72        Despite their considerable deleterious impact on daily life, frequent comorbidity, and increasing share of the  
73        global disease burden [1], mental disorders continue to receive insufficient research attention [2]. Among nearly  
74        twenty disorder categories in the DSM-5, feeding and eating disorders (ED) are characterized by a long-term  
75        disturbance in eating-related behaviors that has a substantial effect on physical and psychosocial functioning [3].  
76        Restrictive disorders, especially anorexia nervosa (AN), bulimic disorders, and binge-eating disorders (BED) are  
77        considered typical ED and have been the main focus of ED research [4]. An ED-related increased mortality risk  
78        in young adulthood has been reported [5]. Yet, ED prevalence in middle age is not uncommon [6, 7]. Moreover,  
79        individuals suffering from ED often present with mental comorbidity, especially anxiety disorders [3, 5], which  
80        occur more frequently in that subgroup than in the general population [8].

81        Comorbidity is defined as the presence/accumulation of  $\geq 2$  distinct health conditions (physical and/or  
82        mental) in the same individual; it is linked with increased symptom severity, poorer health outcomes [9] and  
83        reduced quality of life [10]. In the case of ED, comorbid anxiety has been associated with worse ED  
84        psychopathology and increased ED symptom severity relative to pure ED or to comorbid depression [11, 12].  
85        Longitudinal evidence has shown that mental comorbidity in ED can predict poor outcomes, including greater  
86        risk for relapse and premature death [13].

87        Whereas by definition ED feature problematic dietary intake [3], anxiety status, especially trait anxiety, has  
88        also been shown to impact dietary intake [14–16]. Individuals with AN avoid high-energy food rich in sugar and  
89        fat [17, 18], whereas intake of such foods seems to be positively associated with BED [18–20]. As regards  
90        anxiety disorders, epidemiological studies suggest an inverse association between diet quality and risk of anxiety,  
91        although nutritional interventions are needed to confirm this effect [16]. Recent research revealed a decrease in  
92        total caloric intake and an increase in sugar consumption among young adults self-reporting anxiety symptoms  
93        [21]. However, there is a paucity of research on the link between macronutrient intake and anxiety [14–16].  
94        Despite reported associations between trait anxiety and food/nutrient intake [14, 15, 17, 19, 20], possible  
95        mediating and/or moderating effects of anxiety regarding ED [22–24], and the high ED-anxiety comorbidity [3],  
96        no study, to our knowledge, has investigated dietary/nutrient intake among individuals with such comorbidity.  
97        We hypothesized that individuals with anxiety and/or ED have different macronutrient intakes from people  
98        without these disorders, and that unfavorable dietary intake (underscored by reduced nutrient diversity) is more  
99        pronounced in the case of mental comorbidity. Therefore, the aim of this population-based cross-sectional study

100 was to evaluate macronutrient intakes according to the presence of anxiety and/or ED in pure or comorbid form,  
101 in a large adult sample.

## 102 **2. Material and methods**

### 103 **2.1. The NutriNet-Santé web-cohort**

104 NutriNet-Santé is a French ongoing prospective web-cohort launched in 2009. Details about its design,  
105 protocol, and main research goals can be found elsewhere [25]. Briefly, media announcements (*e.g.*, television,  
106 radio, Internet, printed press) are used to recruit adults aged 18 years and older from the general population.  
107 Apart from age, the inclusion criteria pertain to comprehension of written French and ability to follow an  
108 Internet-based protocol (<https://etude-nutrinet-sante.fr/>). NutriNet-Santé was approved by the Institutional  
109 Review Board of the French Institute for Health and Medical Research and by the National Commission on  
110 Informatics and Liberty. The cohort is registered (# NCT03335644) at [www.ClinicalTrials.gov](http://www.ClinicalTrials.gov). Interested  
111 volunteers provide informed consent before enrolling in the cohort.

112 At inclusion and yearly thereafter, participants are asked to fill out a set of five questionnaires (described  
113 below) gathering data on socio-demographic and lifestyle characteristics, anthropometrics, physical activity, diet,  
114 and health status. In addition, participants are asked to complete one nutrition- or health-related questionnaire per  
115 month, as part of the follow-up.

### 116 **2.2. Measures**

#### 117 **2.2.1. Dietary data**

118 Macronutrient intake was the main outcome in this analysis. In NutriNet-Santé, dietary intake is evaluated at  
119 baseline and every six months thereafter, each time using three non-consecutive 24-h dietary records. The dietary  
120 data collection tool has been validated against both dietitian interviews and various nutritional status biomarkers  
121 [26–28]. For each diet assessment day, participants were asked to report each food, beverage, and/or composite  
122 dish consumed, including the portion size/quantity, preparation method, and meal setting (place, time, etc.).  
123 Estimation of portion sizes is aided by validated photographs [29]. Next, NutriNet-Santé has its own food  
124 composition table that includes >3,500 items; it was used to estimate mean daily energy and nutrient intake [30].  
125 All collected dietary data were weighted in order to respect the 5:7 and 2:7 ratios of weekdays and weekend days.  
126 For this analysis, each participant's dietary macronutrient intake was averaged across a minimum of three 24-h  
127 dietary records completed over a 2.5-year window around the anxiety assessment date (described below); it was  
128 energy-adjusted using the residual method [31]. Individuals with aberrant daily energy values (<500 kcal [32]),  
129 with fewer than three 24-h records and pregnant females at any of the dietary assessment points, were excluded

130 from the analysis. Likewise, individuals with prevalent or incident diabetes mellitus (type 1 or type 2) were  
131 ineligible for this study due to potential dietary specificities, especially regarding the intake of carbohydrates.

132 The following outcome variables related to macronutrient intake were selected: percentage energy in the total  
133 diet from carbohydrates, protein and fat, respectively; mean total carbohydrates (*g/d*); mean complex  
134 carbohydrates (*g/d*); mean simple sugars (*g/d*); mean added sugars (*g/d*); mean total protein (*g/d*); mean animal  
135 protein (*g/d*); mean plant-based protein (*g/d*); mean total fat (*g/d*); mean saturated fatty acids (SFA) (*g/d*); mean  
136 monounsaturated fatty acids (MUFA) (*g/d*); mean polyunsaturated fatty acids (PUFA) (*g/d*); mean total  
137 cholesterol (*mg/d*); and mean total fiber (*g/d*).

### 138 **2.2.2. Anxiety assessment**

139 Anxiety was assessed during the period 2013-2016 by self-reports on the French version of the State-Trait  
140 Anxiety Inventory Form Y (STAI) which has been validated for use with general-population adults [33]. A total  
141 of 119,451 participants received the questionnaire, of whom 40,809 completed it once. STAI is one of the most  
142 widely used tools for the assessment of general anxiety proneness (as a state and as a trait), distinguishing it from  
143 depression [34]. State and trait anxiety are assessed by separate sets of 20 questions scored on a 4-point Likert  
144 scale from “Almost never” to “Almost always”; each set has its own psychometric evaluation. The higher the  
145 score, the greater the proneness to anxiety. Considering the objectives of this study and for purposes of  
146 consistency with prior research [14, 15], only the trait-anxiety subscale (STAI-T) was used for this analysis. It  
147 evaluates trait anxiety, characterized by a relatively stable tendency to exhibit tension and anxiety (i.e., state  
148 anxiety) in a variety of situations. Trait anxiety measured by the STAI-T has been highly correlated with the  
149 generalized anxiety disorder [35]. As in prior studies, and given the lack of an established cut-off value,  
150 participants were considered as having “high trait anxiety” if their total score was  $\geq 40$  points or as having “low  
151 trait anxiety” if their total score was  $< 40$  points [14].

### 152 **2.2.3. ED assessment**

153 Screening for ED took place in 2014 via the validated self-administered 5-item SCOFF questionnaire [36,  
154 37]. In total, 125,279 enrollees received the SCOFF, of whom 51,073 returned a completed questionnaire.  
155 Participants who did not complete the SCOFF in 2014 but did so in 2017 were also included in the study. Each  
156 of the five items is a Yes/No question, with two or more positive responses indicating a strong likelihood of ED;  
157 the score has been shown to approximate actual ED point prevalence [38]. Next, the *Expali* validated algorithmic  
158 tool, based on the SCOFF score and Body mass index (BMI,  $\text{kg/m}^2$ ), was used to identify four ED types:  
159 restrictive (RS; including AN, atypical AN, and restrictive food intake disorder), bulimic (BL; including bulimia

160 nervosa and low-frequency/short-duration bulimia nervosa), hyperphagic (HP; including BED and low-  
161 frequency/short-duration BED), and other (not otherwise specified) ED [39].

#### 162 **2.2.4. Mental health status with regard to anxiety and ED**

163 Mental health status (i.e., no disorder, pure or comorbid ED and anxiety) was the main exposure in this  
164 analysis. Participants were divided into 10 groups by cross-tabulating their anxiety status (low or high) and their  
165 ED status (no disorder, RS, BL, HP, or other ED). Therefore, the following 10 groups were modelled as the  
166 exposure: no disorder; pure anxiety; pure RS; anxiety + RS; pure BL; anxiety + BL; pure HP; anxiety + HP;  
167 other ED only; and anxiety + other ED.

#### 168 **2.2.5. Covariate data**

169 A validated socio-demographic questionnaire was used to collect self-reported data on age, sex, educational  
170 level, socio-professional category, marital status, alcohol use, and smoking status [40]. The International  
171 Physical Activity Questionnaire assessed physical activity levels based on an established scoring protocol [41].  
172 Self-reported height and weight data were collected using a validated anthropometrics questionnaire [42], which  
173 allowed the calculation of BMI and its main categories (underweight: <18.5, normal weight: 18.5-24.9,  
174 overweight: 25.0-29.9, and obese:  $\geq 30.0$ ). As all of the above questionnaires are administered at baseline and  
175 annually thereafter; in the present analysis we used covariate data collected within a 2.5-year window around the  
176 STAI-T completion date.

#### 177 **2.3. Statistical analysis**

178 Descriptive characteristics across mental health status reflect number (percent) from chi-squared tests  
179 (categorical variables) and mean ( $\pm$ SD) from ANOVA (continuous variables). The associations between mental  
180 health status (exposure) and macronutrient intake (outcome) were assessed using analyses of covariance  
181 (ANCOVA) adjusted for age (*years*, continuous scale), sex, alcohol consumption (*g ethanol/d*, continuous scale),  
182 smoking status (never, former, current smoker), physical activity level (low, moderate, high), educational level  
183 (less than high school, high school diploma or equivalent, college/undergraduate degree, graduate degree), socio-  
184 professional category (homemaker/disabled/unemployed, student, manual/blue collar worker, office  
185 work/administrative staff, professional/executive staff, retired), marital status (living alone or  
186 married/cohabiting), and number of 24-h dietary records (continuous scale). The underlying assumptions of the  
187 ANOVA/ANCOVA were checked and interpretation of the results was guided by published empirical evidence  
188 [43, 44]. Next, many-to-one comparisons applying the Dunnett-Hsu's method (reference= no disorder) were

189 performed. The main tests were two-sided and  $p < 0.050$  was considered as evidence for statistical significance.  
190 SAS version 9.4 (SAS Institute, Inc., Cary NC, USA) was used for all statistical analyses.

### 191 3. Results

#### 192 3.1. Description of sample

193 In total, 35,472 participants completed both the STAI-T and SCOFF questionnaires ( $n = 33,193$  with SCOFF  
194 in 2014;  $n = 1,559$  with SCOFF in 2017). Among them, those with fewer than three 24-h dietary records, with  
195 aberrant energy intake values and/or pregnant females ( $n = 7,222$ ) were excluded from the analysis. Next,  
196 participants with diabetes mellitus ( $n = 1,171$ ) and those lacking complete covariate data ( $n = 2,308$ ) were also  
197 excluded. Thus, 24,771 participants were included in the analysis [**Figure 1**] (74.0% female; mean age =  $53.2 \pm$   
198  $13.7$  years). Participants included in the analysis were generally older, more likely to be retired, to report higher  
199 levels of physical activity, and were less likely to be obese or current smokers compared to those who were  
200 excluded from the analysis (all  $p < 0.001$ ; data not tabulated). The individuals in our sample were divided into 10  
201 groups according to their mental health status, as follows: no disorder  $n = 13,881$ ; pure anxiety  $n = 7,977$ ; pure RS  
202  $n = 55$ ; anxiety + RS  $n = 152$ ; pure BL  $n = 236$ ; anxiety + BL  $n = 461$ ; pure HP  $n = 631$ ; anxiety + HP  $n = 974$ ; other  
203 ED  $n = 181$ ; and anxiety + other ED  $n = 223$ .

204 Descriptive characteristics across mental health status are presented in **Table 1**. In general, individuals with  
205 a mental health disorder (anxiety or ED) were more likely to be female, younger (except for HP and other ED),  
206 current smokers (except for HP), to live alone, and to consume less alcohol compared to those without a disorder  
207 (all  $p < 0.001$ ). In the full sample, the mean number of 24-h dietary records was  $8.8 \pm 3.5$ . Overall, individuals  
208 with RS had the lowest caloric intake, which was  $1,595.1 (\pm 495.9)$  Kcal/d in the case of pure RS and  $1,438.7$   
209  $(\pm 385.1)$  Kcal/d in the case of comorbid RS.

#### 210 3.2. Association between mental health status and macronutrient intake

211 The main results in the form of least-squares (LS) means (standard error) are summarized in **Table 2**.  
212 Overall, ANCOVA revealed significant differences in mean intake across the 10 groups for all macronutrients  
213 ( $p < 0.001$ ) except for PUFA ( $p > 0.185$ ). The detailed results from the main analysis are presented in  
214 **Supplementary Figures S1 to S16**.

215 We observed that the anxiety + RS group had a significantly higher percentage of energy from  
216 carbohydrates (LS mean  $\Delta = +4.6$  %/d,  $p < 0.001$ ), higher intakes of total carbohydrates (LS mean  $\Delta = +14.2$  g/d,  
217  $p < 0.001$ ), simple sugars (LS mean  $\Delta = +12.9$  g/d,  $p < 0.001$ ), plant-based protein (LS mean  $\Delta = +3.1$  g/d,  
218  $p < 0.001$ ), lower intakes of total fat (LS mean  $\Delta = -6.6$  g/d,  $p < 0.001$ ), SFA (LS mean  $\Delta = -3.6$  g/d,  $p < 0.001$ ),

219 MUFA (LS mean  $\Delta$ = -2.8 g/d,  $p$ <0.001), and cholesterol (LS mean  $\Delta$ = -46.8 mg/d,  $p$ <0.001) in comparison with  
220 the “no disorder” group, whereas the results for the pure RS group were not significant. Both the pure RS and  
221 anxiety + RS groups had a significantly higher percentage of energy from protein (LS mean  $\Delta$ = +1.5 %/d,  
222  $p$ <0.002; LS mean  $\Delta$ = +0.9 %/d,  $p$ <0.004, respectively), a lower percentage of energy from fat (LS mean  $\Delta$ = -  
223 2.3 %/d,  $p$ <0.017; LS mean  $\Delta$ = -5.3 %/d,  $p$ <0.001, respectively), and a higher intake of fiber (LS mean  $\Delta$ = +2.4  
224 g/d,  $p$ <0.008; LS mean  $\Delta$ = +4.9 g/d,  $p$ <0.001, respectively) compared to the “no disorder” group.

225 The anxiety + BL group had a significantly higher percentage of energy from protein (LS mean  $\Delta$ =  
226 +0.7 %/d,  $p$ <0.001), a lower percentage of energy from fat (LS mean  $\Delta$ = -0.8 %/d,  $p$ <0.020), and a higher intake  
227 of protein (LS mean  $\Delta$ = +1.9 g/d,  $p$ <0.001) than the “no disorder” group, whereas the results for the pure BL  
228 were not significant. Both pure and comorbid BL had significantly higher intakes of plant-based protein (LS  
229 mean  $\Delta$ = +1.5 g/d,  $p$ <0.001; LS mean  $\Delta$ = +0.9 g/d;  $p$ <0.005, respectively), fiber (LS mean  $\Delta$ = +2.3 g/d;  
230  $p$ <0.001, LS mean  $\Delta$ = +1.4 g/d;  $p$ <0.001, respectively), and a lower intake of SFA (LS mean  $\Delta$ = -1.6 g/d,  
231  $p$ <0.003; LS mean  $\Delta$ = -1.2 g/d,  $p$ <0.001, respectively) compared to the “no disorder” group.

232 Next, the pure HP group had significantly lower intakes of added sugars (LS mean  $\Delta$ = -2.0 g/d,  $p$ <0.011),  
233 plant-based protein (LS mean  $\Delta$ = -0.7 g/d,  $p$ <0.013), and a higher intake of cholesterol (LS mean  $\Delta$ = +19.8 mg/d,  
234  $p$ <0.001) in comparison with the “no disorder” group. Both pure and comorbid HP were associated with  
235 significantly lower percentage of energy from carbohydrates (LS mean  $\Delta$ = -1.3 %/d,  $p$ <0.001; LS mean  $\Delta$ = -  
236 0.7 %/d,  $p$ <0.004, respectively), higher percentage of energy from protein (LS mean  $\Delta$ = +1.3 %/d,  $p$ <0.001; LS  
237 mean  $\Delta$ = +0.9 %/d,  $p$ <0.001, respectively), lower intakes of total carbohydrates (LS mean  $\Delta$ = -6.0 g/d,  $p$ <0.001;  
238 LS mean  $\Delta$ = - 2.9 g/d,  $p$ <0.002, respectively), simple sugars (LS mean  $\Delta$ = -3.4 g/d,  $p$ <0.001; LS mean  $\Delta$ = -2.1  
239 g/d,  $p$ <0.030, respectively), higher intakes of total protein (LS mean  $\Delta$ = +4.3 g/d,  $p$ <0.001; LS mean  $\Delta$ = +3.1  
240 g/d,  $p$ <0.001, respectively), and animal protein (LS mean  $\Delta$ = +5.0 g/d,  $p$ <0.001; LS mean  $\Delta$ = +3.5 g/d,  $p$ <0.001,  
241 respectively) compared to the “no disorder” group.

242 The anxiety + other ED group had a significantly higher intake of protein (LS mean  $\Delta$ = +2.7 %/d,  $p$ <0.006),  
243 whereas the results for the other ED group were not significant. Both pure and comorbid other ED had higher %  
244 protein (LS mean  $\Delta$ = -0.7 %/d,  $p$ <0.020; LS mean  $\Delta$ = -0.8 %/d,  $p$ <0.001, respectively), and higher intakes of  
245 animal protein (LS mean  $\Delta$ = +3.0 g/d,  $p$ <0.031; LS mean  $\Delta$ = +3.3 g/d,  $p$ <0.004, respectively) compared to the  
246 “no disorder” group.

247 Finally, the pure anxiety group had a significantly higher percentage of energy from carbohydrates (LS  
248 mean  $\Delta$ = +0.6 %/d,  $p$ <0.001), a lower percentage of energy from protein (LS mean  $\Delta$ = -0.2 %/d,  $p$ <0.002),

249 higher intakes of total carbohydrates (LS mean  $\Delta = +1.1$  g/d,  $p < 0.033$ ), complex carbohydrates (LS mean  $\Delta =$   
250  $+1.2$  g/d,  $p < 0.003$ ), added sugars (LS mean  $\Delta = +0.9$  g/d,  $p < 0.001$ ), lower intakes of protein (LS mean  $\Delta = -0.5$   
251 g/d,  $p < 0.033$ ), and fiber (LS mean  $\Delta = +0.2$  g/d,  $p < 0.014$ ) compare to the “no disorder” group.

#### 252 4. Discussion

253 This large population-based cross-sectional study revealed some significant differences in macronutrient  
254 intake according to mental health status regarding anxiety and ED. The observed differences largely depended  
255 on ED type.

256 Our main hypotheses that individuals with anxiety and/or ED would display different macronutrient intake  
257 compared to their counterparts without mental disorders and that unfavorable dietary intake (*e.g.*, reduced  
258 diversity) would be more pronounced in the case of comorbidity were only partially supported. The strongest  
259 support for our hypotheses was found for RS. Generally, the difference in macronutrient intake between pure and  
260 comorbid forms seemed to be well pronounced in RS and much less pronounced in BL and other ED. Even  
261 though macronutrient intake exhibited similar trends across pure and comorbid ED, we observed a number of  
262 differences in terms of significance levels and absolute values in comparison with the “no disorder” group.

263 To our knowledge, this is the first epidemiological study investigating dietary intake across pure and  
264 comorbid anxiety-ED conditions among adults recruited from the general population. Prior research has reported  
265 that individuals with depression and anxiety, especially in the case of comorbidity, have a lower dietary quality  
266 than healthy controls [45]. Another previous study – based on a sample of 27,111 middle-aged male smokers –  
267 reported dietary intake according to the presence of pure or comorbid mental disorders [46]. These authors  
268 studied depression, anxiety, insomnia, and the comorbidity of all three disorders and did not find marked  
269 differences in micro- or macronutrient intake according to mental health status [46].

270 Several case-control studies have reported that compared to healthy controls, people with AN (*i.e.*, the most  
271 common form of RS) were less likely to prefer/consume fat, animal protein, and were more likely to consume  
272 plant-based protein [17, 18] and vegetables [47, 48], which is consistent with the results of our study. We found  
273 that fiber intake was higher in both pure and comorbid RS, whereas the pure anxiety group had a significantly  
274 lower fiber intake in comparison with the “no disorder” group. It has been evoked that a high-fiber diet might be  
275 used by individuals suffering from AN in order to alleviate symptoms of gastroparesis [49]. In addition, the  
276 inverse association between dietary fiber intake and anxiety reported in some studies [50] might not be universal  
277 but rather dependent on sex and obesity status [51]. Moreover, we found that the restrictive eating behaviors and  
278 reduced dietary diversity that are typical of AN were more pronounced in comorbid than in pure RS. The lower

279 intake of total fat, SFA, MUFA, and dietary cholesterol and the higher intake of plant-based protein observed  
280 only in the group with anxiety-RS comorbidity but not in pure RS group, suggested that dietary homogeneity  
281 (*e.g.*, exclusion of red meat and meat products) is more pronounced in the case of comorbidity. A literature  
282 review reported that the more anxious individuals with AN were, the more likely they were to engage in  
283 restrictive eating behaviors in order to avoid weight gain [52]. Also, the observed higher intake of simple sugars,  
284 but not added sugars, among those with anxiety-RS comorbidity may reflect their preference for plant-based  
285 foods such as fruit (*i.e.*, a source of fructose).

286 In our study, the highest intake of cholesterol was seen in those with pure HP; it was nearly 20 mg/d higher  
287 than that observed in the “no disorder” group. Findings based on a nationally-representative sample of U.S.  
288 adults indicated that among the three main ED types, only BED (*i.e.*, the most common form of HP) was  
289 associated with high cholesterol intake [53], which is consistent with our results. Interestingly, unlike pure HP,  
290 cholesterol intake in the anxiety + HP group was not significantly different from that in the “no disorder” group.  
291 Likewise, the differences from the “no disorder” group in added sugar intake were -0.8 g/d ( $p>0.618$ ) and -2.0  
292 g/d ( $p<0.011$ ) for comorbid and pure HP, respectively. These results suggest that comorbidity might not have a  
293 harmful impact on dietary intake among individuals suffering from HP. Research with obese females revealed  
294 that BED mediated the association between anxiety and caloric intake [54]. A community-based study also  
295 reported that anxiety status partly explained the variance of binge eating symptoms, which suggested that anxiety  
296 might have a role in the development and maintenance of BED [24]. However, these authors indicated that binge  
297 eating might attenuate anxiety symptoms [24], which could help explain the present findings. As regards BL, the  
298 fact that individuals could also present AN and BED-like behaviors [18] might obscure any substantial  
299 differences between the pure and comorbid forms.

300 In terms of potential psychosocial mechanisms of the observed associations, the results of network analyses  
301 have suggested that ED and anxiety (measured with STAI-T) might be linked through avoidance of social eating  
302 and low self-esteem [55]. It has also been shown that anxiety disorders were more closely linked with the  
303 severity of ED symptoms than were affective or substance-related disorders [56]. Regarding physiological  
304 mechanisms, there is a growing body of diet-mental health research exploring disruptions in circadian rhythm,  
305 gut-brain axis regulation, and hormonal homeostasis, leading to systemic and neuro-inflammation and oxidative  
306 stress [57, 58].

307 This study is subject to some limitations. First, the cross-sectional design does not allow for causal or  
308 chronological inference. Prior research has shown that dietary intake and mental health status can mutually

309 impact each other [14, 15, 58, 59]. Future prospective research in this domain is needed to shed light not only on  
310 causality but also on the potential bidirectional association between macronutrient intake and comorbidity of  
311 anxiety and ED. Even though the present cross-sectional data did not permit the establishment of the  
312 chronological sequence of anxiety and ED onset, it appears that anxiety is more likely to precede ED than vice  
313 versa [60, 61]. Second, our study is based on trait anxiety which is regarded as a relatively stable personality  
314 characteristic. Even though trait anxiety and ED were assessed with validated tools, neither one could be  
315 considered as representing a clinical diagnosis. The proportion of participants with high anxiety proneness or  
316 with ED in our study was somewhat higher than the respective proportions reported by recent literature reviews  
317 [62, 63]. Yet, it should be kept in mind that these disorders are likely under-diagnosed in the general population  
318 [4, 5, 64]. Next, categorizing participants into 10 groups according to their mental health status resulted in  
319 several groups with a relatively small number of individuals (*e.g.*, pure RS: n=55), which may have had an  
320 impact on the available statistical power. Further, in spite of the large number of covariates used for statistical  
321 adjustment, residual unmeasured confounding (*e.g.*, ethnoracial status, family history of anxiety or ED) could not  
322 be excluded. Finally, as with any epidemiological cohort, NutriNet-Santé relies on voluntary participation, which  
323 might introduce selection bias and might limit generalizability, as it includes a higher proportion of females and  
324 individuals of higher socio-economic status compared to the respective proportions found in the general French  
325 population [65]. Likewise, dietary intake in the cohort exhibited some differences compared to that found in a  
326 representative sample of the French population [66].

327 Despite these limitations, the study presents several important strengths. To our knowledge, it is the first  
328 epidemiological study to reveal associations between comorbidity of anxiety-ED and macronutrient intake. All  
329 data were collected with validated questionnaires, using a very large and diverse sample of adults recruited from  
330 the general population. Moreover, macronutrient intakes were estimated based on a mean of nearly nine 24-h  
331 dietary records, validated against dietitian interviews and various biomarkers of nutritional status [26–28]. Given  
332 the high prevalence of mental comorbidity, the results of our study can be used for public health needs  
333 assessment. Our findings could help guide future epidemiological research, interventions, and policy  
334 development in the field of mental health, which is attracting attention in the Covid-19 pandemic context [67]  
335 yet is still far from being a public health priority [2].

## 336 **5. Conclusions**

337 This large population-based epidemiological study found some support for differences in macronutrient  
338 intake among individuals with pure or comorbid anxiety and ED and those without either disorder; these

339 differences depended primarily on the ED type. Future prospective studies using clinically-defined anxiety and  
340 ED featuring mediation and moderation analyses are needed to elucidate causality as well as potential effect  
341 modification of the observed associations.

## References

1. Rehm J, Shield KD (2019) Global burden of disease and the impact of mental and addictive disorders. *Curr Psychiatry Rep* 21:10. <https://doi.org/10.1007/s11920-019-0997-0>
2. Saxena S, Kestel D, Sunkel C, et al (2019) Countdown global mental health 2030. *The Lancet* 393:858–859. [https://doi.org/10.1016/S0140-6736\(19\)30424-6](https://doi.org/10.1016/S0140-6736(19)30424-6)
3. American Psychiatric Association (2013) *Diagnostic and Statistical Manual of Mental Disorders, 5th ed (DSM-5)*. American Psychiatric Association, Washington, DC
4. Hilbert A (2019) Binge-eating disorder. *Psychiatr Clin North Am* 42:33–43. <https://doi.org/10.1016/j.psc.2018.10.011>
5. Keski-Rahkonen A, Mustelin L (2016) Epidemiology of eating disorders in Europe: prevalence, incidence, comorbidity, course, consequences, and risk factors. *Curr Opin Psychiatry* 29:340–345. <https://doi.org/10.1097/YCO.0000000000000278>
6. Andreeva VA, Tavoracci M-P, Galan P, et al (2019) Sociodemographic correlates of eating disorder subtypes among men and women in France, with a focus on age. *J Epidemiol Community Health* 73:56–64. <https://doi.org/10.1136/jech-2018-210745>
7. Ng ISF, Cheung KCK, Chou K-L (2013) Correlates of eating disorder in middle-aged and older adults: evidence from 2007 British National Psychiatric Morbidity Survey. *J Aging Health* 25:1106–1120. <https://doi.org/10.1177/0898264313494798>
8. Swinbourne JM, Touyz SW (2007) The co-morbidity of eating disorders and anxiety disorders: a review. *Eur Eat Disord Rev J Eat Disord Assoc* 15:253–274. <https://doi.org/10.1002/erv.784>
9. Valderas JM, Starfield B, Sibbald B, et al (2009) Defining comorbidity: implications for understanding health and health services. *Ann Fam Med* 7:357–363. <https://doi.org/10.1370/afm.983>
10. Watson HJ, Swan A, Nathan PR (2011) Psychiatric diagnosis and quality of life: the additional burden of psychiatric comorbidity. *Compr Psychiatry* 52:265–272. <https://doi.org/10.1016/j.comppsy.2010.07.006>
11. Elran-Barak R, Goldschmidt AB (2021) Differences in severity of eating disorder symptoms between adults with depression and adults with anxiety. *Eat Weight Disord EWD* 26:1409–1416. <https://doi.org/10.1007/s40519-020-00947-y>
12. Lydecker JA, Grilo CM (2021) Psychiatric comorbidity as predictor and moderator of binge-eating disorder treatment outcomes: an analysis of aggregated randomized controlled trials. *Psychol Med* 1–9. <https://doi.org/10.1017/S0033291721001045>

13. Keshishian AC, Tabri N, Becker KR, et al (2019) Eating disorder recovery is associated with absence of major depressive disorder and substance use disorders at 22-year longitudinal follow-up. *Compr Psychiatry* 90:49–51. <https://doi.org/10.1016/j.comppsy.2019.01.002>
14. Kose J, Cheung A, Fezeu LK, et al (2021) A comparison of sugar intake between individuals with high and low trait anxiety: Results from the nutrinet-santé study. *Nutrients* 13:1526. <https://doi.org/10.3390/nu13051526>
15. Kose J, Fezeu LK, Touvier M, et al (2021) Dietary macronutrient intake according to sex and trait anxiety level among non-diabetic adults: A cross-sectional study. *Nutr J* 20:78. <https://doi.org/10.1186/s12937-021-00733-1>
16. Kris-Etherton PM, Petersen KS, Hibbeln JR, et al (2021) Nutrition and behavioral health disorders: depression and anxiety. *Nutr Rev* 79:247–260. <https://doi.org/10.1093/nutrit/nuaa025>
17. Schebendach JE, Uniacke B, Walsh BT, et al (2019) Fat preference and fat intake in individuals with and without anorexia nervosa. *Appetite* 139:35–41. <https://doi.org/10.1016/j.appet.2019.04.008>
18. Segura-García C, De Fazio P, Sinopoli F, et al (2014) Food choice in disorders of eating behavior: Correlations with the psychopathological aspects of the diseases. *Compr Psychiatry* 55:1203–1211. <https://doi.org/10.1016/j.comppsy.2014.02.013>
19. Bragg MA, White MA (2013) Examining the relationship between soda consumption and eating disorder pathology. *Adv Eat Disord Abingdon U K Print* 1:10. <https://doi.org/10.1080/21662630.2013.742317>
20. Goodman EL, Breithaupt L, Watson HJ, et al (2018) Sweet taste preference in binge-eating disorder: A preliminary investigation. *Eat Behav* 28:8–15. <https://doi.org/10.1016/j.eatbeh.2017.11.005>
21. Keck MM, Vivier H, Cassisi JE, et al (2020) Examining the role of anxiety and depression in dietary choices among college students. *Nutrients* 12:2061. <https://doi.org/10.3390/nu12072061>
22. Christian CB, Ngo BK, Brosol LC, Levinson CA (2021) Social appearance anxiety moderates the relationship between thin-ideal internalization and eating disorder symptoms cross-sectionally and prospectively in adolescent girls. *Eat Weight Disord EWD* 26:2065–2070. <https://doi.org/10.1007/s40519-020-01050-y>
23. Lim MC, Parsons S, Goglio A, Fox E (2021) Anxiety, stress, and binge eating tendencies in adolescence: a prospective approach. *J Eat Disord* 9:94. <https://doi.org/10.1186/s40337-021-00444-2>
24. Rosenbaum DL, White KS (2015) The relation of anxiety, depression, and stress to binge eating behavior. *J Health Psychol* 20:887–898. <https://doi.org/10.1177/1359105315580212>

25. Hercberg S, Castetbon K, Czernichow S, et al (2010) The Nutrinet-Santé study: A web-based prospective study on the relationship between nutrition and health and determinants of dietary patterns and nutritional status. *BMC Public Health* 10:242. <https://doi.org/10.1186/1471-2458-10-242>
26. Lassale C, Castetbon K, Laporte F, et al (2015) Validation of a Web-based, self-administered, non-consecutive-day dietary record tool against urinary biomarkers. *Br J Nutr* 113:953–962. <https://doi.org/10.1017/S0007114515000057>
27. Lassale C, Castetbon K, Laporte F, et al (2016) Correlations between fruit, vegetables, fish, vitamins, and fatty acids estimated by web-based nonconsecutive dietary records and respective biomarkers of nutritional status. *J Acad Nutr Diet* 116:427-438.e5. <https://doi.org/10.1016/j.jand.2015.09.017>
28. Touvier M, Kesse-Guyot E, Méjean C, et al (2011) Comparison between an interactive web-based self-administered 24 h dietary record and an interview by a dietitian for large-scale epidemiological studies. *Br J Nutr* 105:1055–1064. <https://doi.org/10.1017/S0007114510004617>
29. Le Moullec N, Deheeger M, Preziosi P (1996) Validation du manuel-photos utilisé pour l'enquête alimentaire de l'étude SU. VI. MAX [Validation of the photo manual used for the food survey of the SU. VI. MAX study]. *Cah Nutr Diététique* 31:158–64
30. Etude NutriNet-Santé (2013) Table de composition des aliments [Food composition table]. Économica, Paris
31. Willett W (2012) *Nutritional Epidemiology*. Oxford University Press
32. Raatz SK, Jahns L, Johnson LK, et al (2015) Nutritional adequacy of dietary intake in women with anorexia nervosa. *Nutrients* 7:3652–3665. <https://doi.org/10.3390/nu7053652>
33. Langevin V, Boini S, François M, Riou A (2012) Inventaire d'anxiété état-trait forme Y [State-Trait Anxiety Inventory (STAI-Y)]. *Réf En Santé Au Trav* 131:161–4
34. Spielberger C, Gorsuch R, Lushene R, et al (1983) *Manual for the State-Trait Anxiety Inventory*. Consulting Psychologists Press, Palo Alto, CA
35. Chambers JA, Power KG, Durham RC (2004) The relationship between trait vulnerability and anxiety and depressive diagnoses at long-term follow-up of Generalized Anxiety Disorder. *J Anxiety Disord* 18:587–607. <https://doi.org/10.1016/j.janxdis.2003.09.001>
36. Garcia FD, Grigioni S, Allais E, et al (2011) Detection of eating disorders in patients: Validity and reliability of the French version of the SCOFF questionnaire. *Clin Nutr* 30:178–181. <https://doi.org/10.1016/j.clnu.2010.09.007>

37. Morgan JF, Reid F, Lacey JH (1999) The SCOFF questionnaire: assessment of a new screening tool for eating disorders. *BMJ* 319:1467–1468. <https://doi.org/10.1136/bmj.319.7223.1467>
38. Botella J, Sepúlveda AR, Huang H, Gambará H (2013) A meta-analysis of the diagnostic accuracy of the SCOFF. *Span J Psychol* 16:E92. <https://doi.org/10.1017/sjp.2013.92>
39. Tavoracci M-P, Gillibert A, Zhu Soubise A, et al (2019) Screening four broad categories of eating disorders: suitability of a clinical algorithm adapted from the SCOFF questionnaire. *BMC Psychiatry* 19:366. <https://doi.org/10.1186/s12888-019-2338-6>
40. Vergnaud AC, Touvier M, Méjean C, et al (2011) Agreement between web-based and paper versions of a socio-demographic questionnaire in the NutriNet-Santé study. *Int J Public Health* 56:407–417. <https://doi.org/10.1007/s00038-011-0257-5>
41. Craig CL, Marshall AL, Sjöström M, et al (2003) International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc* 35:1381–1395. <https://doi.org/10.1249/01.MSS.0000078924.61453.FB>
42. Lassale C, Péneau S, Touvier M, et al (2013) Validity of web-based self-reported weight and height: Results of the Nutrinet-Santé study. *J Med Internet Res* 15:e152. <https://doi.org/10.2196/jmir.2575>
43. Blanca MJ, Alarcón R, Arnau J (2017) Non-normal data: Is ANOVA still a valid option? *Psicothema* 552–557. <https://doi.org/10.7334/psicothema2016.383>
44. Blanca MJ, Alarcón R, Arnau J, et al (2018) Effect of variance ratio on ANOVA robustness: Might 1.5 be the limit? *Behav Res Methods* 50:937–962. <https://doi.org/10.3758/s13428-017-0918-2>
45. Gibson-Smith D, Bot M, Brouwer IA, et al (2018) Diet quality in persons with and without depressive and anxiety disorders. *J Psychiatr Res* 106:1–7. <https://doi.org/10.1016/j.jpsychires.2018.09.006>
46. Hakkarainen R, Partonen T, Haukka J, et al (2004) Food and nutrient intake in relation to mental wellbeing. *Nutr J* 3:14. <https://doi.org/10.1186/1475-2891-3-14>
47. Jáuregui Lobera I (2009) Choice of diet in patients with anorexia nervosa. *Nutr Hosp* 0–0. <https://doi.org/10.3305/nh.2009.24.6.4552>
48. Misra M, Tsai P, Anderson EJ, et al (2006) Nutrient intake in community-dwelling adolescent girls with anorexia nervosa and in healthy adolescents. *Am J Clin Nutr* 84:698–706
49. Mehler PS, Brown C (2015) Anorexia nervosa – medical complications. *J Eat Disord* 3:11. <https://doi.org/10.1186/s40337-015-0040-8>

50. Taylor AM, Holscher HD (2020) A review of dietary and microbial connections to depression, anxiety, and stress. *Nutr Neurosci* 23:237–250. <https://doi.org/10.1080/1028415X.2018.1493808>
51. Saghafian F, Sharif N, Saneei P, et al (2021) Consumption of dietary fiber in relation to psychological disorders in adults. *Front Psychiatry* 12:587468. <https://doi.org/doi:10.3389/fpsy.2021.587468>
52. Lloyd EC, Haase AM, Foster CE, Verplanken B (2019) A systematic review of studies probing longitudinal associations between anxiety and anorexia nervosa. *Psychiatry Res* 276:175–185. <https://doi.org/10.1016/j.psychres.2019.05.010>
53. Udo T, Grilo CM (2019) Psychiatric and medical correlates of DSM-5 eating disorders in a nationally representative sample of adults in the United States. *Int J Eat Disord* 52:42–50. <https://doi.org/10.1002/eat.23004>
54. Peterson RE, Latendresse SJ, Bartholome LT, et al (2012) Binge eating disorder mediates links between symptoms of depression, anxiety, and caloric intake in overweight and obese women. *J Obes* 2012:407103. <https://doi.org/10.1155/2012/407103>
55. Forrest LN, Sarfan LD, Ortiz SN, et al (2019) Bridging eating disorder symptoms and trait anxiety in patients with eating disorders: A network approach. *Int J Eat Disord* 52:701–711. <https://doi.org/10.1002/eat.23070>
56. Spindler A, Milos G (2007) Links between eating disorder symptom severity and psychiatric comorbidity. *Eat Behav* 8:364–373. <https://doi.org/10.1016/j.eatbeh.2006.11.012>
57. Godos J, Currenti W, Angelino D, et al (2020) Diet and mental health: Review of the recent updates on molecular mechanisms. *Antioxid Basel Switz* 9:E346. <https://doi.org/10.3390/antiox9040346>
58. Murphy M, Mercer JG (2013) Diet-Regulated Anxiety. *Int J Endocrinol* 2013:701967. <https://doi.org/10.1155/2013/701967>
59. Mörkl S, Wagner-Skacel J, Lahousen T, et al (2020) The role of nutrition and the gut-brain axis in psychiatry: A review of the literature. *Neuropsychobiology* 79:80–88. <https://doi.org/10.1159/000492834>
60. Kaye WH, Bulik CM, Thornton L, et al (2004) Comorbidity of anxiety disorders with anorexia and bulimia nervosa. *Am J Psychiatry* 161:2215–2221. <https://doi.org/10.1176/appi.ajp.161.12.2215>
61. Swinbourne J, Hunt C, Abbott M, et al (2012) The comorbidity between eating disorders and anxiety disorders: Prevalence in an eating disorder sample and anxiety disorder sample. *Aust N Z J Psychiatry* 46:118–131. <https://doi.org/10.1177/0004867411432071>

62. Galmiche M, Déchelotte P, Lambert G, Tavolacci MP (2019) Prevalence of eating disorders over the 2000–2018 period: a systematic literature review. *Am J Clin Nutr* 109:1402–1413. <https://doi.org/10.1093/ajcn/nqy342>
63. Remes O, Brayne C, van der Linde R, Lafortune L (2016) A systematic review of reviews on the prevalence of anxiety disorders in adult populations. *Brain Behav* 6:e00497. <https://doi.org/10.1002/brb3.497>
64. DeMartini J, Patel G, Fancher TL (2019) Generalized anxiety disorder. *Ann Intern Med* 170:ITC49–ITC64. <https://doi.org/10.7326/AITC201904020>
65. Andreeva VA, Salanave B, Castetbon K, et al (2015) Comparison of the sociodemographic characteristics of the large NutriNet-Santé e-cohort with French census data: The issue of volunteer bias revisited. *J Epidemiol Community Health* 69:893–898. <https://doi.org/10.1136/jech-2014-205263>
66. Andreeva VA, Deschamps V, Salanave B, et al (2016) Comparison of dietary intakes between a large online cohort study (Etude NutriNet-Santé) and a nationally representative cross-sectional study (Etude Nationale Nutrition Santé) in France: addressing the issue of generalizability in e-epidemiology. *Am J Epidemiol* 184:660–669. <https://doi.org/10.1093/aje/kww016>
67. Gloster AT, Lamnisos D, Lubenko J, et al (2020) Impact of COVID-19 pandemic on mental health: An international study. *PloS One* 15:e0244809. <https://doi.org/10.1371/journal.pone.0244809>

**Table 1.** Descriptive characteristics of participants (n= 24,771, NutriNet-Santé Study, France)

	<b>No disorder</b>		<b>Pure anxiety</b>		<b>Pure restrictive disorder</b>		<b>Anxiety + restrictive disorder</b>		<b>Pure bulimic disorder</b>		<b>Anxiety + bulimic disorder</b>		<b>Pure hyperphagic disorder</b>		<b>Anxiety + hyperphagic disorder</b>		<b>Other eating disorders</b>		<b>Anxiety + other eating disorders</b>	
	<b>n=13881</b>		<b>n=7977</b>		<b>n=55</b>		<b>n=152</b>		<b>n=236</b>		<b>n=461</b>		<b>n=631</b>		<b>n=974</b>		<b>n=181</b>		<b>n=223</b>	
<b>Sex</b>																				
Female	9442	(68.0)	6406	(80.3)	47	(85.5)	149	(98.0)	205	(86.9)	425	(92.2)	484	(76.7)	852	(87.5)	134	(74.0)	187	(83.9)
Male	4439	(32.0)	1571	(19.7)	8	(14.6)	3	(2.0)	31	(13.1)	36	(7.8)	147	(23.3)	122	(12.5)	47	(26.0)	36	(16.1)
<b>Age, years, mean (SD)</b>																				
	54.8	(13.4)	51.4	(13.8)	46.6	(15.1)	40.6	(12.5)	49.1	(13.8)	44.9	(13.0)	55.6	(11.9)	51.7	(12.9)	55.5	(13.7)	49,8	(14,1)
<b>Age category</b>																				
18-39 y	2295	(16.5)	1904	(23.9)	21	(38.2)	84	(55.3)	67	(28.4)	185	(40.1)	75	(11.9)	202	(20.7)	29	(16.0)	58	(26,0)
40-65 y	7533	(54.3)	4453	(55.8)	24	(43.6)	60	(39.5)	130	(55.1)	236	(51.2)	392	(62.1)	604	(62.0)	94	(51.9)	126	(56,5)
≥ 65 y	4053	(29.2)	1620	(20.3)	10	(18.2)	8	(5.3)	39	(16.5)	40	(8.7)	164	(26.0)	168	(17.3)	58	(32.0)	39	(17,5)
<b>Educational level</b>																				
≤ High school	4652	(33.5)	2632	(33.0)	16	(29.1)	38	(25.0)	76	(32.2)	148	(32.1)	254	(40.3)	419	(43.0)	89	(49.2)	105	(47,1)
> High school	9229	(66.5)	5345	(67.0)	39	(70.9)	114	(75.0)	160	(67.8)	313	(67.9)	377	(59.7)	555	(57.0)	92	(50.8)	118	(52,9)
<b>Employment status<sup>1</sup></b>																				

Without professional activity	982 (7.1)	902 (11.3)	6 (10.9)	32 (21.1)	24 (10.2)	57 (12.4)	40 (6.3)	126 (12.9)	11 (6.1)	36 (16.1)
With professional activity	7052 (50.8)	4597 (57.6)	34 (61.8)	106 (69.7)	146 (61.9)	336 (72.9)	311 (49.3)	552 (56.7)	84 (46.4)	125 (56.1)
Retired	5847 (42.1)	2478 (31.1)	15 (27.3)	14 (9.2)	66 (28.0)	68 (14.8)	280 (44.4)	296 (30.4)	86 (47.5)	62 (27.8)
<b>Marital status</b>										
Living alone	3037 (21.9)	2140 (26.8)	15 (27.3)	68 (44.7)	64 (27.1)	126 (27.3)	153 (24.3)	278 (28.5)	43 (23.8)	52 (23.3)
Married/cohabiting	10844 (78.1)	5837 (73.2)	40 (72.7)	84 (55.3)	172 (72.9)	335 (72.7)	478 (75.8)	696 (71.5)	138 (76.2)	171 (76.7)
<b>Physical activity<sup>2</sup></b>										
Low	2635 (19.0)	2002 (25.1)	10 (18.2)	31 (20.4)	54 (22.9)	119 (25.8)	152 (24.1)	287 (29.5)	40 (22.1)	55 (24.7)
Moderate	5633 (40.6)	3386 (42.5)	25 (45.5)	74 (48.7)	78 (33.1)	186 (40.4)	255 (40.4)	397 (40.8)	61 (33.7)	86 (38.6)
High	5613 (40.4)	2589 (32.5)	20 (36.4)	47 (30.9)	104 (44.1)	156 (33.8)	224 (35.5)	290 (29.8)	80 (44.2)	82 (36.8)
<b>Body Mass Index (BMI, <math>kg/m^2</math>), mean (SD)</b>										
	23.9 (3.8)	23.4 (4.1)	20.1 (3.1)	17.9 (2.7)	22.9 (2.9)	22.8 (3.7)	27.5 (5.1)	27.9 (5.8)	26.9 (5.4)	25.6 (5.2)
<b>BMI category</b>										
Underweight	9469 (68.2)	5690 (71.3)	55 (100.0)	152 (100.0)	211 (89.4)	414 (89.8)	191 (30.3)	300 (30.8)	77 (42.5)	118 (52.9)

and normal weight (<24.9)																			
Overweight and obese ( $\geq 25.0$ )	4412 (31.8)	2287 (28.7)	0 (0.0)	0 (0.0)	25 (10.6)	47 (10.2)	440 (69.7)	674 (69.2)	104 (57.5)	105 (47.1)									
<b>Smoking status</b>																			
Non-smoker (including former smokers)	12616 (90.9)	7146 (89.6)	42 (76.4)	126 (82.9)	214 (90.7)	400 (86.8)	581 (92.1)	858 (88.1)	162 (89.5)	191 (85.7)									
Smoker	1265 (9.1)	831 (10.4)	13 (23.6)	26 (17.1)	22 (9.3)	61 (13.2)	50 (7.9)	116 (11.9)	19 (10.5)	32 (14.3)									
<b>Alcohol use, g ethanol/d, mean (SD)</b>																			
	7.7 (10.2)	6.6 (9.3)	6.0 (11.2)	3.8 (6.6)	6.5 (8.5)	5.6 (8.0)	7.0 (9.9)	5.9 (8.9)	7.8 (11.5)	6.7 (9.7)									
<b>Total energy intake, Kcal/d, mean (SD)</b>																			
	1821.4 (486.9)	1779. (461.8)	1595. (495.9)	1438. (385.1)	1701. (468.2)	1651. (432.4)	1713. (494.1)	1688. (490.1)	1722. (546.7)	1650. (468.7)									
	)	1 )	1 )	7 )	8 )	5 )	1 )	0 )	0 )	1 )									
<b>Number of 24-h dietary records, mean (SD)</b>																			
	9.0 (3.5)	8.6 (3.5)	8.3 (3.6)	8.8 (3.4)	8.7 (3.7)	7.9 (3.4)	8.9 (3.6)	8.3 (3.6)	8.4 (3.8)	8.1 (3.3)									

Values refer to number (%) except when noted otherwise, derived from chi-squared tests or ANOVA, as appropriate, and rounded off to one decimal place; all  $P$  values <0.001; <sup>1</sup> "Without professional activity" includes "homemaker/disabled/unemployed" and "student". <sup>2</sup> Assessed with the International Physical Activity Questionnaire-Short Form according to established scoring

---

criteria.

ANCOVA: Analysis of covariance

---

**Table 2.** Macronutrient intake according to mental health status (n= 24,771, NutriNet-Santé Study, France)<sup>1,2</sup>

	<b>No disorder</b>	<b>Pure anxiety</b>	<b>Pure restrictive disorder</b>	<b>Anxiety + restrictive disorder</b>	<b>Pure bulimic disorder</b>	<b>Anxiety + bulimic disorder</b>	<b>Pure hyperphagic disorder</b>	<b>Anxiety + hyperphagic disorder</b>	<b>Other eating disorders</b>	<b>Anxiety + other eating disorders</b>
	<b>n=13881</b>	<b>n=7977</b>	<b>n=55</b>	<b>n=152</b>	<b>n=236</b>	<b>n=461</b>	<b>n=631</b>	<b>n=974</b>	<b>n=181</b>	<b>n=223</b>
<b>Energy from carbohydrates (%)</b>	41.0 (0.1)	<b>41.4</b> (0.1)	41.8 (0.8)	<b>45.6</b> (0.5)	41.4 (0.4)	41.2 (0.3)	<b>39.7</b> (0.3)	<b>40.3</b> (0.2)	40.4 (0.4)	40.3 (0.4)
<b>Energy from protein (%)</b>	16.7 (0.1)	<b>16.5</b> (0.1)	<b>18.2</b> (0.4)	<b>17.6</b> (0.3)	17.0 (0.2)	<b>17.4</b> (0.1)	<b>18.0</b> (0.1)	<b>17.6</b> (0.1)	<b>17.4</b> (0.2)	<b>17.5</b> (0.2)
<b>Energy from fat (%)</b>	38.8 (0.1)	38.8 (0.1)	<b>36.5</b> (0.7)	<b>33.5</b> (0.5)	38.1 (0.4)	<b>38.0</b> (0.3)	38.7 (0.2)	38.7 (0.2)	38.7 (0.4)	38.9 (0.4)
<b>Total carbohydrates (g/d)</b>	195.6 (0.5)	<b>196.7</b> (0.5)	196.9 (3.6)	<b>209.8</b> (2.2)	196.5 (1.8)	196.7 (1.3)	<b>189.6</b> (1.1)	<b>192.8</b> (0.9)	191.7 (2.0)	192.8 (1.8)
<b>Complex carbohydrates (g/d)</b>	104.4 (0.4)	<b>105.6</b> (0.4)	102.0 (3.0)	105.5 (1.8)	102.6 (1.5)	104.4 (1.1)	101.9 (1.0)	103.6 (0.8)	102.9 (1.7)	100.8 (1.5)
<b>Simple sugars (g/d)</b>	90.6 (0.4)	90.6 (0.4)	94.3 (2.9)	<b>103.5</b> (1.8)	93.3 (1.4)	91.7 (1.0)	<b>87.2</b> (0.9)	<b>88.5</b> (0.8)	88.1 (1.6)	91.3 (1.5)
<b>Added simple sugars (g/d)</b>										

	37.1	(0.3)	<b>38.0</b>	(0.3)	37.3	(2.1)	35.4	(1.3)	35.6	(1.0)	36.6	(0.8)	<b>35.1</b>	(0.7)	36.3	(0.5)	35.3	(1.2)	37.0	(1.1)
<b>Protein (g/d)</b>																				
	77.4	(0.2)	<b>76.9</b>	(0.2)	81.3	(1.6)	78.0	(1.0)	78.2	(0.8)	<b>79.3</b>	(0.6)	<b>81.7</b>	(0.5)	<b>80.5</b>	(0.4)	79.6	(0.9)	<b>80.1</b>	(0.8)
<b>Animal protein (g/d)</b>																				
	52.2	(0.2)	51.9	(0.3)	55.1	(1.8)	49.7	(1.1)	51.5	(0.9)	53.2	(0.7)	<b>57.2</b>	(0.6)	<b>55.7</b>	(0.5)	<b>55.2</b>	(1.0)	<b>55.5</b>	(0.9)
<b>Plant-based protein (g/d)</b>																				
	25.2	(0.1)	25.1	(0.1)	26.1	(0.7)	<b>28.3</b>	(0.4)	<b>26.7</b>	(0.4)	<b>26.1</b>	(0.3)	<b>24.5</b>	(0.2)	24.7	(0.2)	24.5	(0.4)	24.7	(0.4)
<b>Fat (g/d)</b>																				
	82.6	(0.2)	82.5	(0.2)	79.9	(1.5)	<b>76.0</b>	(0.9)	81.8	(0.7)	81.4	(0.5)	83.0	(0.5)	82.8	(0.4)	83.2	(0.8)	83.0	(0.7)
<b>SFA (g/d)</b>																				
	34.1	(0.1)	34.2	(0.1)	33.1	(0.9)	<b>30.6</b>	(0.5)	<b>32.6</b>	(0.4)	<b>32.9</b>	(0.3)	34.1	(0.3)	34.1	(0.2)	34.1	(0.5)	34.5	(0.4)
<b>MUFA (g/d)</b>																				
	30.9	(0.1)	30.8	(0.1)	29.6	(0.8)	<b>28.1</b>	(0.5)	31.0	(0.4)	30.6	(0.3)	31.1	(0.2)	31.0	(0.2)	31.4	(0.4)	30.8	(0.4)
<b>PUFA (g/d)</b>																				
	11.5	(0.1)	11.5	(0.1)	11.2	(0.4)	11.6	(0.3)	12.1	(0.2)	11.7	(0.2)	11.5	(0.1)	11.6	(0.1)	11.5	(0.2)	11.6	(0.2)
<b>Cholesterol (mg/d)</b>																				
	320.6	(1.6)	317.1	(1.7)	328.6	(12.4)	<b>273.7</b>	(7.6)	314.5	(6.1)	317.0	(4.5)	<b>340.3</b>	(3.9)	327.6	(3.2)	334.1	(6.9)	327.0	(6.3)
<b>Fiber (g/d)</b>																				

19.7 (0.1) **19.5** (0.1) **22.1** (0.7) **24.6** (0.4) **22.0** (0.4) **21.1** (0.3) 19.3 (0.2) 19.4 (0.2) 19.1 (0.4) 19.8 (0.4)

---

Values refer to least-squares means (standard error). ANCOVA models adjusted for age, sex, BMI, smoking status, physical activity level, socio-professional category, marital status, alcohol consumption, and number of 24-h dietary records.  $p < 0.001$  for all tests/variables except for PUFA ( $p > 0.185$ ).

Least-squares means significantly different from the reference category (=no disorder) in the Dunnett-Hsu's tests presented in bold.

<sup>1</sup>Anxiety evaluated by Spielberger Trait Anxiety Inventory (STAI-T) form Y with threshold of 40 points; score range between 20 and 80 points, with higher scores reflecting higher proneness to anxiety. <sup>2</sup>Types of eating disorders categorized using the *Expali* algorithm applied to SCOFF questionnaire data. Values are rounded off to one decimal place.

ANCOVA: Analysis of covariance, BMI: Body mass index, MUFA: Monounsaturated fatty acids, PUFA: Polyunsaturated fatty acids, SFA: Saturated fatty acids.

---