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# Associations between anxiety disorders and diet quality in a Swiss cohort study

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ABSTRACT

*Objectives:* Anxiety disorders are common in the general population and can have a major impact on a person's behavior. These disorders may also affect shopping and cooking habits, which may lead to a less healthy diet. Thus, we aimed to assess whether any current anxiety disorder or current specific anxiety disorders were associated with diet quality.

*Methods:* Data of 6392 observations of 3993 participants were retrieved from 2 data waves of a population-based prospective cohort study conducted in an urban area in Switzerland. To assess the associations of anxiety status with diet quality measured by the Alternate Healthy Eating Index (AHEI), we performed cross-sectional multilevel random-effects linear regression analyses, which accounted for potential repeated participation and a series of potential confounders.

*Results:* We observed an association between the presence of any current anxiety disorder and lower diet quality. For the most conclusive model, the AHEI was 1.2 points lower among those with current anxiety disorders compared to those participants with no anxiety disorder ($p = 0.016$). When specific anxiety disorders were included separately into the model, panic disorder was associated with lower diet quality in the fully adjusted model ($p = 0.037$).

*Conclusions:* Our findings of reduced diet quality in people with any current anxiety disorder suggest that practical support is needed when it comes to buying and processing food. This might be systematically addressed in psychotherapy and external interdisciplinary support (e.g. occupational therapy and dietary counselling) should be involved. However, further data is needed to strengthen the findings of the present study.

## 1. Introduction

Anxiety disorders are common in the general population. A systematic review including 44 countries worldwide estimated the current prevalence of anxiety disorders to be at 7.3%. Worldwide estimates of current prevalence varied between 0.9% in China to 28.3% in Afghanistan and the current prevalence was estimated to be 10.4% in Euro/Anglo cultures [1]. Looking at types of anxiety disorders, in the US, the twelve-month prevalence of anxiety disorders in the population was estimated at 8.7% for specific phobias, 6.8% for social phobias, 3.1% for generalized anxiety disorder (GAD) and 0.8% for agoraphobia [2]. Estimations for the prevalence of anxiety disorders over lifetime slightly differ by the type of disorder: for specific phobias 6–12%, followed by social phobia (10%), GAD (3–5%), and agoraphobia (2%) [3].

In the Global Burden of Disease Study in 2010, anxiety disorders accounted for 14.6% of DALYs (Disability-Adjusted Life Years) caused by any mental or substance use disorders [4]. This is the second most frequent leading cause of DALY's among mental health disorders after

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depression, which accounts for 40.5%. Furthermore, an estimated one in nine individuals will suffer from an anxiety disorder during the course of a year [4]. Thus, anxiety and depressive disorders are a major public health concern.

Studies have already assessed associations of mental disorders with diet, but most of these studies assessed the effects of dietary habits on psychological well-being, often referred to as "nutritional psychiatry" [5–7]. Mostly, the effects of diet quality scores such as the Alternate Healthy Eating Index (AHEI) the Mediterranean Diet Score (MDS), or micronutrient intake, on mental health were investigated. A systematic review including cohort and cross-sectional studies observed conflicting levels of evidence in studies examining depression as a predictor for healthy diet [7].

Despite the knowledge on the association between diet quality and depression, there is no study examining the associations of dietary habits with specific anxiety disorders (GAD, panic disorder, agoraphobia, and social phobia) or with the combined category of any anxiety disorder. One study [8] observed less healthy eating habits (assessed by the AHEI) in people with comorbid anxiety and depressive disorders assessed using the Composite International Diagnostic Interview according to the Diagnostic and Statistical Manual of Mental Disorders - IV (DSM-IV). Another study observed significant associations between current anxiety disorders, following the International Statistical Classification of Diseases and Related Health Problems ICD-10, and binge eating/purging behaviors, such as losing control over how much one is eating [9]. Given the major impact that these disorders can exert on a person's behavior, they are also likely to influence shopping and eating habits, leading to limited food selection. Furthermore, restlessness and gastro-intestinal symptoms related to anxiety disorders might also result in changes in cooking behaviors and dietary habits.

Anxiety disorders often co-occur with Major Depressive Disorder (MDD) [10,11], which is also associated with changes in dietary habits [7,8,12–15]. In addition, certain antidepressants that can be prescribed for depression and anxiety disorders are also known to have an effect on appetite [16].

Using data from a community study, we aimed to examine the association of current specific DSM-IV anxiety disorders (i.e., GAD, panic disorder, agoraphobia and social phobia) assessed though diagnostic interviews as well as an overall current anxiety disorder category with diet quality. We determined the associations between ongoing anxiety disorders and diet quality cross-sectionally rather than applying a longitudinal approach, because we hypothesized that these disorders would rather affect dietary choices during the course of these disorders and not necessarily in the longer term. We hypothesized that people diagnosed with an ongoing anxiety disorder would be more prone to eating less healthy foods.

## 2. Methods

### 2.1. Study sample

Data were retrieved from CoLaus|PsyCoLaus [17,18], a prospective cohort study that assesses mental disorders and cardiovascular risk factors in the community and determines their associations. A total of 6734 individuals, aged 35 to 75 years of age, were randomly selected from the inhabitants of the city of Lausanne, in the French-speaking region of Switzerland, according to the civil register from 2003 to 2006. They underwent a physical baseline investigation. Participants aged 35 to 66 years of age were also invited to participate in a baseline psychiatric evaluation. The whole baseline cohort was then solicited to take part in a first (FU1) and second follow-up (FU2), which included both physical and psychiatric assessments and were conducted between 2009 and 2013 and between 2014 and 2018, respectively. Among the scales, a food-frequency questionnaire (FFQ) was introduced from FU1 onwards. Detailed descriptions of the study design and sampling procedures have been reported previously [18].

For the present analyses, we included participants who accepted the physical and psychiatric evaluation either at FU1 or FU2 with complete information from the FFQ and information on anxiety disorder status. Stratified by participating time-points, 1209 individuals only participated in FU1, 385 only in FU2 and 2399 participated in the two FU evaluations resulting in a total of 6392 observations.

The institutional Ethics Committee for clinical research of the Medical and Biological Faculty of the University of Lausanne, which afterwards became the Ethics Committee of the Canton of Vaud for human research (www.cer-vd.ch), approved the CoLaus/PsyCoLaus first (reference numbers 33/09, 239/09), and second (reference numbers 26/14, 239/09) follow-up assessments in agreement with the Helsinki declaration and its former amendments, and with the applicable Swiss legislation. All participants provided written informed consent.

### 2.2. Outcome measurements: dietary assessment and AHEI score

During both the physical FU1 and FU2 investigations, a self-administered, semi-quantitative validated FFQ was used to assess dietary intake for the four weeks prior to participation [19]. The FFQ was developed and validated in the general adult population of Geneva, in Switzerland [20].

The FFQ used in the CoLaus|PsyCoLaus study assesses the consumption of 97 different food items. Consumption was assessed, ranging from "less than once during the last 4 weeks" to "2 or more times per day" using seven categories. Portion size was categorized into "smaller", "equal" or "larger" compared to a given average size. The frequency and portion size information of the daily consumption of the different foods was then transformed into grams (for foods) or millilitres (mL; for drinks). The French CIQUAL food composition table was used to convert foods into nutrients for portion size [21]. The FFQ accounts for >90% of the energy intake of proteins, fat, carbohydrates, alcohol, cholesterol, vitamin D and retinol, and 85% of fibres, carotene, and iron.

Diet quality can be assessed in several ways. Besides considering the consumption of specific foods or nutrients, dietary patterns may be used, which incorporate different aspects of a person's diet. This approach includes so-called a priori dietary patterns, which are based on existing knowledge of nutrition and dietary recommendations [22]. Two frequently used diet quality scores are the AHEI and the MDS, the former aims to assess adherence to the Dietary Guidelines for Americans, and the latter, investigates adherence to a traditional Mediterranean diet [23,24]. Diet quality was assessed using the 2002 version of the AHEI, as it has been extensively used to study the association between diet quality and several chronic diseases, as well as cause-specific or all-cause mortality [25]. Briefly, the AHEI is an index composed of eleven food- and nutritivecomponents, including vegetables, fruit, whole grains (defined as a carbohydrates-to-fibre ratio $\leq$ 10:1), sweetened beverages and fruit juice, nuts and legumes, red and processed meats, trans-fat, fish (as a proxy for long-chain n-3 fatty acids), polyunsaturated fatty acids, sodium, and alcohol intake.

The AHEI was adapted from McCullough et al. [25]. As the amount of *trans* fat was not assessed in the CoLaus|PsyCoLaus study, they were not included in the computation of the score; also, all participants taking multivitamins were considered to have taken them for a duration of $\geq$5 years. Thus, the modified AHEI score ranged from 2.5 to 77.5 in CoLaus|PsyCoLaus instead of from 2.5 to 87.5 for the original AHEI score. Higher values represent a higher diet quality.

### 2.3. Anxiety disorder status and clinical characteristics

Information on anxiety and other major mental disorders including MDD, bipolar disorder, substance use disorders (SUD) and psychotic disorders was collected using the French version [26] of the semi-structured Diagnostic Interview for Genetic Studies (DIGS) [27]. Interviews were conducted by masters-level psychologists who received training on the instruments for an initial one- to two-month period. Each

interview was supervised by a senior psychologist. The French version of the DIGS revealed excellent inter-rater reliability for major mood and psychotic disorders [28] as well as for SUD [28,29], whereas the 6-week test-retest reliability was slightly lower for all these disorders. Diagnoses were assigned following the DSM-IV. As the original DIGS did not include questions assessing GAD, questions were added to the anxiety section using information from the French version [26] of the Schedule for Affective Disorders and Schizophrenia—Lifetime and Anxiety disorder version (SADS-LA) [30,31]. In addition, the brief phobia chapter of the DIGS was replaced by the corresponding more extensive sections of the SADS-LA, assessing information related to social and specific phobias, and agoraphobia with or without panic attacks. Applying the French translation of the SADS-LA, Leboyer et al. (1991) found satisfactory test-retest reliability (mean interval 3.2 months) for phobic disorders (Yule's Y = 0.66), GAD (Yule's Y = 0.61) and panic disorder/agoraphobia (Yule's Y = 0.43). In another study conducted in our unit, we found inter-rater agreement of Yule's Y = 1.00 for all specific anxiety disorders except for agoraphobia (Yule's Y = 0.96), as well as the following Yule's Y coefficients for 6-week test-retest reliability: 0.44 for social phobia, 0.77 for specific phobia, 0.58 for panic disorder, and 0.55 for agoraphobia [32].

For our analyses, we only included anxiety disorders that were still present at the time of the completion of the FFQ. Participants with past anxiety disorders were assigned to the no anxiety group. For each specific anxiety disorder (social phobia, GAD, panic disorder or agoraphobia), a dichotomous variable (yes/no) was created with the overall category of "any anxiety disorder" (presence of at least one of the specific anxiety disorders).

### 2.4. Confounders

Co-variables that may act as confounders (e.g. psychiatric medication, depression) because they are associated with both anxiety disorder status and eating behaviors were included in the analyses and were chosen a priori from the literature. The variables were assessed at FU1 and FU2 via the psychiatric interview or at the physical investigation. Aside from sex and age, data on socio-economic status (SES) was taken from the DIGS. SES was defined according to the Hollingshead Index (5 levels) [33] taking into account the participant's level of education and employment status.

Furthermore, information on a current depressive episode versus not and physical inactivity (less than once a week vs at least once a week) was taken from the DIGS [27]. Information on current living arrangements (living alone, monoparental, couple without children, couple with children), smoking status (never, former, current), and the use of psychotropic medication (antidepressants, antipsychotics or tranquilizers) was elicited during the physical exam.

Body weight and height were measured barefoot and in light indoor clothes. Body weight was measured in kilograms to the nearest 100 g using a Seca® scale (Hamburg, Germany). Height was measured to the nearest 5 mm using a Seca® (Hamburg, Germany) height gauge. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (underweight BMI $<$ 18.5 kg/m2, normal weight BMI $\geq$ 18.5 to $<$25.0 kg/m$^2$, overweight BMI $\geq$ 25.0 to $<$30.0 kg/m$^2$, obesity BMI $\geq$ 30.0 kg/m$^2$).

Total energy intake according to the FFQ was also included in analyses as a potential confounding variable.

### 2.5. Statistical analyses

All statistical analyses were conducted using the STATA software version 16.0 (Stata Corp, College Station, Texas, USA). Statistical significance was defined for a two-sided test at $p < 0.05$. Descriptive statistics were performed for the total of any ongoing anxiety disorder and for each subtype of anxiety disorder separately compared to participants without any ongoing anxiety disorder. Data of individuals participating in FU1 only or FU2 only were used and, for individuals that participated in both waves, data from both waves were used, although only data of FU1 were used for the descriptive statistics. Hence, descriptive data were stratified by individuals that participated only in FU1, only in FU2 or in both waves. Descriptive data included means, medians and percentages.

To summarize, the associations of current anxiety status with diet quality were assessed using all the data, such that one individual may have had two observations (FU1 and FU2). We decided to examine the association cross-sectionally instead of using a longitudinal approach, because we hypothesized that anxiety disorders would affect dietary choices immediately rather than over a longer time period. To account for the fact that individuals may have participated in the two follow-up evaluation waves, we performed multilevel random-effects linear regression analyses. Two sets of models were used, one for any current anxiety disorder (GAD, agoraphobia, social phobia or panic disorder) and one separately including the four specific anxiety disorders. Models were serially adjusted: Model 1 was adjusted for age and sex, Model 2 was adjusted for current major depressive episodes in addition to the adjustments of Model 1, Model 3 additionally adjusted for psychotropic medication (antidepressants, antipsychotics or tranquilizers), smoking status, living status, SES, physical inactivity, BMI, and total energy intake over and above the adjustments of Models 1 and 2. We used the Akaike Information Criterion (AIC) for evaluating how well a model fitted the data and thus, to select the most appropriate model. Additionally, a sensitivity analysis was carried out including medication in a separate step, as antidepressants are often used as treatment for anxiety disorders and could have influenced associations.

Furthermore, because individuals with anxiety disorders may maintain extreme eating habits even over a longer time period, we included all participants in our main analysis. However, in a sensitivity analysis, we excluded participants with very high or very low energy intake ($<$500 and $>$ 3500 kcal for women; $<$800 and $>$ 4000 kcal for men [34]) to determine whether results changed after exclusion of these participants with extremely high or low values.

## 3. Results

Table 1 shows sample characteristics for individuals who participated only in FU1, only in FU2, or in both FU1 and FU2. Comparing individuals only participating in FU1 with those only participating in FU2 and those participating in both FUs, differences between the groups were generally minor.

In Table 2, characteristics for any ongoing anxiety disorders as well as for the single anxiety disorders are described in more detail. Total numbers of specific current anxiety disorders were $n = 131$ for social phobia, $n = 59$ for GAD, $n = 58$ for agoraphobia and $n = 17$ for panic disorders.

Table 3 provides the AHEI scores by anxiety disorder status as well as the associations of anxiety disorders with the AHEI scores according to serially adjusted, multilevel, mixed-effects, linear regression models. The first set of models, including the overall category "any current anxiety disorder", showed statistically significant associations of this variable with lower diet quality scores, regardless of the adjustments applied. For the most conclusive model according to the AIC (model 3), the AHEI score was 1.2 points lower among those with current anxiety disorders compared to those with no anxiety disorder. According to the second set of models, which simultaneously included all four specific anxiety disorders, current panic disorders were associated with statistically significantly lower diet quality scores in all three models. In contrast, for agoraphobia, statistically significant associations with AHEI scores were only observed in models 1 and 2, but not in the fully adjusted model 3. Finally, GAD and social phobia diagnoses were not significantly associated with AHEI scores.

The sensitivity analyses with (a) including medication and (b) excluding participants with high or low energy intake, did not change

**Table 1**
Characteristics of the sample of the CoLaus|PsyCoLaus study in follow-up 1 and follow-up 2.

| Participants of | | only follow-up 1 | | | only follow-up 2 | | | both, follow-up 1 and follow-up 2[†] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | No current anxiety disorder | Any current anxiety disorder[‡] | Total | No current anxiety disorder | Any current anxiety disorder[‡] | Total | No current anxiety disorder | Any current anxiety disorder[‡] |
| Total | n | 1209 | 1143 | 66 | 385 | 360 | 25 | 2399 | 2255 | 144 |
| Age | Mean (SD) | 59.1 (11.2) | 59.3 (11.2) | 55.8 (9.5) | 60.6 (9.5) | 60.7 (9.6) | 58.7 (7.3) | 56.6 (10.0) | 56.7 (10.0) | 54.1 (9.4) |
| Sex, % | Males | 46.0 | 46.6 | 34.9 | 48.6 | 49.2 | 40.0 | 44.9 | 45.8 | 30.6 |
| | Females | 54.0 | 53.4 | 65.2 | 51.4 | 50.8 | 60.0 | 55.1 | 54.2 | 69.4 |
| Body mass index (BMI), % | Underweight (BMI < 18.5 kg/m2) | 1.7 | 1.5 | 4.6 | 1.8 | 1.7 | 4.0 | 1.0 | 1.0 | 1.4 |
| | Normal weight (BMI ≥ 18.5 to <25.0 kg/m$^2$) | 37.1 | 36.7 | 43.9 | 42.3 | 41.9 | 48.0 | 45.9 | 45.4 | 54.2 |
| | Overweight (BMI ≥ 25 to <30.0 kg/m$^2$) | 38.7 | 38.9 | 34.9 | 36.1 | 36.4 | 32.0 | 38.3 | 38.8 | 30.6 |
| | Obesity (BMI ≥ 30 kg/m$^2$) | 21.4 | 21.8 | 15.2 | 18.7 | 18.9 | 16.0 | 14.1 | 14.2 | 12.5 |
| | Missings | 1.2 | 1.1 | 1.5 | 1.0 | 1.1 | 0.0 | 0.7 | 0.7 | 1.4 |
| Socio-economic status (Hollingshead)[§] | Mean (SD) | 3.4 (1.2) | 3.4 (1.2) | 3.1 (1.3) | 3.4 (1.2) | 3.4 (1.2) | 3.4 (1.2) | 3.6 (1.2) | 3.6 (1.7) | 3.5 (1.2) |
| Current living situation, % | Living alone | 30.1 | 30.0 | 31.8 | 29.1 | 28.6 | 36.0 | 26.0 | 25.9 | 27.1 |
| | Monoparental | 5.5 | 5.3 | 9.1 | 4.9 | 5.0 | 4.0 | 6.4 | 6.2 | 9.0 |
| | Couple, no children | 35.9 | 36.5 | 25.8 | 34.3 | 34.4 | 32.0 | 33.6 | 33.8 | 31.3 |
| | Couple, with children | 28.2 | 27.9 | 33.3 | 29.4 | 29.7 | 24.0 | 33.9 | 34.0 | 32.6 |
| | Missings | 0.3 | 0.4 | 0.0 | 2.3 | 2.2 | 4.0 | 0.1 | 0.1 | 0.0 |
| Smoking status, % | Never smokers | 37.6 | 37.6 | 36.4 | 37.9 | 38.6 | 28.0 | 42.6 | 43.0 | 36.1 |
| | Former smokers | 39.0 | 39.2 | 34.9 | 40.3 | 39.7 | 48.0 | 38.3 | 38.0 | 43.1 |
| | Current smokers | 23.3 | 23.0 | 28.8 | 19.5 | 19.4 | 20.0 | 19.1 | 18.9 | 20.8 |
| | Missings | 0.2 | 0.2 | 0.0 | 2.3 | 2.2 | 4.0 | 0.0 | 0.0 | 0.0 |
| Total energy intake | Median (Q1;Q3) | 1683 (1292; 2202) | 1683 (1287; 2195) | 1708 (1400; 2470) | 1746 (13,586; 2237) | 1738 (1329; 2250) | 1889 (1543; 2175) | 1786 (1379; 2227) | 1796 (1389; 2234) | 1650 (1333; 2085) |
| Diet quality score (AHEI) | Mean (SD) | 31.6 (10.3) | 31.5 (10.2) | 32.7 (11.1) | 32.2 (9.9) | 32.1 (10.4) | 31.7 (10.6) | 32.6 (10.1) | 32.5 (10.1) | 30.0 (9.4) |
| Physical activity, % | Once a week or more | 67.1 | 67.9 | 53.0 | 67.8 | 68.1 | 64.0 | 72.7 | 72.9 | 70.1 |
| | Less than once a week | 32.6 | 31.9 | 45.5 | 19.7 | 18.9 | 32.0 | 27.3 | 27.1 | 29.9 |
| | Missings | 0.3 | 0.3 | 1.5 | 12.5 | 13.1 | 4.0 | 0.0 | 0.0 | 0.0 |
| Current Depression, % | No | 86.4 | 87.3 | 69.7 | 86.5 | 87.8 | 68.0 | 87.7 | 88.7 | 70.8 |
| | Yes | 7.2 | 6.8 | 13.6 | 9.4 | 8.3 | 24.0 | 5.8 | 5.0 | 19.4 |
| | Missings | 6.5 | 5.9 | 16.7 | 4.2 | 3.9 | 8.0 | 6.5 | 6.3 | 9.7 |
| Psychotropic medication (antidepressants or antipsychotics or tranquilisants), % | No | 80.4 | 81.5 | 60.6 | 80.8 | 81.7 | 68.0 | 87.6 | 88.2 | 78.5 |
| | Yes | 19.6 | 18.5 | 39.4 | 19.2 | 18.3 | 32.0 | 12.4 | 11.8 | 21.5 |

[†] For those participants who participated twice, data of Follow-Up1 were used.
[‡] At least one of the mentioned anxiety disorders (GAD, Agoraphobia, Social phobia, Panic disorder).
[§] Missings: 0.0% in FU1; 8.6% in FU2. A mean of 3 represents middle class status (Hollingshead, 1975).

the results (data not shown).

## 4. Discussion

To our knowledge, this is the first study to examine the associations of specific anxiety disorders with diet quality. In our study, we observed statistically significant inverse associations of anxiety disorders with diet quality according to the AHEI, also when adjusting for a series of potential confounders. Considering each specific anxiety disorder separately, associations reached the level of statistical significance for panic disorders, even after adjustment for the full series of potential confounders. For agoraphobia, the statistically significant association observed with diet quality in the first two models (adjusting for sex an age in Model 1 and additionally adjusted for current MDD in Model 2) was attenuated and no longer reached statistical significance when the model was further adjusted for physical inactivity, BMI, and total energy intake.

Various studies have shown an association of unhealthy eating with depression, and associations might be explained through mechanisms of inflammation, oxidative stress or gut microbial processes, epigenetic modifications, and neuroplasticity [6,35,36]. However, little was known about whether anxiety disorders are associated with diet quality. Our hypothesis is that a person's behavior may change depending on the symptoms that occur during anxiety disorders. Thus, behaviors such as not leaving one's home, having panic attacks in grocery stores, or having gastrointestinal problems might be associated with diet quality because it might lead to different shopping, cooking and eating habits. To the best of our knowledge, there has been no other study so far that examined the associations of GAD, agoraphobia, social phobia or panic disorder with diet quality. However, one Iranian study observed that participants in the top quartile of AHEI had a 41% lower odds of reporting an anxiety disorder compared with those in the lowest quartile (36% for depression, respectively) [37]. Another study examined different types of anxiety disorders and their associations with binge

**Table 2**
Characteristics of the sample of the CoLaus|PsyCoLaus study in follow-up 1 or follow-up 2.[†]

| | | Total | No current anxiety disorder | Any current anxiety disorder[‡] | Current GAD[‡] | Current Agoraphobia[‡] | Current Social phobia[‡] | Current Panic disorder[‡] |
|---|---|---|---|---|---|---|---|---|
| Total | n | 3993 | 3758 | 235 | 59 | 58 | 131 | 17 |
| Age | Mean (SD) | 57.7 (10.4) | 57.9 (10.5) | 55.1 (9.3) | 54.9 (9.1) | 55.8 (9.5) | 55.2 (9.3) | 53.3 (8.7) |
| Sex, % | Males | 45.6 | 46.4 | 32.8 | 23.7 | 29.3 | 38.9 | 23.5 |
| | Females | 54.4 | 53.6 | 67.2 | 76.3 | 70.7 | 61.1 | 76.5 |
| Body mass index (BMI), % | Underweight (BMI < 18.5 kg/m$^2$) | 1.3 | 1.2 | 2.6 | 0.0 | 1.7 | 4.6 | 0.0 |
| | Normal weight (BMI ≥ 18.5 to <25.0 kg/m$^2$) | 42.9 | 42.4 | 50.6 | 45.8 | 46.6 | 52.7 | 47.1 |
| | Overweight (BMI ≥ 25 to <30.0 kg/m$^2$) | 38.2 | 38.6 | 31.9 | 42.4 | 22.4 | 31.3 | 35.3 |
| | Obesity (BMI ≥ 30 kg/m$^2$) | 16.8 | 17.0 | 13.6 | 11.9 | 25.9 | 10.7 | 17.7 |
| | Missings | 0.9 | 0.9 | 1.3 | 0.0 | 3.5 | 0.8 | 0.0 |
| Socio-economic status (Hollingshead)[§] | Mean (SD) | 3.5 (1.2) | 3.5 (1.2) | 3.3 (1.2) | 3.2 (1.3) | 3.0 (1.2) | 3.4 (1.1) | 3.7 (1.1) |
| Current living situation, % | Living alone | 27.6 | 27.4 | 29.4 | 23.7 | 24.1 | 32.8 | 52.9 |
| | Monoparental | 6.0 | 5.8 | 8.5 | 8.5 | 8.6 | 6.9 | 17.7 |
| | Couple, no children | 34.4 | 34.7 | 29.8 | 28.8 | 41.4 | 29.0 | 11.8 |
| | Couple, with children | 31.7 | 31.7 | 31.9 | 39.0 | 24.1 | 30.5 | 17.7 |
| | Missings | 0.4 | 0.4 | 0.4 | 0.0 | 1.7 | 0.8 | 0.0 |
| Smoking status, % | Never smokers | 40.6 | 41.0 | 35.3 | 42.4 | 32.8 | 37.4 | 47.1 |
| | Former smokers | 38.7 | 38.5 | 41.3 | 32.2 | 50.0 | 41.2 | 29.4 |
| | Current smokers | 20.4 | 20.2 | 23.0 | 25.4 | 17.2 | 20.6 | 23.5 |
| | Missings | 0.3 | 0.3 | 0.4 | 0.0 | 0.0 | 0.8 | 0.0 |
| Total energy intake | Median (Q1;Q3) | 1743 (1358; 2220) | 1746 (1357; 2227) | 1687 (1366; 2161) | 1740 (1253; 2192) | 1558 (1354; 2030) | 1768 (1466; 2166) | 1460 (1383; 1790) |
| Diet quality score (AHEI) | Mean (SD) | 32.1 (10.2) | 32.2 (10.2) | 31.0 (10.1) | 31.5 10.8) | 29.4 (10.7) | 32.1 (10.3) | 27.1 (8.3) |
| Physical activity, % | Once a week or more | 70.5 | 70.9 | 64.7 | 64.4 | 58.6 | 68.7 | 47.1 |
| | Less than once a week | 28.2 | 27.8 | 34.5 | 35.6 | 39.7 | 30.5 | 52.9 |
| | Missings | 1.3 | 1.3 | 0.9 | 0.0 | 1.7 | 0.8 | 0.0 |
| Current Depression, % | No | 87.2 | 88.2 | 70.2 | 59.3 | 81.0 | 71.8 | 52.9 |
| | Yes | 6.6 | 5.9 | 18.3 | 23.7 | 12.1 | 16.0 | 17.7 |
| | Missings | 6.3 | 5.9 | 11.5 | 17.0 | 6.9 | 12.2 | 29.4 |
| Psychotropic medication (antidepressants or antipsychotics or tranquilisants), % | No | 84.8 | 85.6 | 72.3 | 64.4 | 77.6 | 74.8 | 47.1 |
| | Yes | 15.2 | 14.5 | 27.7 | 35.6 | 22.4 | 25.2 | 52.9 |

[†] Participants who participated twice, were only counted once and data of Follow-Up 1 was used.
[‡] Participants may be included several times in the mentioned anxiety disorders (GAD, Agoraphobia, Social phobia, Panic disorder).
[§] Missings: 0.8%. A mean of 3 represents middle class status (Hollingshead, 1975).

**Table 3**
Anxiety disorders and their associations with healthy eating according to the AHEI; Multilevel mixed-effects linear regression models.

| | | Model 1[†] | | | Model 2[‡] | | | Model 3[§] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Diet quality, mean (s.d.)* | *beta* | *SE* | *p-value* | *beta* | *SE* | *p-value* | *beta* | *SE* | *p-value* |
| **Any current anxiety disorder** | 31.0 (10.1) | **−1.146** | **0.51** | **0.026** | **−1.132** | **0.52** | **0.028** | **−1.200** | **0.50** | **0.016** |
| *Akaike information criterion* | | *46,844.86* | | | *46,847.71* | | | *44,030.91* | | |
| **Current specific anxiety disorders[¶]:** | | | | | | | | | | |
| Generalized anxiety disorder | 31.5 (10.8) | −1.030 | 0.92 | 0.262 | −1.033 | 0.92 | 0.261 | −1.023 | 0.89 | 0.248 |
| Agoraphobia | 29.4 (10.7) | **−2.185** | **1.09** | **0.046** | **−2.183** | **1.09** | **0.046** | −1.700 | 1.07 | 0.111 |
| Social phobia | 32.1 (10.3) | −0.107 | 0.70 | 0.878 | −0.094 | 0.70 | 0.893 | −0.213 | 0.68 | 0.753 |
| Panic disorder | 27.1 (8.3) | **−3.655** | **1.75** | **0.037** | **−3.669** | **1.75** | **0.036** | **−3.559** | **1.71** | **0.037** |
| No anxiety disorder | 32.2 (10.2) | 0 (ref) | | | 0 (ref) | | | 0 (ref) | | |

[†] Model 1 adjusted for sex and age.
[‡] Model 2 additionally adjusted for current major depressive episode.
[§] Model 3 additionally adjusted for psychotropic medication (antidepressants, antipsychotics, tranquilizers), smoking status, living status, socioeconomic status, physical inactivity, body-mass index, and total energy intake.
[¶] Specific anxiety disorders were mutually adjusted.

eating/purging behaviors [9]. This study conducted in England was representative of the national population according to age, sex, and geographical region and included >7000 participants. In that study, the prevalence of any anxiety disorder (GAD, agoraphobia, social phobia, panic disorder, or obsessive-compulsive disorder) was estimated to be 6.27%, which is similar to the prevalence in the CoLaus|PsyCoLaus study, although we did not include obsessive-compulsive disorder in this analysis. The English study observed statistically significant positive associations of any type of anxiety disorder with binge eating/purging behaviors. Results were attenuated when adding mood instability (measured by the Structured Clinical Interview for DSM-IV Axis II Personality Disorders and including items from the scales for borderline personality disorder) to the models, and associations only remained statistically significant for GAD, social phobia and OCD [9].

In our analysis, only agoraphobia and panic disorders were significantly associated with AHEI (although the association of agoraphobia was attenuated after adjustment for a series of confounders). This is in line with the DSM-IV, which categorizes panic disorders into panic disorders with or without agoraphobia, showing the close relationship between these two diseases. Thus, a panic attack may occur without any trigger or as a consequence of the anxiety of being in open spaces, public transport or shopping centres or being outside of one's own home (agoraphobia). The symptoms, consequences of the attacks, or subsequent changes made to behaviors have to last more than one month to be diagnosed as panic disorder with agoraphobia or as panic disorder without agoraphobia. Little is known about associations of potential risk factors and protective factors with agoraphobia. One systematic review identified modifiable risk factors and protective factors for the onset of anxiety disorders and came to the conclusion that, for example, alcohol use and cigarette smoking were risk factors for at least one anxiety disorder, whereas, for example, physical activity was a protective factor [38]. Thus, mechanisms underlying the associations of agoraphobia, in particular with worse diet quality, should be explored further. In another study including women with eating-disorders, social phobia was associated with unhealthy eating behavior, whereas agoraphobia was associated with aspects of ego dysfunction (low self-esteem, poor awareness of emotional states and mistrust of other people) [39].

The longitudinal Dutch NESDA study (Netherlands Study of Depression and Anxiety) [8] including 1634 participants examined cross-sectional associations of depression and anxiety disorders including severity and chronicity of the disorders with diet quality. Individuals with comorbid anxiety and depressive disorders had statistically significantly lower AHEI scores than controls, but current depression or current anxiety alone were not significantly associated with AHEI. However, they found individual depressive symptoms to be associated with AHEI (e.g. hypersomnia was associated with a decrease in appetite). Furthermore, they included a Mediterranean diet score as an additional outcome that did reveal significant associations in the sense that participants suffering from a current anxiety or depressive disorder were more likely to consume a less healthy diet. Another CoLaus|PsyCoLaus analysis also concluded that that people with different subtypes of depression differed from healthy controls regarding their eating habits [12]. Indeed, a Western diet was positively associated with a current atypical depressive episode, but inversely associated with current and remitted melancholic depressive episodes. In contrast to a Western diet, a Sweet-Dairy diet was positively associated with current melancholic episodes [12]. But, in contrast to our study, specific anxiety disorders were not examined here. Other studies have examined the associations of anxiety disorders and depression with oral health and, in a recent review, positive associations of depression and anxiety with poor oral health were observed [40]. Poor oral health may also be a marker for low diet quality, as low diet quality, such as eating a lot of foods containing sugar, may affect oral health.

### 4.1. Strengths and limitations

To our knowledge, this is the first study to examine associations of specific anxiety disorders with diet quality. It is an advantage that information on anxiety and depressive disorders was not retrieved from questionnaires but from validated semi-structured diagnostic interviews. Also, a series of confounders were included in the analyses. We examined the association cross-sectionally, because we hypothesized that anxiety disorders would affect dietary choices immediately rather than over a longer period. However, the directions of the associations cannot be determined, and the effect of bidirectional associations can hardly be eliminated by any study design, due to the complexity of the associations between dietary habits and mental disorders. Despite the large study sample, some groups of participants with specific anxiety disorders were small. Indeed, panic disorders were quite rare in this sample; yet, despite this limitation we were able to show statistically significant associations of panic disorders with the AHEI score.

Other psychiatric disorders such as ADHS or ASD are probably associated with both anxiety disorders and dietary habits. We performed a sensitivity analysis including ADHD as a confounder, which did not change our results as the prevalence was very low with 0.4% in our study population. ASD was not assessed in CoLaus/Psycolaus, but can be assumed to be as rare as ADHD in this population. Thus, comorbid anxiety disorder would only marginally affect the results.

Diet was assessed using a validated FFQ [20]. However, FFQs have been shown to be prone to recall bias leading to over- and under-reporting certain foods. However, this is likely to be independent of disease status leading to non-differential recall bias and possibly an underestimation rather than an overestimation of the associations observed in our study. The use of the AHEI as a diet quality score has its strengths and limitations. These quality scores are rather easy to assess and to replicate as they are used in the same way in any study that uses a specific index. They sum up the intake of indicator foods for a healthy diet in just one number, which makes these scores convenient to understand and interpret. However, despite being based on scientific evidence and recent dietary recommendations, these indices only include selected foods and nutrients and may therefore not be comprehensive enough to fully assess diet quality. Second, in the AHEI as well as in other indices, all components of the score are weighted equally [41].

Finally, our study was conducted in a cohort recruited from the general population of the French-speaking part in Switzerland. We have previously reported differences in diet quality between the different Swiss language regions [42] and it is unclear whether our results are generalizable to other regions of Switzerland or to Europe.

### 4.2. Conclusions

Our results suggest that anxiety disorders, in particular panic disorders and to some degree agoraphobia, are associated with lower dietary quality as assessed by the AHEI. If this association is confirmed in other studies, psychiatric-psychotherapeutic treatments might need to systematically include the aspect of nutrition and could also offer specific programs and interventions in this regard, such as including a nutritionist besides a psychotherapist in a multimodal approach, in the future. To improve a patient's diet, a dietitian or nutritionist can help find healthy alternatives. This is not necessarily a Mediterranean or an Oriental diet, but can be built upon healthy foods that are readily available, i.e. increase the consumption of fruit and vegetables, whole grains, nuts and decrease the consumption of processed meats, salty snacks, refined grains and sweet, for example.

Finally, in research settings, the mechanisms underlying the associations of panic disorders or agoraphobia with worse diet quality should be further explored.

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## Conflicts of interest

None.

## Data sharing

The CoLaus|PsyCoLaus cohort data used in this study cannot be fully shared as they contain potentially sensitive patient information. As discussed with the competent authority, the Research Ethic Committee of the Canton of Vaud, transferring or directly sharing this data would be a violation of the Swiss legislation aiming to protect the personal rights of participants. Non-identifiable, individual-level data are available for interested researchers, who meet the criteria for access to confidential data sharing, from the CoLaus Datacenter (CHUV, Lausanne, Switzerland). Instructions for gaining access to the CoLaus data used in this study are available at www.colaus-psycolaus.ch/professionals/how-to-collaborate/.

## CRediT authorship contribution statement

**Aline Richard:** Conceptualization, Investigation, Writing – original draft, Visualization. **Sabine Rohrmann:** Conceptualization, Writing – review & editing. **Giulia Pestoni:** Writing – review & editing. **Marie-Pierre F. Strippoli:** Data curation, Writing – review & editing. **Aurélie Lasserre:** Writing – review & editing. **Pedro Marques-Vidal:** Writing – review & editing. **Martin Preisig:** Funding acquisition, Writing – review & editing. **Caroline L. Vandeleur:** Writing – review & editing.

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