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A cross-sectional ecological analysis of the relationship between nutrient intake and mental health burden across income groups, 1990–2018

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Summary

Mental health disorders, particularly depression and anxiety, represent a growing global public health concern. Although population-level nutrient intake may be associated with mental health burden, ecological evidence across income groups remains limited. This study examined the association between nutrient intake and mental health burden across 120 countries from 1990 to 2018, stratified by income levels. A cross-sectional ecological analysis was conducted using country-level data from the Global Dietary Database and the Global Burden of Disease study. Nutrients were categorised as potentially beneficial (omega-6 fats, folate, protein) or unhealthy (sugar-sweetened beverages, refined grains, processed meats). Mental health burden was measured using prevalence and disability-adjusted life years. Pearson correlations and multivariable linear regression analyses were employed. Unhealthy nutrient consumption increased globally, particularly in low- and middle-income countries. Omega-6 fats and processed meats were positively associated with depressive (β = 1554.04, p = 0.03) and anxiety disorders (β = 1976.09, p = 0.01). Protein intake was associated only with anxiety (β = 17.51, p = 0.02). Upper-middle-income countries exhibited the largest increase in mental health burden. Public health strategies should prioritise nutrient-dense diets, especially in transitioning economies, to mitigate the rising mental health burden. Future research should explore causal mechanisms and longitudinal effects.

Keywords

mental health; anxiety disorder; depressive disorder; nutrients; income groups

Mental health disorders have emerged as a global public health priority due to their increasing prevalence and profound social, economic, and healthcare implications, significantly affecting both individuals and society as a whole [1]. According to the WHO Mental Health Report in 2022 [2], approximately one in eight individuals worldwide lives with a mental disorder. The prevalence of specific mental disorders varies by sex and age; however, anxiety and depressive disorders are the most common among both males and females. Further, depression is one of the leading causes of disability globally, accounting for 11 % of all years lived with disability (YLDs), particularly among women, and contributing to 4.3 % of the global burden of disease [3]. As societies experience demographic transitions, urbanisation, and economic development, the burden of mental illness is increasing disproportionately across regions and income levels [4]. While multiple biopsychosocial factors influence mental health [5, 6], emerging evidence highlights the role of nutrition as a modifiable determinant for mental health that deserves further exploration in global comparative contexts [7].

The relationship between nutrient intake and mental health outcomes is complex and multifactorial [6, 8]. Recent developments in neuro-

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science and epigenetics show that both genetic and environmental factors, including diet quality and socioeconomic status, are linked to mental health issues [9, 10]. Diets rich in essential micronutrients such as omega-3 fatty acids, B vitamins, zinc, magnesium, and iron are positively associated with mental well-being and reduced risk of depression and anxiety [10, 11]. Omega-6 polyunsaturated fatty acids are structural components of neuronal membranes and influence neurotransmitter signalling, though their mental health effects are highly dependent on the dietary omega-6 to omega-3 ratio; an elevated *n*-6/*n*-3 ratio promotes the synthesis of pro-inflammatory eicosanoids that may activate neuroinflammatory pathways implicated in depression and anxiety [10, 11]. Conversely, nutritional deficiencies, especially in low- and middle-income countries (LMICs), may contribute to poor neurodevelopment, increased vulnerability to stress, and heightened susceptibility to mental disorders [12]. At the population level, dietary patterns and nutrient adequacy are influenced by food security, economic resources, education, and health literacy, which vary markedly between and within countries depending on income classification [13]. Lower-income groups often face financial constraints that limit their ability to afford nutrient-dense foods, leading to diets high in refined sugars, unhealthy fats, and low-cost processed items [14, 15].

Globally, the nutrition transition, marked by a shift from traditional diets to processed, calorie-dense, and nutrient-poor foods, has contributed to adverse physical and mental health outcomes, with rising rates of overweight and obesity largely driven by rapid changes in the food system, including increased availability of inexpensive ultra-processed foods and beverages [14]. While high-income countries may face challenges related to overnutrition and the mental health consequences of obesity and metabolic disorders, low-income countries continue to struggle with undernutrition and micronutrient deficiencies [16]. This divergence raises an important question: to what extent does nutrient intake mediate or correlate with the mental health burden across income-diverse settings over time? Understanding the cross-sectional associations between nutrient intake and mental health burden can inform both national and global policies targeting mental health promotion through improved dietary strategies. This is particularly relevant for governments and international organisations aiming to integrate nutritional interventions into broader mental health frameworks and sustainable development agendas.

Although nutritional psychiatry has gained traction as a field examining the influence of dietary patterns on brain function and mental health outcomes [7], few global studies have systematically assessed the relationship between nutrient intake and the burden of mental illness across income-stratified populations [11]. Most existing research is either limited to high-income countries or focuses on individual-level data from small cohorts, leaving a gap in understanding at the population level. Moreover, longitudinal global data linking dietary trends with mental health outcomes are scarce [17]. This study aims to address this gap by assessing country-level data on nutrient intake and mental health burden across 120 countries from 1990 to 2018, using cross-sectional analysis stratified by World Bank income groups. Specifically, the present study seeks to examine global trends in nutrient intake and mental health disorders (depression and anxiety disorders) over nearly three decades. It addresses the following research questions, whether: (1) Is there an association between nutrient intake and mental health burden? (2) Has this association changed over time in the context of globalisation and dietary transitions? and (3) Which nutrients are associated with the mental health burden at the population level?

MATERIAL AND METHODS

Study design and procedure

This cross-sectional ecological study analysed country-level data from 120 countries to examine population-level associations between nutrient intake and the burden of mental health disorders, specifically depressive and anxiety disorders, between 1990 and 2018. The analysis was stratified by World Bank income groups (high, upper-middle, lower-middle, and low income). The burden of disease was measured in terms of both prevalence and disability-adjusted life years (DALYs) per 100 000 population.

Data sources

Country-level dietary intake estimates were obtained from the Global Dietary Database (GDD), an academic research consortium coordinated by the Friedman School of Nutrition Science and Policy at Tufts University (Boston, Massachusetts, USA), which compiles and harmonises dietary data from multiple global sources. The GDD uses nationally representative surveys in combination with a Bayesian hierarchical modelling approach to generate estimates by age, sex, and country. The GDD integrates dietary intake data from diverse worldwide surveys using standardised instruments: primarily 24-hour dietary recalls, food frequency questionnaires (FFQs), and short structured questionnaires (such as Demographic and Health Surveys); where individual data are unavailable, household surveys converted to individual estimates or biomarker data are included to fill gaps across countries and nutrients. GDD's predictive models undergo formal cross-validation to assess how well modelled intakes reflect observed survey means, supporting the reliability of country- and subgroup-level estimates; however, the validity of nutrient measures is constrained by inherent limitations of self-reported dietary instruments and uneven data availability, especially for micronutrients in low-data regions, which introduces recognised measurement uncertainty. Detailed documentation on survey design, sampling procedures, weighting strategies, and fieldwork is provided elsewhere and has been published previously [18].

In the present study, nutrients were classified as potentially beneficial or potentially unhealthy based on established mechanistic and epidemiological evidence. Potentially beneficial nutrients such as total omega-6 fatty acids, folate (vitamin B9), and total protein were selected because prior research suggests these nutrients may support neurobiological processes relevant to mental health [10, 11]. For example, polyunsaturated fatty acids, including omega-6, are integral components of neuronal membranes and influence neurotransmitter signalling, with observational data linking higher omega-6 intake with reduced depressive symptomatology and improved neurochemical function in some populations [12]; folate plays a role in one-carbon metabolism and neurotransmitter synthesis, with several studies reporting inverse associations between folate intake and depression and anxiety symptoms [10]; and protein intake provides essential amino acids that serve as precursors for neurotransmitters implicated in mood regulation, with dietary protein quality linked to mood outcomes in observational nutrition and psychiatry research [13, 15]. In contrast, potentially unhealthy nutrients such as sugar-sweetened beverages, refined grains, and total processed meats were selected due to consistent evidence associating these exposures with adverse health outcomes that overlap with pathways relevant to mental health. High intake of sugar-sweetened beverages and other components of Western diets has been linked to elevated odds of depressive and anxiety symptoms and increased systemic inflammation, which may adversely affect brain health [17]; refined grains and other ultra-processed foods have been associated with a higher risk of depression in meta-analyses of observational data [17] and processed meats are established contributors to metabolic dysregulation and inflammation, which are mechanistically and epidemiologically connected to mood disorders and poor mental health outcomes [15, 17].

Data on the burden of mental health (depressive and anxiety) disorders were obtained from the Global Burden of Disease (GBD) 2021 study (Global Burden of Disease Collaborative Network based at the Institute for Health Metrics and Evaluation, Seattle, Washington, USA), which provides comprehensive and comparable estimates of disease burden for over 350 diseases and injuries across 204 countries and territories. The GBD study employs standardised methodologies to quantify health loss in terms of prevalence, mortality, and DALYs, thereby enabling consistent cross-national and temporal comparisons. The use of DALYs allows for cross-country comparisons of mental health burden by integrating both mortality and morbidity components into a single standardised measure [19].

Data analysis

Prevalence rates of nutrient intake and mental health disorders were summarised across income groups. Summary statistics and trends over time (1990–2018) were analysed to compare patterns between high-income and low-/middle-income countries. Pearson correlation coefficients were calculated to explore bivariate relationships among all variables, including nutrient intake, mental health outcomes, and explanatory socioeconomic indicators such as gross domestic product (*GDP*), healthcare access and quality index (*HAQ*), rural population ratio, and socio-demographic index (*SDI*), across countries.

The study sample comprised 120 countries categorised according to the World Bank income classification. These included 28 high-income countries (e.g., the United States, Norway, New Zealand, the Netherlands, Luxembourg), 32 upper-middle-income countries (e.g., Türkiye, Mexico, Dominica, Argentina), 29 lower-middle-income countries (e.g., Comoros, Kenya, Nepal, Pakistan, Tunisia), and 31 low-income countries (e.g., Eritrea, Malawi, Mozambique, Togo, Uganda).

Multiple linear regression models were conducted to assess the association between nutrient intake and mental health outcomes, specifically the prevalence of depression and anxiety. Separate models were constructed for each outcome variable, with both potentially beneficial and potentially unhealthy nutrients included as independent variables. All models were adjusted for the *GDP* per capita, *HAQ*, and *SDI*. Results are presented as standardised beta coefficients and *p*-values, with significance set at $p < 0.05$.

To assess the robustness of the ecological associations observed at the country level, sensitivity analyses were conducted by excluding outliers, re-estimating the models within income groups, and applying alternative specifications of control variables and time points. These analyses were undertaken to ensure that the observed associations were not driven by specific model assumptions or the influence of individual countries.

Statistical results are reported using standard epidemiological measures. Pearson correlation coefficients (*r*) were used to quantify the strength and direction of linear associations between country-level variables, with values ranging from –1 to +1, where values closer to ±1 indicate stronger associations. Multivariable linear regression coefficients (β) represent the estimated change in the dependent variable associated with a one-unit increase in the independent variable, adjusted for covariates included in the model. Ninety-five percent confidence intervals (95% *CI*) are reported to indicate the precision of the estimated parameters; a 95% *CI* represents the range within which the true population parameter is expected to lie with 95% confidence under repeated sampling assumptions. All estimates reflect population-level associations consistent with the ecological study design.

All variables were normalised where necessary to ensure comparability, and diagnostic tests were conducted to check for multicollinearity and heteroscedasticity. All analyses were performed using the Statistical Package for Social Sciences (SPSS) version 27.0 (SPSS, Chicago, Illinois, USA).

RESULTS AND DISCUSSION

Descriptive analysis

Tab. 1 presents the prevalence of potentially beneficial and unhealthy nutrient intake across 120 countries between 1990 and 2018, years by country income group. Globally, a modest increase was observed in the intake of potentially beneficial nutrients, such as omega-6 fats and vitamin B9 (0.26 $\mu g \cdot d^{-1}$ dietary folate equivalents, 95% *CI* 0.18–0.44 $\mu g \cdot d^{-1}$), while protein intake declined notably (–0.23 $g \cdot d^{-1}$, 95% *CI* (–0.30)–(–0.18) $g \cdot d^{-1}$). Unhealthy nutrients like sugar-sweetened beverages (0.20 $g \cdot d^{-1}$, 95% *CI* 0.15–0.25 $g \cdot d^{-1}$) and processed meats (0.16 $g \cdot d^{-1}$, 95% *CI* 0.12–0.20 $g \cdot d^{-1}$) increased significantly, indicating a dietary shift toward more energy-dense and processed foods. Tab. 1 illustrates a global nutritional shift with disparities by income group. While nutrient adequacy, such as increased intake of folate and protein, improved across all income groups, the consumption of unhealthy foods has been increasing, particularly in LMICs.

Tab. 2 presents the prevalence and burden (measured in DALYs) of depressive and anxiety disorders across 120 countries, stratified by income groups and reported for the years 1990 and 2018. At the global level, the prevalence of both depressive and anxiety disorders has increased, with depressive disorders showing a more substantial rise (per 100 000 population) from 3 305.96 (95% *CI* 2 979.80–3 738.07) to 3 708.47 (95% *CI* 3 339.69–4 145.62), with a 12% increase (95% *CI* 0.10–0.13), compared to a 5% increase (95% *CI* 0.04–0.06) for anxiety disorders. In high-income countries, the prevalence and burden of both depressive and anxiety disorders remained relatively stable. In contrast, upper-middle-income countries exhibited the largest increases across both mental disorders. Depressive disorder prevalence increased by 20 % (95% *CI* 0.18–0.21), and DALYs by 18 % (95% *CI* 0.17–0.19), while anxiety disorders saw rises of 13 % (95% *CI* 0.11–0.15) in prevalence and 12 % (95% *CI* 0.11–0.13) in DALYs (all values per 100 000 population).

Tab. 3 displays bivariate correlations between key variables, such as depressive and anxiety disorders, nutritional indicators, *GDP*, *HAQ* index, *SDI*, and rural population ratio, for 1990 and 2018. In both years, total protein intake shows significantly positive correlations with depressive and anxiety disorders ($r = 0.32$ and $r = 0.55$) in 1990 and ($r = 0.20$ and $r = 0.44$) in 2018, respectively. While omega-6 fats correlate weakly with depressive disorders ($r = 0.25$) in 1990 and anxiety disorders ($r = 0.30$) in 1990, these associations diminish in 2018. Vitamin B9 shows a modest positive correlation with anxiety ($r = 0.27$) in 1990, but loses significance by 2018. In 1990, sugar-sweetened beverages show a weak negative correlation with depressive disorders and rural population ratio ($r = –0.18$ and $r = –0.28$, respectively), yet by 2018, these associations become statistically insignificant.

Tab. 4 displays the results of two multiple linear regression models estimating the independent associations between dietary, demographic, and health system variables and national-level prevalence rates of depressive and anxiety disorders, respectively. In both models, total omega-6 fat

Tab. 1. Prevalence of daily intake of nutrients in 120 countries between 1990–2018 years by country income groups.

	1990		2018		Change	
	Daily intake					
	Mean	95% *CI*	Mean	95% *CI*	Mean	95% *CI*
POTENTIALLY BENEFICIAL NUTRIENTS						
Global						
Total omega-6 fat* [%]	2.7	2.6–2.7	2.7	2.7–2.7	0.0	0.0–0.0
Vitamin B9 (folate) [$\mu g \cdot d^{-1}$]	198.12	177.07–226.86	250.77	220.19–297.11	0.26	0.18–0.44
Total protein [$g \cdot d^{-1}$]	83.95	51.61–56.73	64.44	61.55–67.81	–0.23	(–0.30)–(–0.18)
High-income countries						
Total omega-6 fat* [%]	2.6	2.6–2.7	2.7	2.6–2.7	0.0	0.0–0.0
Vitamin B9 (folate) [$\mu g \cdot d^{-1}$]	241.11	184.28–318.75	257.55	198.98–338.54	0.06	0.03–0.08
Total protein [$g \cdot d^{-1}$]	80.20	72.12–89.82	83.54	75.16–93.56	0.04	0.02–0.06
Upper-middle-income countries						
Total omega-6 fat* [%]	2.6	2.5–2.7	2.6	2.5–2.8	0.0	0.0–0.0
Vitamin B9 (folate) [$\mu g \cdot d^{-1}$]	261.52	198.00–357.93	298.11	226.50–408.51	0.14	0.08–0.19
Total protein [$g \cdot d^{-1}$]	57.41	49.38–67.22	73.93	63.73–86.52	0.29	0.21–0.35
Lower-middle-income countries						
Total omega-6 fat* [%]	2.6	2.4–2.7	2.6	2.5–2.7	0.0	0.0–0.0
Vitamin B9 (folate) [$\mu g \cdot d^{-1}$]	201.87	150.59–277.57	237.93	177.49–326.77	0.17	0.12–0.21
Total protein [$g \cdot d^{-1}$]	54.60	47.38–63.09	63.32	55.34–72.67	0.15	0.09–0.20
Low-income countries						
Total omega-6 fat* [%]	2.6	2.5–2.8	2.6	2.5–2.8	0.0	0.0–0.0
Vitamin B9 (folate) [$\mu g \cdot d^{-1}$]	205.25	154.68–278.73	253.86	189.99–325.12	0.23	0.17–0.28
Total protein [$g \cdot d^{-1}$]	51.19	43.16–60.72	55.61	47.15–65.78	0.08	0.05–0.11
POTENTIALLY UNHEALTHY NUTRIENTS						
Global						
Sugar-sweetened beverages [$g \cdot d^{-1}$]	86.47	82.44–90.98	103.47	96.33–111.61	0.20	0.15–0.25
Refined grains [$g \cdot d^{-1}$]	289.46	253.34–339.89	292.56	259.68–336.61	0.01	0.00–0.02
Total processed meats [$g \cdot d^{-1}$]	14.91	12.73–18.25	17.30	14.84–20.84	0.16	0.12–0.20
High-income countries						
Sugar-sweetened beverages [$g \cdot d^{-1}$]	131.79	109.68–161.41	139.82	115.11–172.74	0.06	0.03–0.09
Refined grains [$g \cdot d^{-1}$]	105.26	78.13–134.40	122.92	91.46–157.68	0.17	0.13–0.22
Total processed meats [$g \cdot d^{-1}$]	27.47	20.27–38.32	33.95	24.46–45.93	0.24	0.16–0.29
Upper-middle-income countries						
Sugar-sweetened beverages [$g \cdot d^{-1}$]	188.28	143.41–249.76	244.11	320.80–185.61	0.30	0.25–0.35
Refined grains [$g \cdot d^{-1}$]	261.82	198.44–338.34	251.97	186.21–342.71	–0.04	(–0.02)–0.06
Total processed meats [$g \cdot d^{-1}$]	28.27	16.99–45.61	40.27	26.55–57.76	0.42	0.35–0.49
Lower-middle-income countries						
Sugar-sweetened beverages [$g \cdot d^{-1}$]	123.59	90.76–170.14	188.48	136.84–260.21	0.52	0.43–0.60
Refined grains [$g \cdot d^{-1}$]	251.08	202.94–313.49	273.65	226.04–335.31	0.09	0.06–0.12
Total processed meats [$g \cdot d^{-1}$]	13.19	6.89–26.43	15.50	8.45–28.42	0.17	0.12–0.21
Low-income countries						
Sugar-sweetened beverages [$g \cdot d^{-1}$]	85.33	58.18–124.98	224.24	16.76–306.18	1.63	1.51–1.74
Refined grains [$g \cdot d^{-1}$]	216.31	165.45–281.52	251.64	198.05–316.85	0.16	0.14–0.21
Total processed meats [$g \cdot d^{-1}$]	9.77	3.51–15.56	14.43	5.74–31.92	0.48	0.40–0.55

CI – confidence interval, * – percentage of a person's total daily energy (calorie) intake comes from omega-6 fatty acids.

Tab. 2. Prevalence and disability-adjusted life years for depressive and anxiety disorder rates in 120 countries between 1990–2018 years by country income groups (per 100 000 population).

	1990		2018		Change	
	Mean	95% *CI*	Mean	95% *CI*	Mean	95% *CI*
DEPRESSIVE DISORDERS						
Global						
Prevalence	3 305.96	2 979.80–3 738.07	3 708.47	3 339.69–4 145.62	0.12	0.10–0.13
DALYs	556.37	389.02–753.82	616.37	431.61–841.01	0.10	0.09–0.11
High-income countries						
Prevalence	4 438.75	3 945.50–5 035.64	4 455.08	3 961.64–5 028.41	0.00	0.00–0.01
DALYs	757.88	524.39–1031.58	767.88	532.71–1048.34	0.01	0.00–0.01
Upper-middle-income countries						
Prevalence	2 943.30	2 563.15–3 411.47	3 531.27	3 093.50–4 062.18	0.20	0.18–0.21
DALYs	501.43	342.37–686.21	594.18	405.87–814.50	0.18	0.17–0.19
Lower-middle-income countries						
Prevalence	3 253.31	2 812.50–3 822.25	3 668.27	3 182.67–4 277.39	0.13	0.12–0.14
DALYs	563.65	380.07–774.78	627.91	424.61–857.75	0.11	0.10–0.12
Low-income countries						
Prevalence	3 511.78	3 004.92–4 164.64	3 610.51	3 095.78–4 276.17	0.03	0.02–0.04
DALYs	609.94	409.57–838.92	627.94	420.30–861.59	0.03	0.02–0.04
ANXIETY DISORDERS						
Global						
Prevalence	3 617.36	3 086.83–4 247.09	3 796.61	3 272.85–4 433.64	0.05	0.04–0.06
DALYs	431.17	296.50–591.48	450.13	311.34–612.40	0.04	0.03–0.05
High-income countries						
Prevalence	5 891.00	4 913.20–7 064.94	5 954.68	4 988.27–7 076.79	0.01	0.00–0.02
DALYs	697.23	472.86–957.79	700.26	478.67–957.36	0.00	0.00–0.01
Upper-middle-income countries						
Prevalence	3 760.55	3 067.74–4 632.60	4 243.10	3 499.14–5 145.35	0.13	0.11–0.15
DALYs	450.44	301.65–630.25	504.45	339.46–697.97	0.12	0.11–0.13
Lower-middle-income countries						
Prevalence	3 124.45	2 514.88–3 900.22	3 449.59	2 803.15–4 257.47	0.10	0.08–0.11
DALYs	373.99	247.94–527.90	412.37	275.32–578.83	0.10	0.09–0.11
Low-income countries						
Prevalence	2 987.99	2 360.63–3 804.57	3 185.81	2 515.71–4 054.13	0.06	0.05–0.07
DALYs	355.96	232.59–509.22	381.80	248.53–544.21	0.07	0.06–0.08

DALYs – disability-adjusted life years, 95% *CI* – confidence interval.

Tab. 3. Correlations among dietary factors and mental health variables across 120 countries, 1990–2018.

Dietary factors	Depressive disorders	Anxiety disorders	*GDP*	*HAQ*	Rural population ratio	*SDI*
	Coefficient *r*					
1990						
Total omega-6 fat	0.25*	0.30*	0.10	0.12	–0.21*	0.11
Vitamin B9 (folate)	0.10	0.27**	0.16	0.24*	–0.43**	0.25*
Total protein	0.32**	0.55**	0.48**	0.51**	–0.50**	0.52**
Sugar-sweetened beverages	–0.18	0.16	–0.03	0.05	–0.28**	0.14
Refined grains	0.26**	0.33**	0.36**	0.34**	0.04	0.28**
Total processed meats	0.16	0.11	0.21*	0.30**	–0.33**	0.36**
2018						
Total omega-6 fat	0.28**	0.27**	0.11	0.16	–0.06	0.12
Vitamin B9 (folate)	–0.03	0.14	0.08	0.05	–0.12	0.03
Total protein	0.20*	0.44**	0.38**	0.52**	–0.06	0.54**
Sugar-sweetened beverages	–0.14	–0.05	–0.18	–0.15	–0.03	–0.10
Refined grains	0.16	0.31**	0.40**	0.35**	0.19*	0.33**
Total processed meats	–0.15	0.07	0.23*	0.31**	–0.04	0.35**

Rural population ratio - the percentage of a country's total population that lives in rural areas.
GDP – gross domestic product, *HAQ* - healthcare access quality index, *SDI* - socio-demographic index.
Statistical significance: * – $p < 0.05$, ** – $p < 0.01$.

Tab. 4. Regression results of mental health variables.

Dietary factors	Coefficient β	95% *CI*		*p* value
		Lower	Upper	
DEPRESSIVE DISORDERS				
Total omega-6 fat	1 554.04	276.52	2 831.57	0.03
Vitamin B9 (folate)	–1.22	–3.35	0.90	0.18
Total protein	6.63	–3.10	14.20	0.06
Sugar-sweetened beverages	–0.09	–0.96	0.77	0.23
Refined grains	0.15	–1.33	1.65	0.35
Total processed meats	9.51	4.51	13.46	< 0.01
Rural population ratio	–4.59	–11.49	2.30	0.25
Nagelkerke R^2	0.28			
ANXIETY DISORDERS				
Total omega-6 fat	1 976.09	256.30	3 695.88	0.01
Vitamin B9 (folate)	0.58	–2.28	3.45	0.36
Total protein	17.51	4.40	30.10	0.02
Sugar-sweetened beverages	0.77	–0.39	1.94	0.17
Refined grains	0.25	–1.75	2.26	0.24
Total processed meats	9.88	5.13	14.45	0.03
Rural population ratio	–6.05	–15.33	3.23	0.19
Nagelkerke R^2	0.36			

Multivariable models were constructed after adjusting for gross domestic product (GDP), healthcare access and quality index (*HAQ*), and socio-demographic index (*SDI*).
Nagelkerke R^2 – pseudo R^2, measure indicating the explanatory power of the model; higher values reflect better model fit.
CI – confidence interval.

intake emerged as a statistically significant and positively associated predictor of depressive (β = 1 554.04, 95% *CI* 276.52–2 831.57) and anxiety (β = 1 976.09, 95% *CI* 256.30–3 695.88) disorders. A similar pattern was observed for processed meat consumption, which also demonstrated significant positive associations with both depressive (β = 9.51, 95% *CI* 4.51–13.46) and anxiety disorders (β = 9.88, 95% *CI* 5.13–14.45). Total protein intake was significantly associated only with anxiety disorders (β = 17.51, 95% *CI* 4.40–30.10), while its association with depressive disorders was marginal and did not reach statistical significance. In contrast, other dietary variables, such as sugar-sweetened beverage intake, refined grain intake, and vitamin B9 (folate), were not significantly associated with either depressive or anxiety disorders after adjusting for the other variables in the model.

This cross-sectional ecological study, which analysed country-level data on nutrient intake and mental health burden across 120 countries from 1990 to 2018, identifies population-level associations between dietary factors and mental health outcomes. By contributing to the expanding field of nutritional psychiatry [7], these findings underscore the role of diet in shaping brain health. Notably, the study reveals significant associations between specific nutrient intakes and the prevalence of depressive and anxiety disorders, with clear disparities observed across income groups. The analysis revealed a global shift in dietary patterns over the nearly three-decade study period. The intake of potentially beneficial nutrients, such as omega-6 fatty acids and vitamin B9 (folate), increased modestly, while protein intake declined. Conversely, the consumption of unhealthy nutrients, including sugar-sweetened beverages and processed meats, rose significantly. These trends align with the broader "nutrition transition" described in prior research [20], where diets shift toward energy-dense, processed foods at the expense of nutrient-rich whole foods. This transition is most clearly characterised by the global spread of the Western dietary pattern and the rise of processed food consumption. Processed foods simultaneously deliver high loads of refined sugars, unhealthy fats, sodium, and additives while being depleted in fibre, micronutrients, and bioactive compounds. The displacement of traditional, fibre-rich, whole-food dietary patterns by ultra-processed alternatives may therefore represent a key mechanistic pathway linking the nutrition transition to the rising mental health burden, particularly in low- and middle-income countries where this shift has been most rapid. Today, almost every country in the world is experiencing these changes [14]; however, the transition has been most pronounced in LMICs, where the rise in unhealthy nutrient intake has coincided with the largest increases in depressive and anxiety disorders [21]. These trends may be associated with poorer mental health outcomes, as deficiencies in antioxidants, known for their protective effects against depression, may contribute to the development or worsening of depressive symptoms [22]. However, the current study revealed that the prevalence and DALYs associated with depressive and anxiety disorders have increased over time, particularly in countries experiencing rising income levels. A possible explanation may be that awareness and prioritisation of mental health issues remain limited in many LMICs, resulting in the insufficient availability of screening, referral, and treatment services [23, 24].

While omega-6 fats are essential for brain function, excessive intake, particularly when unbalanced with omega-3 fatty acids, has been linked to pro-inflammatory processes [25] that may exacerbate mental health disorders [26]. Furthermore, a systematic review and meta-analysis identified an association between a high *n*-6/*n*-3 polyunsaturated fatty acid ratio and an increased risk of depression [27]. These results are partially consistent with the findings of the present cross-sectional study, which identified a significant contribution of omega-6 intake to the prevalence of depressive disorders. It should also be noted that the impact of fatty acids is influenced by the overall nutrient profile and lifestyle factors, including diet quality, physical activity, and comorbid health conditions. Numerous studies have also emphasised that a balanced intake of omega-6 fatty acids plays a significant role in the prevention and management of depressive disorders [27, 28]. These findings underscore the importance of examining not just individual nutrients but their ratios and broader dietary patterns.

Processed meats are typically high in saturated fats, sodium, and preservatives like nitrates, which may disrupt gut microbiota and promote systemic inflammation, a known risk factor for mental health disorders [29]. Consistent with the findings of the current study, findings from multiple meta-analyses of cross-sectional studies have demonstrated that higher consumption of processed foods is significantly associated with increased odds of experiencing depressive and anxiety symptoms [30]. This highlights the importance of dietary composition, as lean protein intake has been inversely associated with depression and anxiety, while processed meat intake shows a positive association with anxiety [31]. However, higher consumption of red meat, which is considered a lean protein, has been linked to an increased risk of depressive symptoms, anxiety, and psychological distress in women, as demonstrated by a cross-sectional study [32]. A possible explanation for the observed associations is that the quality and source of macronutrients may influence mental health outcomes through both biological mechanisms (e.g., neuroinflammation) and behavioural factors (e.g., overall dietary patterns). Furthermore, differences in metabolic or hormonal responses to red meat intake, as well as lifestyle factors such as physical activity, smoking, alcohol consumption, socioeconomic status, and stress levels between groups, may also contribute to the observed associations [14, 15, 21]. Divergent findings on this issue have been reported in the literature. The relationship between meat consumption and depression was examined in a meta-analysis comprising two case-control studies, three cohort studies, and three cross-sectional studies. Overall, the analysis found no significant association between red meat intake and increased risk of depression. However, some cohort studies within the meta-analysis did report that meat consumption was associated with a 13% higher risk of developing depression [33].

Interestingly, in this study, sugar-sweetened beverages, refined grains and folate did not show significant associations in adjusted models, despite their well-documented links to metabolic disorders [9, 14]. Results from a multi-population survey showed that higher consumption of sugar-sweetened beverages is individually associated with increased levels of psychological and behavioural problems [33], despite contradictory findings reported in a more recent study [30] On the other hand, findings from systematic review and meta-analysis of observational studies suggested that refined grain intake was not significantly correlated to the risk of anxiety [33]. This discrepancy may arise from the ecological nature of the present study, where population-level data obscure individual-level effects, or from the influence of other mediating factors (e.g., physical activity, genetic predispositions). The lack of association for folate contrasts with meta-analyses showing that folate supplementation can reduce depressive symptoms [11]. This divergence may stem from methodological differences. Firstly, the present study assessed dietary folate at the country level, whereas clinical trials often focus on high-dose supplementation in deficient individuals.

The disparities across income groups also merit discussion. High-income countries, despite higher intakes of processed meats and sugar-sweetened beverages, exhibited stable mental health trends. This could reflect better health-care access, stronger social safety nets, or earlier adoption of public health interventions [13]. The observed positive correlation between higher nutrient intake and mental disorder prevalence in high-income countries likely reflects diagnostic ascertainment differences rather than a direct biological effect of nutrients. High-income countries benefit from substantially more developed psychiatric infrastructure, including a greater density of mental health professionals, broader population coverage of mental health services, routine screening programmes, and reduced cultural stigma surrounding diagnosis and help-seeking behaviour. These systemic factors increase the rate of case detection and formal diagnosis, which elevates reported prevalence figures independently of the true underlying burden of disease. Conversely, LMICs face a "double burden" of malnutrition and rising mental health disorders, exacerbated by rapid urbanisation and unequal resource distribution [16]. This finding aligns with a priori analyses showing that LMICs are experiencing rapid growth in the consumption of processed foods and beverages. Furthermore, these countries can reach the same high levels of consumption observed in high-income countries, along with the associated negative health impacts [20]. As a result, the GBD prevalence estimates used in this study are not purely reflective of true illness burden but are also shaped by each country's capacity for detection and reporting. This has direct implications for the interpretation of our regression findings: nutrients consumed at higher levels in wealthier countries – such as omega-6 fatty acids and processed meats – may appear positively correlated with mental disorder prevalence partly because both are simultaneously elevated in high-income, high-detection settings, rather than because of any true dietary relationship. All cross-national comparisons of mental health prevalence in this study should therefore be interpreted with this systematic ascertainment differential in mind.

While the study offers valuable insights, several limitations must be acknowledged. The ecological design of this study introduces the risk of ecological fallacy, as associations observed at the country level may not reflect individual-level relationships. Therefore, the findings cannot be interpreted as evidence of causal effects at the individual level. Second, both nutrient intake and mental health estimates are based on modelled data rather than direct measurements, which may limit their precision. Furthermore, potential unmeasured confounders, such as stress, trauma, or cultural factors, were not accounted for in the analysis. Finally, substantial heterogeneity exists across countries in terms of healthcare systems, diagnostic practices, data quality, and socioeconomic conditions. These differences may influence both nutrient intake estimates and reported mental health burden, potentially affecting cross-country comparability. An additional limitation relates to the use of modelled secondary data sources. The GDD relies on self-reported dietary assessment instruments, which are subject to well-documented measurement errors, including recall bias, social desirability bias, and inaccuracies in portion size estimation. Moreover, data availability is uneven across countries and nutrients, particularly in low-data regions, introducing model-based uncertainty that may be greatest in the low-income country subgroup most relevant to our findings. Similarly, estimates of depressive and anxiety disorders from the GBD study are derived from statistical models that synthesise multiple data inputs of varying quality and coverage across countries. Differences in data availability, diagnostic practices, and reporting systems may affect the accuracy and comparability of these estimates. The combined use of two modelled datasets may introduce compounded uncertainty, which could influence the magnitude and precision of the observed associations. Therefore, the findings should be interpreted as approximate population-level associations rather than precise estimates, and caution is warranted when comparing results across countries and income groups.

CONCLUSIONS

This cross-sectional ecological study of 120 countries from 1990 to 2018 provides critical insights into the complex relationship between nutrient intake and mental health burden across income groups. The findings highlight significant global dietary shifts, marked by increased consumption of unhealthy nutrients such as sugar-sweetened beverages and processed meats, alongside modest improvements in potentially beneficial nutrients like omega-6 fats and vitamin B9. These trends were particularly pronounced in low- and middle-income countries, reflecting the broader nutrition transition toward energy-dense, nutrient-poor diets. Notably, the mental health burden, measured by prevalence and DALYs for depressive and anxiety disorders, increased globally, with the most substantial rises observed in upper-middle-income countries.

The results underscore the importance of integrating nutritional strategies into mental health policies, particularly in low- and middle-income settings. Public health initiatives should prioritise reducing the consumption of processed foods and promoting diets rich in potentially beneficial nutrients to mitigate the growing mental health burden. Tailoring such interventions to the socioeconomic and cultural contexts of specific income groups will be essential to address disparities in dietary quality and mental health outcomes. Given the cross-sectional design, causal inferences cannot be drawn, and further longitudinal and interventional studies are warranted to clarify the temporal and mechanistic pathways linking nutrient intake with mental health burden.

REFERENCES

1. Durmuş, V.: Analysis of mental health and substance use disorders, and self-harm among young people in 185 countries. Journal of Child and Family Studies, *33*, 2024, pp. 3035–3050. DOI: 10.1007/s10826-024-02899-8.
2. World Mental Health Report: Transforming mental health for all. In: WHO [online]. Geneva : World Health Organization, 2022 [cited 10 October 2025]. ISBN: 9789240049338. <https://www.who.int/publications/i/item/9789240049338>
3. Comprehensive Mental Health Action Plan (2013–2030). In: WHO [online]. Geneva : World Health Organization, 2021 [cited 15 November 2025]. ISBN: 9789240031029. <https://www.who.int/publications/i/item/9789240031029>
4. Kirkbride, J. B. – Anglin, D. M. – Colman, I. – Dykxhoorn, J. – Jones, P. B. – Patalay, P. – Pitman, A. – Soneson, E. – Steare, T. – Wright, T. – Griffiths, S. L.: The social determinants of mental health and disorder: evidence, prevention and recommendations. World Psychiatry, *23*, 2024, pp. 58–90. DOI: 10.1002/wps.21160.
5. Rezaei, S. J. – Chen, M. L. – Kim, J. – Linos, E.: Mental health, sleep and general health among individuals with dermatologic conditions: a US population-based study using the National Health and Nutrition Examination Survey (NHANES). Experimental Dermatology, *33*, 2024, article e15195. DOI: 10.1111/exd.15195.
6. Ammar, A. – Trabelsi, K. – Hammouda, O. – Clark, C. C. T.: Nutrition and wellbeing: how do energy intake, fasting and prudent diets affect mental health. Frontiers in Nutrition, *11*, 2024, article 1461415. DOI: 10.3389/fnut.2024.1461415.
7. Mudd, M.: Using nutrition as a therapeutic modality. Psychiatric News, *60*, 2025, pp. 1–4. DOI: 10.1176/appi.pn.2025.01.1.18.
8. Sparling, T. M. – Deeney, M. – Cheng, B. – Han, X. – Lier, C. – Lin, Z. – Offner, C. – Santoso, M. V. – Pfeiffer, E. – Emerson, J. A. – Amadi, F. M. –

Mitu, K. – Corvalan, C. – Verdeli, H. – Araya, R. – Kadiyala, S.: Systematic evidence and gap map of research linking food security and nutrition to mental health. Nature Communications, *13*, 2022, article 4608. DOI: 10.1038/s41467-022-32116-3.

9. Adan, R. A. H. – van der Beek, E. M. – Buitelaar, J. K. – Cryan, J. F. – Hebebrand, J. – Higgs, S. – Schellekens, H. – Dickson, S. L.: Nutritional psychiatry: Towards improving mental health by what you eat. European College of Neuropsychopharmacology, *29*, 2019, pp. 1321–1332. DOI: 10.1016/j.euroneuro.2019.10.011.
10. Bekdash, R. A.: Epigenetics, nutrition, and the brain: improving mental health through diet. International Journal of Molecular Sciences, *25*, 2024, article 4036. DOI: 10.3390/ijms25074036.
11. Grajek, M. – Krupa-Kotara, K. – Białek-Dratwa, A. – Sobczyk, K. – Grot, M. – Kowalski, O. – Staśkiewicz, W.: Nutrition and mental health: A review of current knowledge about the impact of diet on mental health. Frontiers in Nutrition, *9*, 2022, article 943998. DOI: 10.3389/fnut.2022.943998.
12. Opie, R. S. – Itsiopoulos, C. – Parletta, N. – Sanchez-Villegas, A. – Akbaraly, T .N. – Ruusunen, A. – Jacka, F. N.: Dietary recommendations for the prevention of depression. Nutritional Neuroscience, *20*, 2017, pp. 161–171. DOI: 10.1179/1476830515Y.0000000043.
13. Bayati, M. – Arkia, E. – Emadi, M.: Socio-economic inequality in the nutritional deficiencies among the world countries: evidence from global burden of disease study 2019. Journal of Health, Population and Nutrition, *44*, 2025, article 8. DOI: 10.1186/s41043-025-00739-z.
14. Popkin, B. M. – Corvalan, C. – Grummer-Strawn, L. M.: Dynamics of the double burden of malnutrition and the changing nutrition reality. The Lancet, *395*, 2020, pp. 65–74. DOI: 10.1016/S0140-6736(19)32497-3.
15. Cherak, S. J. – Fiest, K. M. – VanderSluis, L. – Basualdo-Hammond, C. – Lorenzetti, D. L. – Buhler, S. – Stadnyk, J. – Driedger, L. – Hards, L. – Gramlich, L. – Fenton, T. R.: Nutrition interventions in populations with mental health conditions: a scoping review. Applied Physiology, Nutrition, and Metabolism, *45*, 2020, pp. 687–697. DOI: 10.1139/apnm-2019-0683.
16. Ahmed, S. K. – Mohammed, R. A.: Obesity: prevalence, causes, consequences, management, preventive strategies and future research directions. Metabolism Open, *27*, 2025, article 100375. DOI: 10.1016/j.metop.2025.100375.
17. Ashtree, D. N. – Orr, R. – Lane, M. M. – Akbaraly, T. N. – Bonaccio, M. – Costanzo, S. – Gialluisi, A. – Grosso, G. – Lassale, C. – Martini, D. – Monasta, L. – Santomauro, D. – Stanaway, J. – Jacka, F. N. – O'Neil, A.: Estimating the burden of common mental disorders attributable to lifestyle factors: protocol for the Global Burden of Disease Lifestyle and Mental Disorder (GLAD) Project. JMIR Research Protocols, *14*, 2025, article e65576. DOI: 10.2196/65576.
18. Miller, V. – Singh, G. M. – Onopa, J. – Reedy, J. – Shi, P. – Zhang, J. – Tahira, A. – Shulkin Morris, M. L. – Marsden, D. P. – Kranz, S. – Stoyell, S. – Webb, P. – Micha, R. – Mozaffarian, D.: Global Dietary Database 2017: data availability and gaps on 54 major foods, beverages and nutrients among 5.6 million children and adults from 1220 surveys worldwide. BMJ Global Health, *6*, 2021, article e003585. DOI: 10.1136/bmjgh-2020-003585.
19. Brauer, M. – Roth, G. A. – Aravkin, A. Y. et al.: Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. The Lancet, 403, 2024, pp. 2162–2203. DOI: 10.1016/S0140-6736(24)00933-4.
20. Popkin, B. M. – Ng, S. W.: The nutrition transition to a stage of high obesity and noncommunicable disease prevalence dominated by ultra processed foods is not inevitable. Obesity Reviews, *23*, 2022, article e13366. DOI: 10.1111/obr.13366.
21. Smith, L. – Shin, J. I. – McDermott, D. – Jacob, L. – Barnett, Y. – Lopez-Sanchez G. F. – Veronese, N. – Yang, L. – Soysal, P. – Oh, H. – Grabovac, I. – Koyanagi, A.: Association between food insecurity and depression among older adults from low and middle income countries. Depression and Anxiety, *38*, 2021, pp. 439–446. DOI: 10.1002/da.23147.
22. Li, Y. – Lv, M. R. – Wei, Y. J. – Sun, L. – Zhang, J. X. – Zhang, H. G. – Li, B.: Dietary patterns and depression risk: a meta analysis. Psychiatry Research, *253*, 2017, pp. 373–382. DOI: 10.1016/j.psychres.2017.04.020.
23. Moitra, M. – Owens, S. – Hailemariam, M. – Wilson, K. S. – Mensa-Kwao, A. – Gonese, G. – Kamamia, C. K. – White, B. – Young, D. M. – Collins, P. Y.: Global mental health: where we are and where we are going. Current Psychiatry Reports, *25*, 2023, pp. 301–311. DOI: 10.1007/s11920-023-01426-8.
24. Kola, L. – Kohrt, B. A. – Hanlon, C. – Naslund, J. A. – Sikander, S. – Balaji, M. – Benjet, C. – Cheung, E. Y. L. – Eaton, J. – Gonsalves, P. – Hailemariam, M. – Luitel, N. P. – Machado, D. B. – Misganaw, E. – Omigbodun, O. – Roberts, T. – Salisbury, T. T. – Shidhaye, R.: COVID-19 mental health impact and responses in low income and middle income countries: reimagining global mental health. The Lancet Psychiatry, *8*, 2021, pp. 535–550. DOI: 10.1016/S2215-0366(21)00025-0.
25. Bentsen, H.: Dietary polyunsaturated fatty acids, brain function and mental health. Microbial Ecology in Health and Disease, *28*, 2017, issue sup1, article 1281916. DOI: 10.1080/16512235.2017.1281916.
26. Simopoulos, A. P.: The omega-6/omega-3 fatty acid ratio: health implications. Oléagineux, Corps gras, Lipides, *17*, 2010, pp. 267–275. DOI: 10.1051/ocl.2010.0325.
27. Wang, Y. – Dong, L. – Pan, D. – Xu, D. – Lu, Y. – Yin, S. – Wang, S. – Xia, H. – Liao, W. – Sun, G.: Effect of high ratio of *n*-6/*n*-3 PUFAs on depression: a meta analysis of prospective studies. Frontiers in

Nutrition, *9*, 2022, article 889576. DOI: 10.3389/fnut.2022.889576.
28. Suárez-López, L. M. – Bru-Luna, L. M. – Martí-Vilar, M.: Influence of nutrition on mental health: scoping review. Healthcare, *11*, 2023, article 2183. DOI: 10.3390/healthcare11152183.
29. Norde, M. M. – Collese, T. S. – Giovannucci, E. – Rogero, M. M.: A posteriori dietary patterns and their association with systemic low-grade inflammation in adults: a systematic review and meta analysis. Nutrition Reviews, *79*, 2021, pp. 331–350. DOI: 10.1093/nutrit/nuaa010.
30. Lane, M. M. – Gamage, E. – Travica, N. – Dissanayaka, T. – Ashtree, D. N. – Gauci, S. – Lotfaliany, M. – O'neil, A. – Jacka, F. N. – Marx, W.: Ultra processed food consumption and mental health: a systematic review and meta analysis of observational studies. Nutrients, *14*, 2022, article 2568. DOI: 10.3390/nu14132568.
31. Johnson, N. R. – Stastny, S. N. – Garden-Robinson, J.: Intakes of lean proteins and processed meats and differences in mental health between rural and metro adults 50 years and older. Nutrients, *16*, 2024, article 3056. DOI: 10.3390/nu16183056.
32. Darooghegi Mofrad, M. – Mozaffari, H. – Sheikhi, A. – Zamani, B. – Azadbakht, L.: The association of red meat consumption and mental health in women: a cross sectional study. Complementary Therapies in Medicine, *56*, 2021, article 102588. DOI: 10.1016/j.ctim.2020.102588.
33. Zhang, H. – Li, M. – Mo, L. – Luo, J. – Shen, Q. – Quan, W.: Association between western dietary patterns, typical food groups, and behavioral health disorders: an updated systematic review and meta analysis of observational studies. Nutrients, *16*, 2023, article 125. DOI: 10.3390/nu16010125.

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