

The relationship between the World Index for Sustainability and Health (WISH) score and mental health in women: A cross-sectional study

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ABSTRACT

Diet quality has been associated with mental health, and recently, there has been growing interest in the association between sustainability of diets and human health. The objective of this cross-sectional study was to explore the relationship between a newly developed dietary index for health and sustainability, and psychological disorders among Iranian women. Participants in this cross-sectional study included 479 women living in Tehran with no history of chronic disease. A validated 168-item food frequency questionnaire was used to assess dietary intake. The World Index for Sustainability and Health (WISH) was calculated, consisting of four sub-scores: less healthy, healthy, low environmental impact, and high environmental impact. Participants' psychological status was assessed using the Depression Anxiety Stress Scale-21. Logistic regression models were used to examine the association between WISH and psychological disorders. Participant ages ranged from 20-50 years, with a mean age of 31.86 (SD:7.68) years. After adjusting for potential confounders (age, energy, BMI, marital status, education, family history of chronic disease, body satisfaction, socio-economic status, physical activity, smoking), women in the highest tertile of the healthy sub-score had significantly lower odds of experiencing depression (OR: 0.40; 95% CI: 0.24-0.67), anxiety (OR: 0.45; 95% CI: 0.23-0.87) and psychological distress (OR: 0.46; 95% CI: 0.28-0.77) compared to the reference group. Similarly, the less healthy sub-score was significantly associated with depression (OR: 0.51; 95% CI: 0.32-0.89), anxiety (OR: 0.44; 95% CI: 0.25-0.78), and psychological distress (OR: 0.57; 95% CI: 0.36-0.90). An inverse association was observed between the low environmental impact sub-score and depression (OR: 0.32; 95% CI: 0.19-0.54), anxiety (OR: 0.38; 95% CI: 0.18-0.76), and psychological distress (OR: 0.30; 95% CI: 0.17-0.51). However, no further significant associations were found with the high environmental impact sub-score, except with depression (OR: 0.57; 95% CI: 0.33-0.96). The healthy and low environmental impact sub-scores of the WISH were found to be inversely associated with depression, anxiety, and psychological distress. However, due to the cross-sectional study design, causality cannot be inferred. Further prospective studies are required to validate and expand upon these findings and explore potential mechanisms and alternative explanations, such as reverse causation. While this study suggests that choosing a diet that is both healthy for individuals and sustainable for the environment may be associated with lower risk of mental health issues among women, more research is needed.

INTRODUCTION

Anxiety, depression, and psychological distress are recognized as leading causes of disability; and according to the 2017 Global Burden of Disease report, depression has impacted 264 million people worldwide ⁽¹⁾. Notably, international and national statistics consistently report a higher prevalence of depression among women compared to men ⁽²⁾. In Iran, approximately 20% of the adult population experience anxiety and depression, with higher prevalence among women compared to men ⁽³⁾. Recent reviews have highlighted strong connections between mental and physical health, particularly with cardiovascular diseases ⁽⁴⁾, cancer ⁽⁵⁾, all-cause mortality, ⁽⁶⁾, and reduced life expectancy.

Research has consistently shown that women face unique challenges and vulnerabilities that can potentially impact their mental well-being. Recognizing this gender-specific burden, the World Health Organization (WHO) has identified women's health as a critical priority, highlighting the need for focused research in this area due to the historically limited and sometimes unreliable body of research dedicated to women's health ⁽⁷⁾. Furthermore, women's mental health during the reproductive years holds particular significance, as it can have far-reaching implications, including for fertility outcomes.

Diet has gained attention as a modifiable risk factor for mental health problems. A recent review emphasized the importance of eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), vitamin E, magnesium, and folic in psychiatric disorders ⁽⁸⁾. Furthermore, previous studies have observed associations between higher consumption of fruits, vegetables, fish, legumes, and nuts with lower risk of psychological disorders ^(9; 10; 11; 12; 13; 14; 15; 16). Conversely, a recent meta-analysis demonstrated a positive association between intake of red and processed meat and depression ⁽¹⁷⁾. Considering the synergistic effects of nutrients and foods, investigating diet-disease associations from a holistic perspective (examining the entire diet) is a desirable approach.

Previous studies have explored the relationship between mental health and various diet quality scores, including the Mediterranean Diet Score (MDS) ⁽¹⁸⁾, the Healthy Eating Index (HEI) ⁽¹⁹⁾, the Dietary Phytochemical Index (DPI) ⁽²⁰⁾, the Food Quality Score (FQS) ⁽²¹⁾, Dietary Total Antioxidant Capacity (DTAC) ⁽²²⁾, and the Recommended Food Score (RFS) ⁽²³⁾. These indices primarily recommend increased consumption of plant-based foods while limiting intake of animal foods ^(18; 19; 20; 21; 22).

In recent years, due to the growing prevalence of diet-related diseases and the bidirectional impact of food systems on climate change, researchers have shown increased

interest in sustainable diets ^(24; 25; 26). Sustainable diets are characterized by their affordability and cultural acceptability, health-promoting effects, and lower environmental impacts ⁽²⁷⁾. They primarily consist of plant-based foods that provide protection against both adverse health outcomes and environmental consequences ⁽²⁶⁾. Notably, Willett et al. recently developed specific guidelines known as the EAT-Lancet recommendations for a healthy diet from sustainable food systems ⁽²⁵⁾. These recommendations emphasize high consumption of whole grains, vegetables, fruits, legumes, nuts, and unsaturated oils, moderate intake of poultry and seafood, and limited or no consumption of refined grains, starchy vegetables, red and processed meat, and added sugar ⁽²⁵⁾. Several indices have been proposed to combine the environmental and health aspects of diet ^(28; 29). The WISH was established based on the EAT-Lancet recommendations ⁽²⁵⁾ and encompasses both diet quality and environmental sustainability in a single scoring system ⁽²⁹⁾. However, to date, the association between WISH and mental disorders has not been investigated. Therefore, the current observational study aims to evaluate the potential relationship between WISH and mental health outcomes, including depression, anxiety, and psychological distress in a population of Iranian women.

METHODS AND MATERIALS

Study population

This cross-sectional study was conducted with women who attended ten healthcare centers in the south of Tehran from September 2017 to September 2018. The prevalence of mental disorders was used to estimate the sample size, with $P = 26\%$ ⁽³⁰⁾; $\alpha = 0.05$; $d = 4.12$, using the formula: $N = \frac{[(z_{1-\frac{\alpha}{2}})^2 P(1-P)]}{d^2}$. The following inclusion criteria were considered: 1) being an Iranian woman aged 20-50 years, 2) having no history of chronic disease (cardiovascular disease, cancer, diabetes, thyroid disease, liver disease, pulmonary disease, multiple sclerosis, epilepsy, or kidney dysfunction), or psychological disease requiring antipsychotic medications, and 3) not currently following a specific diet. Pregnant, lactating, and menopausal women were excluded. Participants with energy intake higher than 3,500 or lower than 500 kcal/d ($n=31$) and those with missing psychological profile data on the Depression and Anxiety Stress Scale-21 ($n=3$) were excluded from the analysis. Ultimately, 479 individuals were eligible for the current study.

Dietary intake assessment

Participants' dietary intakes were collected using a validated semi-quantitative 168-item Iranian food frequency questionnaire (FFQ), administered through face-to-face interviews⁽³¹⁾. A trained dietitian asked about the frequency of consumption on a daily, weekly, or monthly basis, as well as the usual serving size of food items. Then, a guideline for household measures⁽³²⁾ was used to convert serving sizes to grams per day. Finally, energy and main nutrients were computed using a modified version of NUTRITIONIST IV software for Iranian foods (version 7.0; N-Squared Computing, Salem, OR, USA).

World Index for Sustainability and Health (WISH) calculation

The WISH was determined based on a method developed by Trijsburg et al.⁽²⁹⁾, which scores both diet healthiness and environmental impact. Detailed information about the construction and validation of WISH has been provided elsewhere⁽²⁹⁾. WISH scores have been applied and calculated to other lower- and middle-income countries (e.g. for women in rural East Africa), supporting the index's broader applicability⁽³³⁾. The WISH index considered thirteen food groups, including vegetables, fruits, whole grains, fish, red meat, dairy, chicken, eggs, nuts, legumes, saturated oils, unsaturated oils, and added sugars. Food groups were categorized based on their health-related (protective, neutral, or limited) and environmental (low, medium, or high) impacts. This score includes four sub-scores: healthy (vegetables, fruits, whole grains, fish, dairy, egg, chicken, nuts, legumes, unsaturated oils), less healthy (red meat, saturated oils, added sugar), low environmental impact (whole grains, vegetables, fruits, legumes, unsaturated oils, added sugars), and high environmental impact (red meat, dairy, egg, chicken, nuts, fish, saturated oils). For the healthy and low environmental sub-scores, a value of 0-10 indicates the lowest to the highest consumption of the components. In the case of the less healthy and high environmental sub-score, higher values correspond to less consumption of the components. Finally, a higher total score indicates a healthier or more environmentally friendly diet.

Psychological profile assessment

The Depression Anxiety Stress Scale-21 (DASS-21), a validated self-reported questionnaire, consists of seven items in three subscales, to assess psychological distress, depression, and anxiety. Answers are given on a four-point Likert scale ranging from 0 (never) to 3 (always). Scores on each subscale range from 0 to 21. The Iranian version of the DASS-21, which has been validated and deemed reliable, was used in this study⁽³⁴⁾. Since the original scale of DASS is based on 42 questions, DASS-21 final scores in each subscale were

doubled. Finally, depression, anxiety, and psychological distress were defined as scores of ≥ 10 , ≥ 8 , and ≥ 15 , respectively. The Cronbach alpha indices for the subscales were as follows: depression = 0.81, anxiety = 0.74, distress = 0.78.

Anthropometric and socio-demographic assessment

Body weight was measured using a digital scale (SECA, Hamburg, Germany) while participants wore minimal clothing and no shoes. Height was measured using an inflexible measuring rod with a precision of 0.1 cm. Body Mass Index (BMI) was calculated as $\text{BMI} = \text{weight (kg)} / \text{height}^2 \text{ (m)}$. Demographic information including age, marital status (married/single), smoking (yes/no), socioeconomic status (SES)⁽³⁵⁾ (education, family size, employment status and occupation, homeownership, home equipment diversity, number of rooms, and domestic/international travel), education, body satisfaction (yes/no), medication or vitamin supplement usage (yes/no), history of chronic disease (cancer, diabetes, cardiovascular, liver, pulmonary, kidney, thyroid diseases, hypertension, multiple sclerosis (MS), epilepsy), and family history of these diseases (yes/no), were collected using an interview-based questionnaire. Physical activity level was determined by having participants directly log the average time and total duration that they devoted to various physical activities over a 24-hour period. Then, physical activity level was computed as metabolic equivalent minutes per week (MET/min/wk)⁽³⁶⁾. Finally, four categories were used to indicate the level of physical activity (light, moderate, strong, and intense).

Statistical analysis

The distribution of variables was analyzed using the Kolmogorov–Smirnov test. Continuous variables were presented as mean \pm standard deviation, while categorical variables were presented as frequencies (N) and percentages (%). Chi-square and one-way ANOVA tests were used to compare the general characteristics of participants across the tertiles of WISH sub-scores. Study participants' dietary intakes across tertiles of WISH scores were compared using ANCOVA adjusted for energy intake. Binary logistic regression analysis was also applied to assess the relationship between less healthy, healthy, low environmental impact, and high environmental impact scores and odds of having each of the three psychological profiles (anxiety, depression, and psychological distress) by including age, energy, BMI, marital status, education, family history of chronic disease, sleep duration, duration of time spent outside, prescription medications, vitamin supplementation, body satisfaction, SES, and physical activity in the multivariable-adjusted model. Covariates were selected based on clinical knowledge and a comprehensive literature review^(20; 21; 37) and

baseline variables associated with having each of the three psychological profiles, as illustrated in Supplementary Figure 1 using a Directed Acyclic Graph (DAG). Variables that met both the statistical criteria (favorable AIC/BIC values, low multicollinearity) and the practical significance criterion (10-15% effect size change) were selected as confounders for inclusion in our multivariable logistic regression models. Statistical analyses were performed with SPSS statistical package software (SPSS Inc., Chicago IL, USA Version 27), and $p < 0.05$ was considered significant.

RESULTS

Table 1 presents the characteristics of women categorized according to WISH sub-scores. The mean age, weight, BMI, and physical activity of the participants was 31.9 (7.7) years, 64.5 (12.0) kg, 24.5 (4.5) kg/m², and 39.9 (6.8) MET/min/wk, respectively. We observed that higher healthy, less healthy, low environmental, and high environmental scores were associated with lower odds of depression and psychological distress. Additionally, women with higher healthy and low environmental, and lower less healthy sub-scores reported lower levels of anxiety. No significant differences in socioeconomic status, education status, supplement usage, medication use, family history of chronic disease, and body satisfaction were observed.

The energy-adjusted dietary intakes of participants across tertiles of healthy, less healthy, low environmental, and high environmental impacts sub-scores are presented in **Table 2**. Higher intakes of carbohydrate, fiber, polyunsaturated fatty acid (PUFA), vitamin A, vitamin B1, vitamin B6, vitamin C, magnesium, vegetables, fruit, fish, legumes, nuts, and unsaturated oil, and lower intakes of cholesterol, vitamin B2, vitamin D, calcium, eggs, meat, and dairy were associated with third tertiles of the healthy sub-score. Women scoring in the highest less healthy tertile had lower consumption of energy, protein, carbohydrates, fat, fiber, monounsaturated fatty acid (MUFA), vitamin B1, vitamin B2, vitamin B6, vitamin B9, calcium, magnesium, zinc, meat, fruit, dairy, saturated oil, and sugar but higher intakes of vitamin A, vegetables, chicken, unsaturated oil, compared to those in the lowest tertile. Women in the third tertile of low environmental impact reported significantly greater intake of energy, protein, fiber, vitamin A, vitamin B2, vitamin B6, vitamin B9, vitamin C, calcium, magnesium, vegetables, fruit, dairy, meat, legumes, and unsaturated oil compared to participants in the first tertile. However, they showed lower intakes of sugar. Participants in the top environmental tertile had lower intakes of energy, protein, carbohydrate, fat, fiber, MUFA, cholesterol, vitamin D, vitamin B1, vitamin B2, vitamin B6, calcium, whole grains,

fruits, egg, dairy, meat, chicken, and saturated oil compared to those in the bottom environmental tertile. Women in the lowest tertile consumed less fish and nuts.

Table 3 shows adjusted ORs for depression, anxiety, and stress comparing tertiles of healthy, less healthy, low, and high environmental scores. The healthy score was inversely associated with the odds of depression (OR: 0.40; 95% CI: 0.24-0.67; $p=0.001$), anxiety (OR: 0.45; 95% CI: 0.23-0.87; $p=0.023$) and distress (OR: 0.46; 95% CI: 0.28-0.77; $p=0.003$). The less healthy score was positively associated with distress (OR: 0.57; 95% CI: 0.36-0.90; $p=0.016$), depression (OR: 0.51; 95% CI: 0.32-0.89; $p=0.004$), and anxiety (OR: 0.44; 95% CI: 0.25-0.78; $p=0.004$). In addition, scores for low environmental impact were inversely associated with depression (OR: 0.32; 95% CI: 0.19-0.54; $p<0.001$), distress (OR: 0.30; 95% CI: 0.17-0.51; $p<0.001$), and anxiety (OR: 0.38; 95% CI: 0.18-0.76; $p=0.012$). An inverse association was found between scores indicating high environmental impact and depression (OR: 0.57; 95% CI: 0.33-0.96; $p=0.031$). However, we failed to detect a significant association between high environmental score with anxiety (OR: 0.56; 95% CI: 0.29-1.08; $p=0.090$) or distress (OR: 0.62; 95% CI: 0.37-1.06; $p=0.080$).

DISCUSSION

In this cross-sectional study, we investigated the mental health of Iranian women in relation to WISH sub-scores. Our results revealed that healthier scores were correlated with lower odds of depression, anxiety, and psychological distress. In addition, we found an inverse correlation between less healthy scores and psychological disorders. Considering environmental dietary indicators, a negative association was seen between the low environmental impact sub-score and depression, anxiety, and psychological distress. However, the high environmental impact sub-score was not related to odds of mental disorders, except for depression. To the best of our knowledge, this is the first study to assess WISH score in relation to depression, anxiety, and psychological distress.

The current study was conducted among a sample of Iranian adult women. Findings indicated that Iranian women consume vegetables, fruits, dairy products, fish, chickens, eggs, nuts, legumes, and unsaturated oils within the EAT-Lancet guidelines suggested range. Nevertheless, due to the moderate environmental impact of dairy products, their consumption could be slightly decreased. In low to middle-income countries, the majority of energy intake comes from carbohydrates⁽³⁸⁾. Based on the results of the present study, the average amount of whole grains consumed by this population is considerably lower than the recommended range. On the other hand, the consumption of less healthy food groups, including red meats,

saturated oils, and added sugar was relatively higher than the recommended values and should be decreased. In summary, our study population could improve their current WISH score by consuming higher amounts of whole grains and fish while limiting less healthy food intake. Notwithstanding the average amounts of food consumed by our population, we should be cautious in generalizing these intake values to the whole Iranian female population, as adherence to the EAT-Lancet recommendations can be relatively expensive and may differ across individuals with various socioeconomic statuses ⁽³⁹⁾.

Vegetables, legumes, whole grains, fruits, and unsaturated oils are the components of both the healthy and low environmental impact sub-scores ⁽²⁹⁾. In addition, fish, chicken, eggs, dairy, and nuts are known to be healthy foods ⁽²⁹⁾. We found an inverse association between the healthy sub-score of WISH and mental disorders. Consistent with our findings, a previous meta-analysis of observational studies found fruits, vegetables, and fish, intake to be inversely linked with psychological disorders within the general population ^(11; 12). Furthermore, another cross-sectional study among 24,776 Chinese participants revealed that consumption of whole grains ≥ 2 times/week was associated with a 32% and 24% lower odds of depression in males and females, respectively ⁽⁴⁰⁾. Similarly, another cross-sectional study of 3,172 Iranian adults also reported a negative association between whole grain consumption and odds of anxiety in women, while a positive association was observed for refined grains and anxiety and depression ⁽⁴¹⁾. A review of 13 studies investigating dairy products in relation to mental disorders found inconsistent results ⁽⁴²⁾. However, because of methodological differences and considering various sub-types of dairy products in the studies included, conclusions could not be made, and further studies were recommended ⁽⁴²⁾.

We found an inverse association between the low environmental impact sub-score and odds of depression, anxiety, and psychological distress. Plant-based food groups as well as added sugars, are considered to have less impact on the environment. We previously mentioned results from earlier studies that had investigated the relation between specific plant-based food groups and mental health ^(11; 12). Added sugars were also included in the less environmental impact sub-score ⁽²⁹⁾. Despite categorization as a low environmental impact food, added sugars were found to be an unhealthy risk factor for mental health conditions. A meta-analysis by *Hu et al.* ⁽⁴³⁾ revealed that intake of sugar-sweetened beverages could be modestly related to depression (OR=1.31). Also, a cohort study of 935 Japanese adults reported that higher soft drink consumption was positively associated with risk of depression ⁽⁴⁴⁾. Additionally, a study among 4,741 adults in South Australia concluded there was a direct

link between consuming soft drinks and psychological disorders ⁽⁴⁵⁾. Similarly, sugar and sweeteners were positively associated with anxiety ⁽⁴⁶⁾. Wattick et al. demonstrated a similar relation between added sugar intake and anxiety in 1,959 college students ⁽⁴⁷⁾. Nevertheless, it is worth mentioning that added sugar is one of the components of the low environmental impact sub-score, and other healthy components such as vegetables, fruits, and whole grains might counteract the deleterious effects of added sugars on mental health. Furthermore, EAT-Lancet guidelines recommended caution associated with added sugar intake, because of the possible health concerns, suggesting a cut-off value of 31 g/day ^(25; 29).

We found that having a less healthy WISH score on any of the sub-scales was related to lower odds of psychological disorders. Higher scores indicate healthier diets with lower consumption of red meats, saturated fats, and added sugars. In our earlier report, *Daroghegi et al.* found that women with the highest levels of red meat intake had substantially increased odds of anxiety, depression, and psychological distress ⁽⁴⁸⁾. A study by *Kouvari et al.* on 1,514 men and 1,528 women revealed that moderate (second tertile) consumption of total meat and red meat was negatively associated with odds of depression indicating a U-shaped association ⁽⁴⁹⁾. Also, *Kazemi et al.* found an increased chance of depression among adults who have higher intakes of red meat, especially among people of normal weight and males ⁽⁵⁰⁾. *Olivan-Blazquez et al.* concluded that adults who consume more than 1 serving/day of red meat had higher likelihood of depressive symptoms ⁽⁵¹⁾. Also, a meta-analysis found that red and processed meat intake could be positively linked to high levels of depression or depression ⁽¹⁷⁾. Furthermore, several animal studies revealed that saturated fatty acids might be a responsible nutrient associated with anxiety ^(52; 53; 54). Despite the deleterious effect of animal products on health as well as the environment, some important nutrients including iron, calcium, zinc, and vitamin B12 are mainly provided by animal-based foods ⁽⁵⁵⁾. Strategies including supplementation, considering meat alternatives and promotion of nutrient absorption from plant-based foods should be considered to overcome the possible deficiencies ⁽⁵⁶⁾.

Dietary intake of individual nutrients and food groups is an important approach for exploring diet-disease associations. However, our dietary intakes are a combination of various foods with different nutritional values, and specific nutrients might interact in the human body. Therefore, considering dietary intake holistically could be a better option for investigating diet in relation to disease. In agreement with our findings, earlier meta-analyses reported an inverse association between the Mediterranean Diet and HEI, which highly

consists of plant-based foods as well as unsaturated fats, and depression^(57; 58). Furthermore, a cross-sectional study on Iranian adults found an inverse association between the Mediterranean Diet and anxiety and psychological distress⁽¹⁸⁾. Also, a cross-sectional study among Australian vegans and vegetarians found a protective relation between a plant-based diet and depression⁽⁵⁹⁾. Similarly, our previous report using the same data revealed an inverse relation between overall and healthful plant-based dietary patterns and anxiety, depression, and psychological distress⁽⁶⁰⁾. However, higher scores for the unhealthful plant-based dietary pattern have been shown to be related to increased odds of depression by 91%⁽⁶⁰⁾. Another cross-sectional study among diabetic women in Iran found that the unhealthful plant-based diet was a predictor of increased depression, anxiety, and stress, but no significant relation was found between the healthful plant-based diet and mental disorders⁽⁶¹⁾. On the other hand, a recent meta-analysis did not find a significant relation between vegetarian diets and risk of anxiety and depression⁽⁶²⁾. It is important to note that discrepancies among studies may be due to different study designs and populations. Most prior studies on the relation between plant-based dietary patterns and mental disorders have been cross-sectional, thus, more prospective studies are required to rule out the possibility of reverse causation.

There are several proposed mechanisms by which healthy and low environmental impact sub-scores may be related to mental health. These sub-scores mainly reflect plant-based foods (providing considerable amounts of fiber, magnesium, and B vitamins), which have been found to be protective for mental disorders^(63; 64; 65). Furthermore, these sub-scores recommend unsaturated fat consumption, which has been inversely associated with depression⁽⁶⁶⁾. The low glycemic index of plant-based diets could be another possible mechanism. Adhering to a low glycemic index diet could reduce insulin resistance, which has been found to be negatively associated with mental health^(67; 68). Also, inflammation is a key factor in the pathophysiology of psychological disorders⁽⁶⁹⁾, and adherence to plant-based diets could be an important approach for controlling inflammation^(70; 71).

In the current study, we considered possible confounding of several factors in the association between WISH score and mental disorders. These confounders included age, energy, BMI, marital status, educational level, family history of chronic disease, body satisfaction, SES, physical activity, and smoking. The associations we observed were mostly unchanged after adjusting for these confounders. It should be acknowledged that residual confounding may still exist due to errors in classifying participants based on the confounding variables or due to errors in measuring confounders. Also, there may be additional

confounders that we did not collect data on. For instance, sleep and psychological disorders share common causes and also have bidirectional associations (e.g. sleep disturbances have been found to be a strong causal factor for mental disorders ⁽⁷²⁾). Also, abundant evidence indicates a potential role of diet in sleep health ⁽⁷³⁾. Given the points mentioned above, the relation between diet and mental disorders in our study might still be confounded by some mismeasured or unmeasured factors, which should be considered in the interpretation of the results. In addition, reverse causality is an important phenomenon, and the actual associations might be in the reverse direction of which we hypothesized. In this scenario, individuals with depression, anxiety, or stress might alter their dietary intakes in response to their specific mental health conditions. These dietary behaviors (e.g. eating sweet foods) may result from an effort to enhance their mood, poor appetite, or lack of motivation to buy or prepare healthy foods ^(74; 75). For instance, a longitudinal study observed that depressive symptoms were related to changes in vegetables, meats, and dairy products intake,⁽⁷⁶⁾ suggesting that a bidirectional relationship could exist between diet and depression. Such studies in which the relation between diet and mental disorders is explored in both directions are scarce and need to be prioritized in future research. To control for bias from reverse causation, we did not include participants who had used antidepressant drugs as they tend to have more severe mental disorders and are more likely to alter their dietary intakes due to their condition. Notwithstanding, a bidirectional relation may exist between dietary intakes and mental disorders ⁽⁷⁶⁾, and reverse causality cannot be ruled out in our study. It is important to consider this point in interpreting our findings. Further prospective cohort studies are required to understand reverse causation.

There are some strengths of our study. It is the first study to examine the association between WISH scores and mental health conditions. Furthermore, we used validated questionnaires for dietary intake, mental health, and assessment of physical activity. Also, although residual confounding might still remain, several potential confounders were taken into account in our analyses. For the interpretation of the results, several limitations were also important. First, the cross-sectional nature of our study limited our ability to infer causal relationships. Therefore, prospective studies are needed to further explore the relationships between diet and mental disorders. Second, despite using validated DASS-21 and FFQ questionnaires, they are subjected to under- or over-reporting, leading to potential participant misclassification. Third, despite being a universal score, the WISH has not been specifically validated among females, or among Iranians in particular. Therefore, we recommend that

future studies examine the reliability and validity of this index among different populations to assess its robustness. Finally, caution should be taken in generalizing our findings to other populations including males, older adults, and those with other health conditions.

In conclusion, adherence to a healthier diet with less environmental impact was associated with better psychological health among women. Due to the worsening trends in our environment and the increasing prevalence of psychological disorders, more prospective studies that include both genders are warranted to understand the causality of the observed associations and explore potential mechanisms.

ABBREVIATIONS ANOVA: Analysis of Variance; BMI: Body Mass Index; CI: confidence interval; DASS: Depression Anxiety Stress Score; DHA: docosahexaenoic-acid; DPI: Dietary Phytochemical Index; DTAC: Dietary Total Antioxidant Capacity; EPA: eicosapentaenoic-acid; FFQ: Food Frequency Questionnaire; FQS: food quality score; HEI: Healthy Eating Index; MDS: Mediterranean diet score; MET: metabolic equivalent; MS: multiple sclerosis; MUFA: monounsaturated fatty acid; OR: odds ratio; PUFA: polyunsaturated fatty acid; RFS: recommended food score; SES: socioeconomic status; TUMS: Tehran University of Medical Sciences; USA: United States of America; WISH: World Index for Sustainability and Health.

Ethics approval and consent to participate All participants were provided written consent based on the guidelines of Declaration of Helsinki. The study protocol (98-01-161-42024) was approved by the Medical Research Ethics Committee of Tehran University of Medical Sciences (TUMS).

Consent for publication Not applicable

Availability of data and materials The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Competing interests The authors declare that they have no competing interests

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REFERENCES

1. (2018) Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet* **392**, 1789-1858.
2. Evaluation IoHMa. <https://vizhub.healthdata.org/gbd-results/>
3. Naghavi M, Abolhassani F, Pourmalek F *et al.* (2009) The burden of disease and injury in Iran 2003. *Popul Health Metr* **7**, 9.
4. Nielsen RE, Banner J, Jensen SE (2021) Cardiovascular disease in patients with severe mental illness. *Nat Rev Cardiol* **18**, 136-145.
5. Wang YH, Li JQ, Shi JF *et al.* (2020) Depression and anxiety in relation to cancer incidence and mortality: a systematic review and meta-analysis of cohort studies. *Mol Psychiatry* **25**, 1487-1499.
6. Machado MO, Veronese N, Sanches M *et al.* (2018) The association of depression and all-cause and cause-specific mortality: an umbrella review of systematic reviews and meta-analyses. *BMC Med* **16**, 112.
7. Organization WH Women's health. <https://www.who.int/health-topics/women-s-health>
8. Muscaritoli M (2021) The Impact of Nutrients on Mental Health and Well-Being: Insights From the Literature. *Front Nutr* **8**, 656290.
9. Anjom-Shoae J, Sadeghi O, Keshteli AH *et al.* (2020) Legume and nut consumption in relation to depression, anxiety and psychological distress in Iranian adults. *European journal of nutrition* **59**.
10. Grosso G, Estruch R (2016) Nut consumption and age-related disease. *Maturitas* **84**, 11-16.
11. Grosso G, Micek A, Marventano S *et al.* (2016) Dietary n-3 PUFA, fish consumption and depression: A systematic review and meta-analysis of observational studies. *J Affect Disord* **205**, 269-281.
12. Saghafian F, Malmir H, Saneei P *et al.* (2018) Fruit and vegetable consumption and risk of depression: accumulative evidence from an updated systematic review and meta-analysis of epidemiological studies. *British journal of nutrition* **119**, 1087-1101.
13. Lee MF, Eather R, Best T (2021) Plant-based dietary quality and depressive symptoms in Australian vegans and vegetarians: a cross-sectional study. *BMJ Nutr Prev Health* **4**, 479-486.

14. Lee M, Bradbury J, Yoxall J *et al.* (2022) Is dietary quality associated with depression? An analysis of the Australian longitudinal study of women's health data. *Br J Nutr* **129**, 1-8.
15. Lee M, Bradbury J, Yoxall J *et al.* (2023) A longitudinal analysis of Australian women's fruit and vegetable consumption and depressive symptoms. *Br J Health Psychol* **28**, 829-843.
16. Walsh H, Lee M, Best T (2023) The Association between Vegan, Vegetarian, and Omnivore Diet Quality and Depressive Symptoms in Adults: A Cross-Sectional Study. *Int J Environ Res Public Health* **20**.
17. Nucci D, Fatigoni C, Amerio A *et al.* (2020) Red and processed meat consumption and risk of depression: A systematic review and meta-analysis. *International journal of environmental research and public health* **17**, 6686.
18. Sadeghi O, Keshteli AH, Afshar H *et al.* (2021) Adherence to Mediterranean dietary pattern is inversely associated with depression, anxiety and psychological distress. *Nutr Neurosci* **24**, 248-259.
19. Wang K, Zhao Y, Nie J *et al.* (2021) Higher HEI-2015 Score Is Associated with Reduced Risk of Depression: Result from NHANES 2005-2016. *Nutrients* **13**.
20. Darooghegi Mofrad M, Siassi F, Guilani B *et al.* (2019) Association of dietary phytochemical index and mental health in women: a cross-sectional study. *Br J Nutr* **121**, 1049-1056.
21. Darooghegi Mofrad M, Siassi F, Guilani B *et al.* (2020) The association of food quality index with mental health in women: a cross-sectional study. *BMC Res Notes* **13**, 557.
22. Daneshzad E, Keshavarz SA, Qorbani M *et al.* (2020) Dietary total antioxidant capacity and its association with sleep, stress, anxiety, and depression score: A cross-sectional study among diabetic women. *Clin Nutr ESPEN* **37**, 187-194.
23. Lee JE, Kim YJ, Park HJ *et al.* (2019) Association of recommended food score with depression, anxiety, and quality of life in Korean adults: the 2014-2015 National Fitness Award Project. *BMC Public Health* **19**, 956.
24. Myers SS, Smith MR, Guth S *et al.* (2017) Climate change and global food systems: potential impacts on food security and undernutrition. *Annual review of public health* **38**, 259-277.
25. Willett W, Rockström J, Loken B *et al.* (2019) Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. *Lancet* **393**, 447-492.
26. Tepper S, Geva D, Shahar DR *et al.* (2021) The SHED Index: a tool for assessing a Sustainable HEalthy Diet. *European Journal of Nutrition*, 1-13.

27. Burlingame B, Dernini S (2012) *Sustainable diets and biodiversity directions and solutions for policy, research and action*: FAO Headquarters, Rome.
28. Seconda L, Baudry J, Pointereau P *et al.* (2019) Development and validation of an individual sustainable diet index in the NutriNet-Santé study cohort. *British Journal of Nutrition* **121**, 1166-1177.
29. Trijsburg L, Talsma EF, Crispim SP *et al.* (2020) Method for the Development of WISH, a Globally Applicable Index for Healthy Diets from Sustainable Food Systems. *Nutrients* **13**.
30. Noorbala AA, Bagheri Yazdi SA, Yasamy MT *et al.* (2004) Mental health survey of the adult population in Iran. *Br J Psychiatry* **184**, 70-73.
31. Mirmiran P, Esfahani FH, Mehrabi Y *et al.* (2010) Reliability and relative validity of an FFQ for nutrients in the Tehran lipid and glucose study. *Public Health Nutr* **13**, 654-662.
32. Ghaffarpour M, Houshiar-Rad A, Kianfar H (1999) The manual for household measures, cooking yields factors and edible portion of foods. *Tehran: Nashre Olume Keshavarzy* **7**, 42-58.
33. Keding GB, Sarfo J, Pawelzik E (2023) Healthy Diets from Sustainable Food Systems: Calculating the WISH Scores for Women in Rural East Africa. *Nutrients* **15**.
34. Sahebi A, Asghari MJ, Salari RS (2005) Validation of depression anxiety and stress scale (DASS-21) for an Iranian population.
35. Shafiei S, Yazdani S, Jadidfard MP *et al.* (2019) Measurement components of socioeconomic status in health-related studies in Iran. *BMC Res Notes* **12**, 70.
36. Ainsworth BE, Haskell WL, Whitt MC *et al.* (2000) Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc* **32**, S498-504.
37. Zamani B, Zeinalabedini M, Nasli Esfahani E *et al.* (2023) Can Following Paleolithic and Mediterranean Diets Reduce the Risk of Stress, Anxiety, and Depression: A Cross-Sectional Study on Iranian Women. *J Nutr Metab* **2023**, 2226104.
38. Seidelmann SB, Claggett B, Cheng S *et al.* (2018) Dietary carbohydrate intake and mortality: a prospective cohort study and meta-analysis. *The Lancet Public Health* **3**, e419-e428.
39. Hirvonen K, Bai Y, Headey D *et al.* (2020) Affordability of the EAT–Lancet reference diet: a global analysis. *The Lancet Global Health* **8**, e59-e66.
40. Wu H, Zhang S, Meng G *et al.* (2021) The consumption of wholegrain is related to depressive symptoms among Chinese adults: a cross-sectional study. *European Journal of Clinical Nutrition*, 1-8.

41. Sadeghi O, Hassanzadeh-Keshteli A, Afshar H *et al.* (2019) The association of whole and refined grains consumption with psychological disorders among Iranian adults. *Eur J Nutr* **58**, 211-225.
42. Hockey M, McGuinness AJ, Marx W *et al.* (2020) Is dairy consumption associated with depressive symptoms or disorders in adults? A systematic review of observational studies. *Critical reviews in food science and nutrition* **60**, 3653-3668.
43. Hu D, Cheng L, Jiang W (2019) Sugar-sweetened beverages consumption and the risk of depression: A meta-analysis of observational studies. *Journal of affective disorders* **245**, 348-355.
44. Kashino I, Kochi T, Imamura F *et al.* (2021) Prospective association of soft drink consumption with depressive symptoms. *Nutrition* **81**, 110860.
45. Shi Z, Taylor AW, Wittert G *et al.* (2010) Soft drink consumption and mental health problems among adults in Australia. *Public Health Nutr* **13**, 1073-1079.
46. Hoerr J, Fogel J, Van Voorhees B (2017) Ecological correlations of dietary food intake and mental health disorders. *J Epidemiol Glob Health* **7**, 81-89.
47. Wattick RA, Hagedorn RL, Olfert MD (2018) Relationship between Diet and Mental Health in a Young Adult Appalachian College Population. *Nutrients* **10**.
48. Darooghegi Mofrad M, Mozaffari H, Sheikhi A *et al.* (2021) The association of red meat consumption and mental health in women: A cross-sectional study. *Complement Ther Med* **56**, 102588.
49. Kouvari M, Panagiotakos DB, Chrysohoou C *et al.* (2020) Meat consumption, depressive symptomatology and cardiovascular disease incidence in apparently healthy men and women: highlights from the ATTICA cohort study (2002-2012). *Nutr Neurosci*, 1-10.
50. Kazemi S, Keshteli AH, Saneei P *et al.* (2021) Red and White Meat Intake in Relation to Mental Disorders in Iranian Adults. *Front Nutr* **8**, 710555.
51. Oliván-Blázquez B, Aguilar-Latorre A, Motrico E *et al.* (2021) The Relationship between Adherence to the Mediterranean Diet, Intake of Specific Foods and Depression in an Adult Population (45-75 Years) in Primary Health Care. A Cross-Sectional Descriptive Study. *Nutrients* **13**.
52. Meichtry LB, Poetini MR, Dahleh MMM *et al.* (2020) Addition of Saturated and Trans-fatty Acids to the Diet Induces Depressive and Anxiety-like Behaviors in *Drosophila melanogaster*. *Neuroscience* **443**, 164-175.

53. Nakajima S, Fukasawa K, Gotoh M *et al.* (2020) Saturated fatty acid is a principal cause of anxiety-like behavior in diet-induced obese rats in relation to serum lysophosphatidyl choline level. *Int J Obes (Lond)* **44**, 727-738.
54. Sivanathan S, Thavartnam K, Arif S *et al.* (2015) Chronic high fat feeding increases anxiety-like behaviour and reduces transcript abundance of glucocorticoid signalling genes in the hippocampus of female rats. *Behav Brain Res* **286**, 265-270.
55. Magkos F, Tetens I, Bügel SG *et al.* (2020) A perspective on the transition to plant-based diets: a diet change may attenuate climate change, but can it also attenuate obesity and chronic disease risk? *Advances in Nutrition* **11**, 1-9.
56. Bastian GE, Buro D, Palmer-Keenan DM (2021) Recommendations for Integrating Evidence-Based, Sustainable Diet Information into Nutrition Education. *Nutrients* **13**, 4170.
57. Lassale C, Batty GD, Baghdadli A *et al.* (2019) Healthy dietary indices and risk of depressive outcomes: a systematic review and meta-analysis of observational studies. *Mol Psychiatry* **24**, 965-986.
58. Shafiei F, Salari-Moghaddam A, Larijani B *et al.* (2019) Adherence to the Mediterranean diet and risk of depression: a systematic review and updated meta-analysis of observational studies. *Nutrition reviews* **77**, 230-239.
59. Lee MF, Eather R, Best T (2021) Plant-based dietary quality and depressive symptoms in Australian vegans and vegetarians: a cross-sectional study. *BMJ Nutrition, Prevention & Health*, e000332.
60. Zamani B, Daneshzad E, Siassi F *et al.* (2020) Association of plant-based dietary patterns with psychological profile and obesity in Iranian women. *Clinical Nutrition* **39**, 1799-1808.
61. Daneshzad E, Keshavarz S-A, Qorbani M *et al.* (2020) Association of dietary acid load and plant-based diet index with sleep, stress, anxiety and depression in diabetic women. *British Journal of Nutrition* **123**, 901-912.
62. Askari M, Daneshzad E, Darooghegi Mofrad M *et al.* (2020) Vegetarian diet and the risk of depression, anxiety, and stress symptoms: a systematic review and meta-analysis of observational studies. *Critical reviews in food science and nutrition*, 1-11.
63. Skarupski KA, Tangney C, Li H *et al.* (2010) Longitudinal association of vitamin B-6, folate, and vitamin B-12 with depressive symptoms among older adults over time. *The American journal of clinical nutrition* **92**, 330-335.
64. Xu Y, Wang C, J Klabnik J *et al.* (2014) Novel therapeutic targets in depression and anxiety: antioxidants as a candidate treatment. *Current Neuropharmacology* **12**, 108-119.

65. Derom M-L, Sayón-Orea C, Martínez-Ortega JM *et al.* (2013) Magnesium and depression: a systematic review. *Nutritional neuroscience* **16**, 191-206.
66. Sánchez-Villegas A, Verberne L, De Irala J *et al.* (2011) Dietary fat intake and the risk of depression: the SUN Project. *PloS one* **6**, e16268.
67. Kan C, Silva N, Golden SH *et al.* (2013) A systematic review and meta-analysis of the association between depression and insulin resistance. *Diabetes care* **36**, 480-489.
68. Haghghatdoost F, Azadbakht L, Keshteli AH *et al.* (2016) Glycemic index, glycemic load, and common psychological disorders. *The American journal of clinical nutrition* **103**, 201-209.
69. Pariante CM (2017) Why are depressed patients inflamed? A reflection on 20 years of research on depression, glucocorticoid resistance and inflammation. *European neuropsychopharmacology* **27**, 554-559.
70. Medawar E, Huhn S, Villringer A *et al.* (2019) The effects of plant-based diets on the body and the brain: a systematic review. *Translational psychiatry* **9**, 1-17.
71. Bonaccio M, Pounis G, Cerletti C *et al.* (2017) Mediterranean diet, dietary polyphenols and low grade inflammation: results from the MOLI-SANI study. *British journal of clinical pharmacology* **83**, 107-113.
72. Freeman D, Sheaves B, Waite F *et al.* (2020) Sleep disturbance and psychiatric disorders. *Lancet Psychiatry* **7**, 628-637.
73. St-Onge MP, Mikic A, Pietrolungo CE (2016) Effects of Diet on Sleep Quality. *Adv Nutr* **7**, 938-949.
74. van der Pols JC (2018) Nutrition and mental health: bidirectional associations and multidimensional measures. *Public Health Nutr* **21**, 829-830.
75. Northstone K, Joinson C, Emmett P (2018) Dietary patterns and depressive symptoms in a UK cohort of men and women: a longitudinal study. *Public Health Nutr* **21**, 831-837.
76. Elstgeest LEM, Visser M, Penninx B *et al.* (2019) Bidirectional associations between food groups and depressive symptoms: longitudinal findings from the Invecchiare in Chianti (InCHIANTI) study. *Br J Nutr* **121**, 439-450.

Table 1. General characteristic of participants across the tertiles of WISH sub-scores

Variable	Healthy				P-value	Less healthy			P-value	Low environmental impact			P-value	High environmental impact			P-value
	Total (n=478)	T1 (n=154)	T2 (n=161)	T3 (n=158)		T1 (n=194)	T2 (n=38)	T3 (n=247)		T1 (n=151)	T2 (n=176)	T3 (n=151)		T1 (n=146)	T2 (n=167)	T3 (n=166)	
Age (year)	31.86 (7.68)	31.78 (7.83)	31.89 (7.78)	31.89 (7.49)	0.899	32.15 (7.65)	31.03 (7.42)	31.76 (7.76)	0.611	30.97 (7.52)	31.04 (7.65)	33.68 (7.60)	0.002	32.88 (7.48)	32.15 (8.12)	30.66 (7.29)	0.010
Weight (kg)	64.45 (11.99)	63.16 (11.12)	64.40 (12.59)	65.79 (12.11)	0.051	64.56 (11.42)	64.76 (11.59)	64.32 (12.52)	0.829	63.35 (11.30)	63.75 (11.68)	66.37 (12.82)	0.028	64.86 (11.79)	63.87 (12.26)	64.69 (11.93)	0.926
BMI (kg/m²)	24.48 (4.52)	23.94 (4.07)	24.57 (4.97)	24.90 (4.45)	0.059	24.59 (4.48)	24.13 (4.24)	24.44 (4.62)	0.741	23.92 (4.28)	24.16 (4.06)	25.40 (5.13)	0.004	24.77 (4.77)	23.31 (4.40)	24.39 (4.44)	0.477
Physical activity (MET min/wk.)	39.90 (6.79)	39.23 (7.07)	40.06 (7.31)	40.37 (5.91)	0.143	40.08 (7.55)	38.95 (5.92)	39.90 (6.27)	0.797	38.47 (6.80)	40.44 (7.20)	40.66 (6.09)	0.006	40.32 (7.36)	40.06 (7.25)	39.36 (5.70)	0.215
Socioeconomic status, n (%)					0.442				0.518				0.711				0.665
Low	2	1 (50)	1 (50)	0 (0)		1 (50)	0 (0)	1 (50)		1 (50)	1 (50)	0 (0)		1 (50)	1 (50)	0 (0)	
Medium	177	64 (36.2)	53 (29.9)	60 (33.9)		71 (40.1)	18 (10.2)	88 (49.7)		59 (33.3)	64 (36.2)	54 (30.5)		50 (28.2)	62 (35)	65 (36.7)	
High	262	78 (29.8)	96 (36.6)	88 (33.6)		108 (41.2)	15 (5.7)	139 (53.1)		75 (28.6)	99 (37.8)	88 (33.6)		87 (33.2)	89 (34)	86 (32.8)	
Married, n (%)	290	98 (33.8)	98 (33.8)	94 (32.4)	0.723	128 (44.1)	23 (7.9)	139 (47.9)	0.227	83 (28.6)	108 (37.2)	99 (34.1)	0.107	103 (35.5)	97 (33.4)	90 (31)	0.052
Education status, n (%)					0.809				0.446				0.832				0.211

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≤Diploma	164	52 (31.7)	50 (30.4)	54 (32.9)		70 (42.6)	15 (9.1)	71 (43.2)		45 (27.4)	58 (35.3)	53 (32.3)		50 (30.4)	63 (38.4)	43 (26.2)	
>Diploma	379	107 (28.2)	126 (33.2)	109 (28.7)		105 (27.7)	115 (30.3)	122 (32.1)		113 (29.8)	110 (29)	119 (31.3)		112 (29.5)	113 (29.8)	117 (30.8)	
Smoking, n (%)	4	0	3	1	0.180	4	0	0	0.052	2	2	0	0.385	0	3	1	0.202
Family history of chronic disease, n (%)	264	91 (34.5)	89 (33.7)	84 (31.8)	0.718	108 (40.5)	20 (7.6)	137 (51.9)	0.988	81 (30.7)	100 (37.9)	83 (31.4)	0.721	81 (30.7)	93 (35.2)	90 (34.1)	0.886
Body size satisfaction, n (%)	320	102 (31.9)	107 (33.4)	111 (34.7)	0.736	121 (37.8)	28 (8.8)	171 (53.4)	0.146	96 (30)	123 (38.4)	101 (31.6)	0.569	90 (28.1)	116 (36.3)	114 (35.6)	0.241
Depression, n (%)	240	100 (41.8)	73 (30.5)	66 (27.6)	<0.001	115 (48.1)	16 (6.7)	108 (45.2)	0.003	99 (41.4)	81 (33.9)	59 (24.7)	<0.001	78 (32.6)	92 (38.5)	69 (28.9)	0.028
Anxiety, n (%)	382	136 (35.6)	124 (32.5)	122 (31.9)	0.033	167 (43.7)	33 (8.6)	182 (47.6)	0.003	134 (35.1)	132 (34.6)	116 (30.4)	0.004	123 (32.2)	134 (35.1)	125 (32.7)	0.143
Psychological distress, n (%)	203	81 (39.9)	68 (33.5)	54 (26.6)	0.006	98 (48.3)	16 (7.9)	89 (43.8)	0.009	85 (41.9)	68 (33.5)	50 (24.6)	<0.001	67 (33)	79 (38.9)	57 (28.1)	0.033

WISH; World Index for Sustainability and Health.

Values are means ± SDs; one-way ANOVA for continuous variables and chi-square test for categorical variables were used to generate p-values; BMI, body mass index, MET-h, metabolic equivalent task hours.

Table 2. Energy-adjusted dietary intakes of study participants across the tertiles of WISH sub-scores

Variable	Healthy			P- valu e	Less Healthy			P- valu e	Low Environmental			P- valu e	High Environmental			P- valu e
	T1 (n=15 7)	T2 (n=16 2)	T3 (n=16 0)		T1 (n=19 4)	T2 (n=38)	T3 (n=24 7)		T1 (n=15 1)	T2 (n=17 6)	T3 (n=15 2)		T1 (n=14 6)	T2 (n=16 7)	T3 (n=16 6)	
Energy (kcal/d)	1999. 43 (43.5 9)	2102. 10 (37.5 7)	2096. 21 (22.1 4)	0.07 5	2259. 02 (34.4 2)	2056. 91 (79.7 2)	1916. 73 (27.5 8)	<0.0 01	1960. 07 (44.8 2)	2113. 35 (35.3 7)	2117. 92 (33.4 6)	0.00 4	2257. 45 (38.4 3)	2079. 89 (36.3 2)	1885. 04 (35.0 2)	<0.0 01
Protein (g/d)	74.52 (2.29)	76.48 (1.49)	74.41 (1.25)	0.08 7	80.76 (1.72)	66.89 (3.08)	72.01 (1.22)	<0.0 01	69.36 (1.84)	75.96 (1.34)	79.95 (1.92)	0.00 3	83.96 (2.02)	75.67 (1.53)	66.86 (1.38)	0.01 7
Carbohyd rate (g/d)	273.1 9 (6.19)	293.9 0 (6.06)	296 (5.17)	0.02 0	307.3 8 (5.59)	291.0 7 (11.5 7)	271.9 4 (4.32)	<0.0 01	270.6 5 (6.48)	293.2 8 (5.55)	298.5 3 (5.35)	0.20 4	303.7 1 (6.21)	291.2 0 (5.88)	270.4 1 (5.28)	<0.0 01
Fat (g/d)	73.65 (2.08)	76.43 (1.67)	76.13 (1.69)	0.61 6	86.53 (1.63)	76.35 (3.74)	66.56 (1.22)	<0.0 01	72.42 (2.11)	77.84 (1.66)	75.60 (1.68)	0.10 5	85.98 (1.86)	75.65 (1.60)	65.90 (1.69)	<0.0 01
Fiber (g/d)	13.68 (0.38)	17.25 (0.51)	19.12 (0.46)	<0.0 01	16.88 (0.43)	17.01 (0.84)	16.52 (0.41)	<0.0 01	13.36 (0.44)	16.62 (0.41)	20.12 (0.46)	<0.0 01	17.00 (0.43)	17.15 (0.53)	15.99 (0.47)	0.00 2
PUFA (g/d)	15.30 (0.47)	16.49 (0.43)	17.43 (0.53)	0.03 2	18.14 (0.45)	16.10 (0.84)	15.11 (0.36)	0.46 2	15.51 (0.50)	16.73 (0.45)	16.96 (0.49)	0.84 5	17.48 (0.51)	16.58 (0.45)	15.32 (0.48)	0.63 3
MUFA (g/d)	21.27 (0.67)	22.75 (0.64)	22.46 (0.63)	0.92 5	26.15 (0.55)	23.67 (1.50)	18.81 (0.43)	<0.0 01	21.43 (0.70)	22.80 (0.62)	22.17 (0.62)	0.16 8	25.85 (0.64)	21.99 (0.57)	19.10 (0.62)	0.00 1
Cholester ol (mg/d)	240.6 9 (8.08)	220.8 3 (7.22)	194.4 1 (6.24)	<0.0 01	243.3 8 (7.31)	210.4 0 (14.1 4)	200.2 3 (5.18)	0.50 8	209.9 7 (8.20)	227.1 1 (7.13)	217.0 4 (6.61)	0.41 2	272.9 0 (7.43)	218.5 6 (6.69)	170.6 3 (5.71)	<0.0 01
Vitamin A (RAE/d)	1112. 13 (49.3 3)	1432. 49 (76.4 4)	1546. 47 (67.1 8)	<0.0 01	1362. 23 (45.2 9)	1307. 83 (116. 1)	1377. 05 (63.7 5)	0.01 6	1027. 48 (43.4 6)	1326. 49 (52.3 6)	1746. 65 (87.5 8)	<0.0 01	1463. 07 (57.9 4)	1412. 37 (77.0 1)	1232. 70 (61.2 4)	0.71 3

Vitamin D (mg/d)	2.39 (0.15)	2.19 (0.13)	1.71 (0.09)	<0.0 01	2.16 (0.11)	1.95 (0.26)	2.06 (0.11)	0.11 3	1.78 (0.11)	2.24 (0.14)	2.23 (0.12)	0.14 2	2.65 (0.13)	2.22 (0.15)	1.47 (0.08)	<0.0 01
Vitamin B1 (mg/d)	1.44 (0.04)	1.54 (0.03)	1.61 (0.03)	0.00 1	1.61 (0.03)	1.51 (0.08)	1.47 (0.02)	0.00 1	1.41 (0.03)	1.54 (0.03)	1.64 (0.03)	0.43 2	1.60 (0.03)	1.53 (0.03)	1.46 (0.03)	<0.0 01
Vitamin B2 (mg/d)	1.84 (0.05)	1.87 (0.05)	1.74 (0.04)	<0.0 01	1.89 (0.04)	1.73 (0.11)	1.73 (0.04)	<0.0 01	1.62 (0.05)	1.88 (0.04)	1.93 (0.04)	<0.0 01	2.06 (0.05)	1.86 (0.05)	1.56 (0.04)	<0.0 01
Vitamin B6 (mg/d)	1.18 (0.04)	1.36 (0.04)	1.44 (0.03)	<0.0 01	1.37 (0.03)	1.36 (0.08)	1.29 (0.03)	<0.0 01	1.15 (0.04)	1.34 (0.03)	1.49 (0.04)	<0.0 01	1.36 (0.04)	1.38 (0.04)	1.24 (0.04)	<0.0 01
Vitamin B9 (µg/d)	267.2 3 (7.00)	319.1 1 (7.56)	364.0 8 (8.27)	<0.0 01	327.3 3 (7.29)	316.3 5 (16.9)	309.2 3 (6.72)	0.00 4	260.6 5 (7.26)	313.4 9 (7.17)	377.4 4 (7.70)	<0.0 01	333.0 8 (7.40)	316.9 2 (8.42)	303.3 0 (8.50)	0.16 0
Vitamin B12 (µg/d)	4.50 (0.20)	4.69 (0.25)	4.46 (0.22)	0.50 8	4.86 (0.20)	4.93 (0.81)	4.25 (0.15)	0.15 7	4.13 (0.23)	4.89 (0.22)	4.57 (0.23)	0.38 9	5.03 (0.21)	4.61 (0.23)	4.07 (0.22)	0.93 5
Vitamin C (mg/d)	110.0 3 (5.19)	150.2 4 (6.86)	159.1 3 (4.65)	<0.0 01	144.9 4 (5.59)	140.8 4 (10.5)	136.0 5 (4.66)	0.05 9	114.1 2 (6.22)	140.4 2 (5.72)	165.3 2 (4.99)	<0.0 01	141.6 1 (5.95)	143.7 9 (6.26)	134.8 7 (5.43)	0.03 0
Calcium (mg/d)	1061.63 (33.47)	1072.00 (25.51)	1005.50 (21.64)	0.00 6	1068.58 (24.60)	973.01 (56.11)	1040.25 (22.48)	<0.0 01	928.57 (28.34)	1078.02 (26.90)	1126.80 (25.03)	<0.0 01	1168.57 (28.83)	1076.43 (30.06)	908.69 (19.09)	0.00 2
Magnesium (mg/d)	242.2 1 (6.02)	272.9 6 (6.09)	281.3 1 (4.98)	<0.0 01	273.5 6 (4.98)	264.9 8 (13.5)	259.5 8 (4.82)	<0.0 01	232.1 5 (5.71)	267.7 3 (5.54)	296.5 9 (5.19)	<0.0 01	281.1 1 (5.58)	272.0 7 (6.36)	245.6 6 (5.17)	0.12 2
Zinc (mg/d)	8.96 (0.42)	9.08 (0.20)	8.91 (0.18)	0.29 2	9.74 (0.31)	7.79 (0.38)	8.57 (0.19)	0.01 1	8.33 (0.28)	8.98 (0.19)	9.63 (0.37)	0.09 4	10.03 (0.39)	9.11 (0.22)	7.93 (0.22)	0.39 5
Whole grain (g/d)	10.95 (0.93)	12.19 (1.09)	11.68 (1.01)	0.91 7	11.52 (0.93)	10.88 (2.21)	11.80 (0.81)	0.05 8	10.16 (0.91)	11.62 (1.01)	13.05 (1.10)	0.40 6	10.81 (0.97)	13.41 (1.09)	10.52 (0.95)	0.02 1
Vegetable (g/d)	243.5 7	337.9 3	423.1 1	<0.0 01	325.5 2	343.1 0	342.0 8	0.02 4	231.1 0	312.3 2	465.9 0	<0.0 01	347.8 4	331.6 1	328.4 2	0.75 3

	(10.6 5)	(15.4 2)	(15.4 2)		(10.9 5)	(30.9 8)	(13.8 9)		(9.51)	(12.3 0)	(16.9 2)		(14.3 7)	(16.4 3)	(14.4 5)	
Egg (g/d)	24.72	21.62	16.39	<0.0	22.09	21.63	19.83	0.41	19.39	21.43	21.74	0.63	28.61	21.09	13.89	<0.0
	(1.22)	(1.31)	(1.02)	01	(1.26)	(2.31)	(0.86)	5	(1.20)	(1.30)	(1.10)	9	(1.31)	(1.28)	(0.70)	01
Fish (g/d)	6.46	10.58	11.84	0.03	10.21	9.55	9.23	0.71	9.74	9.04	10.28	0.63	7.24	10.55	10.87	0.00
	(0.52)	(2.07)	(0.78)	0	(1.74)	(1.69)	(0.56)	4	(2.21)	(0.61)	(0.78)	5	(0.55)	(2.01)	(0.78)	2
Fruit (g/d)	251.7	336.7	326.3	0.00	311.0	304.3	301.1	0.01	249.8	314.2	350.4	0.00	301.9	319.6	294.1	0.00
	2	9	6	3	9	3	4	1	1	7	3	3	8	1	8	9
	(17.0 0)	(18.8 0)	(12.0 3)		(17.5 9)	(30.2 3)	(11.3 2)		(18.7 5)	(15.1 1)	(14.6 0)		(17.7 3)	(17.8 7)	(13.6 5)	
Dairy (g/d)	495.2	471.1	388.5	<0.0	465.2	369.0	453.2	0.00	387.1	479.6	482.6	0.00	546.3	467.6	351.6	<0.0
	5	6	4	01	6	2	9	1	8	6	5	6	7	5	9	01
	(21.0 8)	(17.9 3)	(13.4 2)		(16.4 9)	(30.8 1)	(14.6 5)		(18.0 5)	(16.9 6)	(18.3 1)		(19.8 0)	(19.4 0)	(10.6 5)	
Meat (g/d)	48.04	45.23	38.58	0.00	57.22	21.03	37.01	<0.0	49.05	43.46	39.39	0.00	56.74	41.63	34.98	<0.0
	(3.44)	(2.43)	(2.12)	9	(2.42)	(0.64)	(2.15)	01	(3.49)	(2.27)	(2.33)	3	(2.83)	(2.07)	(2.95)	01
Chicken (g/d)	19.82	18.80	16.91	0.09	17.92	15.12	19.48	0.01	18.06	17.89	19.66	0.49	21.51	18.33	16.04	0.01
	(1.24)	(1.07)	(0.85)	2	(0.90)	(1.76)	(0.91)	9	(0.98)	(0.92)	(1.29)	6	(1.46)	(0.89)	(0.79)	5
Legume (g/d)	37.18	45.05	63.86	<0.0	49.23	40.98	49.58	0.09	31.89	47.59	66.85	<0.0	53.08	45.17	48.55	0.25
	(2.32)	(2.60)	(3.75)	01	(2.89)	(4.12)	(2.52)	8	(2.47)	(2.82)	(3.30)	01	(2.96)	(2.77)	(3.43)	9
Nut (g/d)	8.32	12.13	13.83	<0.0	12.50	14.24	10.19	0.08	9.98	11.79	12.51	0.42	10.44	12.42	11.36	<0.0
	(0.54)	(0.77)	(0.82)	01	(0.75)	(2.27)	(0.46)	9	(0.83)	(0.72)	(0.66)	2	(0.61)	(0.80)	(0.78)	01
Unsaturated oil (g/d)	11.46	12.56	14.45	0.00	12.06	10.73	13.76	<0.0	11.14	13.25	14.02	0.00	12.38	12.86	13.19	0.06
	(0.49)	(0.53)	(0.66)	2	(0.49)	(1.15)	(0.47)	01	(0.51)	(0.48)	(0.70)	8	(0.68)	(0.52)	(0.52)	3
Saturated oil (g/d)	11.89	12.12	11.67	0.73	19.90	17.55	4.74	0.00	12.46	12.09	11.11	0.15	19.27	11.06	6.25	<0.0
	(1.27)	(1.10)	(1.05)	2	(1.17)	(2.63)	(0.44)	1	(1.31)	(1.06)	(1.05)	7	(1.46)	(0.98)	(0.71)	01
Sugar (g/d)	33.26	35.49	31.24	0.65	55.48	34.82	15.72	<0.0	58.29	28.60	14.03	<0.0	37.72	35.80	27.00	0.71
	(3.17)	(4.77)	(3.44)	9	(4.83)	(6.62)	(0.79)	01	(6.05)	(2.15)	(2.23)	01	(3.52)	(5.07)	(2.40)	9

SFA: saturated fatty acid; PUFA: polyunsaturated fatty acid; MUFA; monounsaturated fatty acid; WISH: World Index for Sustainability and Health.

Values are mean \pm SE. All values are adjusted for energy intake using ANCOVA

Table 3. Multiple-adjusted odds ratio (OR) and 95% confidence intervals (CI) across the tertiles of WISH sub-scores

Variable	Healthy			P tren d	Less healthy			P tren d	Low environmental impact			P tren d	High environmental impact			P tren d
	T1 (n=157)	T2 (n=162)	T3 (n=160)		T1 (n=194)	T2 (n=38)	T3 (n=247)		T1 (n=151)	T2 (n=176)	T3 (n=152)		T1 (n=133)	T2 (n=143)	T3 (n=145)	
Depression																
Crude	1	0.47 (0.29-0.75)	0.38 (0.23-0.61)	<0.001	1	0.46 (0.21-1.01)	0.59 (0.40-0.88)	0.012	1	0.50 (0.31-0.81)	0.34 (0.21-0.56)	<0.001	1	1.02 (0.64-1.64)	0.63 (0.40-1.02)	0.056
Model ¹	1	0.48 (0.29-0.80)	0.40 (0.24-0.67)	0.001	1	0.41 (0.18-0.93)	0.51 (0.32-0.89)	0.004	1	0.51 (0.31-0.84)	0.32 (0.19-0.54)	<0.001	1	0.96 (0.58-1.60)	0.57 (0.33-0.96)	0.031
Anxiety																
Crude	1	0.47 (0.25-0.88)	0.44 (0.23-0.82)	0.013	1	0.83 (0.29-2.36)	0.43 (0.25-0.73)	0.001	1	0.37 (0.19-0.72)	0.38 (0.19-0.75)	0.009	1	0.67 (0.36-1.24)	0.52 (0.28-0.95)	0.032

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Model ¹	1	0.43 (0.22- 0.83)	0.45 (0.23- 0.87)	0.023	1	0.90 (0.31 - 2.61)	0.44 (0.25- 0.78)	0.00 4	1	0.33 (0.17- 0.66)	0.38 (0.18- 0.76)	0.012	1	0.64 (0.34- 1.22)	0.56 (0.29- 1.08)	0.09 0
Stress																
Crude	1	0.68 (0.42- 1.09)	0.44 (0.27- 0.72)	0.001	1	0.64 (0.29 - 1.40)	0.55 (0.37- 0.83)	0.00 4	1	0.43 (0.27- 0.69)	0.32 (0.19- 0.53)	<0.0 01	1	0.90 (0.56- 1.45)	0.60 (0.37- 0.98)	0.03 9
Model ¹	1	0.68 (0.41- 1.12)	0.46 (0.28- 0.77)	0.003	1	0.66 (0.29 - 1.49)	0.57 (0.36- 0.90)	0.01 6	1	0.40 (0.24- 0.67)	0.30 (0.17- 0.51)	<0.0 01	1	0.88 (0.53- 1.47)	0.62 (0.37- 1.06)	0.08 0

WISH: World Index for Sustainability and Health.

These values are odds ratios (95% CIs)

¹Logistic regression model included age, energy, BMI, marriage, education, family history of chronic disease, body satisfaction, SES, physical activity, smoking