

Associations of Dietary and Circulating Nutritional Indicators with Self-rated Health among Adult Cancer Survivors: A Cross-sectional Analysis of the National Health and Nutrition Examination Survey

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Abstract: *Background:* Self-rated health (SRH) is a validated, patient-centered proxy for overall physiological reserve and an independent predictor of survival in people living with and beyond cancer. Although malnutrition is highly prevalent among cancer survivors, it remains unclear how specific dietary and circulating nutritional biomarkers jointly map onto the perceived health of this population. *Objective:* To quantify the independent associations of dietary and blood-based nutritional indicators with SRH in a sample of U.S. adult cancer survivors, and to explore potential effect modification by sex and systemic inflammation. *Methods:* We analyzed data from adults who reported a physician diagnosis of cancer or malignancy in the National Health and Nutrition Examination Survey (NHANES). The outcome was SRH, an ordinal five-level variable (1 = excellent to 5 = poor). Exposure indicators comprised mean two-day dietary fiber intake, serum pyridoxal 5'-phosphate (vitamin B6), red-blood-cell folate (vitamin B9), mean two-day vitamin B12 intake, serum triglycerides, and body-mass index. Multivariable ordinal logistic regression was used to estimate adjusted odds ratios (ORs) with 95% confidence intervals (CIs). Pre-specified stratified analyses were performed by sex and subgroup analyses by C-reactive protein (CRP) status (< 1 vs. ≥ 1 mg/dL). Restricted cubic splines (RCS) characterized dose-response shapes. *Results:* A total of 308 cancer survivors (mean age 53.2 ± 13.0 years; 61.7% female) were included; 86 (27.9%) reported fair or poor health. In the fully adjusted model, higher dietary fibre (OR 0.949 per 1 g/day; 95% CI 0.922–0.977; $p = 0.0005$), vitamin B6 (OR 0.994 per 1 nmol/L; 0.990–0.997; $p = 0.0006$) and vitamin B12 (OR 0.922 per 1 mcg; 0.857–0.991; $p = 0.028$) were independently associated with lower odds of poorer SRH, while higher RBC folate showed a protective trend that did not reach conventional significance (OR 0.999 per 1 ng/mL; 0.998–1.000; $p = 0.055$); in contrast, higher triglycerides (OR 1.003 per 1 mg/dL; 1.001–1.006; $p = 0.001$) and BMI (OR 1.031 per 1 kg/m²; 1.003–1.059; $p = 0.028$) were associated with poorer SRH. Stratified analyses indicated that the protective association of dietary fiber was statistically robust in female survivors (OR 0.921 per 1 g/day; 0.885–0.959; $p < 0.001$) but not in males, and that the beneficial profile of fiber, vitamin B6 and vitamin B12 persisted in the low-inflammation (CRP < 1 mg/dL) subgroup. RCS analyses confirmed largely monotonic dose-response relationships without obvious threshold effects. *Conclusion:* Among U.S. adult cancer survivors, a more favorable nutritional profile, higher dietary fiber, vitamins B6 and B12 (with a consistent protective trend for vitamin B9), together with lower triglycerides and healthier BMI, was independently associated with better self-rated health. These findings support dietary and metabolic optimization as a pragmatic, modifiable lever for improving perceived health in cancer survivorship and warrant confirmation in longitudinal cohorts.

Keywords: Cancer survivors; Self-rated health; Nutritional status; Dietary fiber; B vitamins; NHANES; Ordinal logistic regression; Restricted cubic splines

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1. Introduction

Cancer remains one of the most pressing public-health challenges worldwide. With continuous improvements in early detection and treatment, the number of global cancer survivors is growing rapidly, and attention is progressively shifting from tumor control alone towards the broader quality of life, functional status, and long-term health of those living with and beyond the disease. Among the patient-reported outcomes that best capture this holistic perspective, self-rated health (SRH), an individual's subjective, global appraisal of their own health on an ordinal scale, has emerged as one of the most informative and economic indicators^[1,2]. Nutritional status is a cornerstone of health in cancer survivorship: both the tumor itself and its treatments can precipitate anorexia, catabolism, malabsorption and systemic inflammation, which erode lean body mass, micronutrient reserves and metabolic homeostasis, and cancer-related malnutrition has been linked to impaired immune function, treatment-related toxicity, poorer quality of life and reduced survival^[3]. The growing recognition that lifestyle and nutrition shape long-term outcomes has made survivorship a research priority^[4]. Yet most existing studies have examined individual nutrients in isolation, focused on biochemical endpoints rather than patient-reported health, or relied on homogeneous clinical samples, and there is comparatively little nationally representative evidence on how a panel of dietary and circulating nutritional indicators, considered jointly, relates to the perceived health of cancer survivors.

Accordingly, the present study leveraged data from the National Health and Nutrition Examination Survey (NHANES) to evaluate the independent and joint associations of selected dietary and circulating nutritional indicators with SRH among adult cancer survivors. We further examined whether these associations were modified by sex (a known determinant of both nutritional biology and health perception) and by systemic inflammation, indexed by C-reactive protein (CRP). Restricted cubic splines were used to characterize the shape of the dose–response relationships. We hypothesized that more favorable nutritional status, higher fiber, B vitamins, and a healthier metabolic profile would be independently associated with better SRH in this vulnerable group^[5-7].

2. Methods

2.1. Study design

This cross-sectional study used pooled, publicly available data from NHANES, a nationally representative, stratified, multistage probability survey of the civilian, non-institutionalized U.S. population conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention^[8]. The NHANES protocol was approved by the NCHS Research Ethics Review Board, and all participants provided written informed consent; the present secondary analysis of de-identified, publicly released data was therefore deemed exempt from additional ethical review. For the present analysis, the analytical population was restricted to adults (aged ≥ 18 years) who answered affirmatively to the medical-conditions question on ever being told they had cancer or a malignancy of any kind.

2.2. Outcome variable

The outcome was SRH, assessed by the question: “Would you say your health in general is...” with responses on a five-level ordinal scale: 1 = excellent, 2 = very good, 3 = good, 4 = fair, and 5 = poor. Higher values therefore denote worse perceived health. For descriptive comparison and for the RCS prediction of “fair/poor health”, participants were additionally dichotomized at a score of 4 (i.e., fair or poor vs. excellent/very good/good).

2.3. Exposure variables (nutritional indicators)

Six indicators were selected a priori to represent both dietary intake and circulating nutritional status. Dietary intake was derived from two 24-hour dietary recalls and averaged across the two days to reduce day-to-day variability: mean dietary fiber (g/day, avg_fibe) and mean vitamin B12 intake (mcg/day, avg_tvb12). Circulating biomarkers comprised serum pyridoxal 5'-phosphate (PLP, the active form of vitamin B6, nmol/L; lbxplp), red-blood-cell folate (a long-term marker of vitamin B9 status, ng/mL; lbdrbf), and serum triglycerides (mg/dL; lbxstr). Body-mass index (kg/m^2 ; bmxBMI) was included as an anthropometric proxy of overall metabolic and nutritional state. Systemic inflammation was indexed by

serum C-reactive protein (CRP, mg/dL).

2.4. Statistical analysis

Continuous variables are presented as mean $\pm$ standard deviation (SD) or median (interquartile range, IQR), and categorical variables as frequency (percentage). Between-group differences in baseline characteristics according to SRH (fair/poor vs. good or better) were assessed using the independent-samples *t* test or Mann–Whitney U test for continuous variables and the chi-square test for categorical variables, as appropriate^[9].

Pre-specified stratified analyses were performed by sex (male vs. female), and subgroup analyses by CRP status using the conventional clinical cut-point of 1 mg/dL to distinguish low (< 1 mg/dL) from elevated (≥ 1 mg/dL) systemic inflammation. To characterize potential non-linearity, restricted cubic splines (RCS) with three knots placed at the 10th, 50th, and 90th percentiles (sensitivity analysis with knots at the 25th, 50th and 75th percentiles) were fitted for each nutritional indicator, and the predicted probability of each SRH category was computed from the fitted ordinal models across the observed exposure range. A two-sided *p* value < 0.05 was considered statistically significant. Analyses were performed in Stata/MP 17.0 (StataCorp, College Station, TX); the analysis code is available from the corresponding author on reasonable request.

3. Results

3.1. Study population

A total of 308 adult cancer survivors with complete data on the SRH outcome and all six nutritional indicators were included in the primary analysis. The mean age was 53.2 ± 13.0 years, 190 (61.7%) were female, and the majority self-identified as Non-Hispanic White (ridreth1 category 3, $n = 195$; 63.3%). Overall, 86 participants (27.9%) reported fair or poor health ($\text{SRH} \geq 4$), while 222 (72.1%) reported good, very good, or excellent health.

3.2. Baseline characteristics by self-rated health

Cancer survivors who reported fair or poor health were older (55.6 ± 12.3 vs. 52.3 ± 13.1 years; $p = 0.043$) and more likely to be female (67.4% vs. 59.5%) than those reporting good or better health, although the sex difference did not reach statistical significance. They were also substantially more likely to be current smokers (30.2% vs. 17.6%), to have hypertension (62.8% vs. 41.9%) and to have diabetes (19.8% vs. 10.8%). Across all six nutritional indicators, the fair/poor-health group exhibited a clearly less favourable profile: lower dietary fibre (median 12.1, IQR 8.0–16.9 vs. 14.9, IQR 12.2–22.4 g/day; Mann–Whitney $p = 3.2 \times 10^{-6}$), lower vitamin B6 (40.0 ± 42.6 vs. 68.5 ± 63.1 nmol/L), lower RBC folate (462.5 ± 218.0 vs. 534.0 ± 222.2 ng/mL), lower vitamin B12 (3.9 ± 2.1 vs. 5.3 ± 3.3 mcg), higher triglycerides (177.0 ± 117.6 vs. 143.4 ± 90.6 mg/dL), higher BMI (31.7 ± 8.6 vs. 29.2 ± 7.5 kg/m²) and higher CRP (0.64 ± 0.90 vs. 0.43 ± 0.71 mg/dL) (Table 1).

Table 1. Baseline characteristics of adult cancer survivors by self-rated health status, NHANES

Characteristic	Overall (n = 308)	Good or better SRH (n = 222)	Fair/poor SRH (n = 86)
Age, years, mean $\pm$ SD	53.2 $\pm$ 13.0	52.3 $\pm$ 13.1	55.6 $\pm$ 12.3
Female sex, n (%)	190 (61.7)	132 (59.5)	58 (67.4)
Race/ethnicity: Non-Hispanic White, n (%)	195 (63.3)	143 (64.4)	52 (60.5)
Current smoker, n (%)	65 (21.1)	39 (17.6)	26 (30.2)
Hypertension, n (%)	147 (47.7)	93 (41.9)	54 (62.8)
Diabetes, n (%)	41 (13.3)	24 (10.8)	17 (19.8)
Dietary fibre, g/day, mean $\pm$ SD	16.3 $\pm$ 8.5	17.6 $\pm$ 8.7	13.0 $\pm$ 7.1
Dietary fibre, g/day, median (IQR)	14.2 (10.3–20.6)	14.9 (12.2–22.4)	12.1 (8.0–16.9)
Vitamin B6 (PLP), nmol/L, mean $\pm$ SD	60.5 $\pm$ 59.4	68.5 $\pm$ 63.1	40.0 $\pm$ 42.6
RBC folate (B9), ng/mL, mean $\pm$ SD	514.0 $\pm$ 223.0	534.0 $\pm$ 222.2	462.5 $\pm$ 218.0
Dietary vitamin B12, mcg, mean $\pm$ SD	4.9 $\pm$ 3.1	5.3 $\pm$ 3.3	3.9 $\pm$ 2.1

Triglycerides, mg/dL, mean $\pm$ SD	152.8 $\pm$ 99.8	143.4 $\pm$ 90.6	177.0 $\pm$ 117.6
BMI, kg/m ² , mean $\pm$ SD	29.9 $\pm$ 7.9	29.2 $\pm$ 7.5	31.7 $\pm$ 8.6
C-reactive protein, mg/dL, mean $\pm$ SD	0.49 $\pm$ 0.77	0.43 $\pm$ 0.71	0.64 $\pm$ 0.90

SRH, self-rated health; SD, standard deviation; IQR, interquartile range; PLP, pyridoxal 5'-phosphate; RBC, red blood cell; BMI, body-mass index. Between-group differences: age $p = 0.043$ (t test); dietary fibre $p = 3.2 \times 10^{-6}$ (Mann–Whitney); smoking $p = 0.029$, hypertension $p = 0.001$ (chi-square).

3.3. Multivariable ordinal logistic regression

In the fully adjusted ordinal logistic model, five of the six nutritional indicators were independently associated with SRH at $p < 0.05$, and the sixth showed a consistent protective trend (**Table 2**). Higher dietary fiber intake was associated with lower odds of poorer health (OR 0.949 per 1 g/day; 95% CI 0.922–0.977; $p = 0.0005$); expressed per a clinically meaningful increment of 5 g/day, this corresponds to an OR of approximately 0.77. Likewise, higher circulating vitamin B6 (OR 0.994 per nmol/L; 0.990–0.997; $p = 0.0006$) and higher dietary vitamin B12 (OR 0.922 per mcg; 0.857–0.991; $p = 0.028$) were each associated with better SRH. Higher RBC folate showed a protective association of similar direction that did not reach conventional significance (OR 0.999 per ng/mL; 0.998–1.000; $p = 0.055$). In contrast, higher triglycerides (OR 1.003 per mg/dL; 1.001–1.006; $p = 0.001$) and higher BMI (OR 1.031 per kg/m²; 1.003–1.059; $p = 0.028$) were associated with poorer SRH. The directions and magnitudes of these associations were consistent and biologically coherent.

Table 2. Adjusted associations of nutritional indicators with self-rated health among cancer survivors: ordinal logistic regression, overall and by sex and CRP subgroup

Indicator (unit increment)	Adjusted OR (95% CI)	<i>p</i> value
OVERALL (n = 308)		
Dietary fiber (per 1 g/day)	0.949 (0.922–0.977)	0.0005
Vitamin B6 / PLP (per 1 nmol/L)	0.994 (0.990–0.997)	0.0006
RBC folate (per 1 ng/mL)	0.999 (0.998–1.000)	0.055
Dietary vitamin B12 (per 1 mcg)	0.922 (0.857–0.991)	0.028
Triglycerides (per 1 mg/dL)	1.003 (1.001–1.006)	0.001
BMI (per 1 kg/m ²)	1.031 (1.003–1.059)	0.028
MALE (n = 118)		
Dietary fibre	0.977 (0.941–1.015)	0.232
Vitamin B6 / PLP	0.996 (0.990–1.003)	0.234
RBC folate	0.999 (0.997–1.001)	0.318
Dietary vitamin B12	0.908 (0.829–0.995)	0.038
Triglycerides	1.003 (0.999–1.006)	0.144
BMI	1.015 (0.953–1.081)	0.649
FEMALE (n = 190)		
Dietary fibre	0.921 (0.885–0.959)	< 0.001
Vitamin B6 / PLP	0.994 (0.989–0.998)	0.010
RBC folate	0.999 (0.998–1.000)	0.078
Dietary vitamin B12	0.919 (0.802–1.053)	0.225
Triglycerides	1.004 (1.001–1.007)	0.004
BMI	1.036 (1.005–1.068)	0.024
CRP < 1 mg/dL (n = 269)		
Dietary fibre	0.950 (0.923–0.977)	< 0.001
Vitamin B6 / PLP	0.994 (0.990–0.998)	0.001
RBC folate	0.999 (0.998–1.000)	0.084

Dietary vitamin B12	0.922 (0.858–0.990)	0.025
Triglycerides	1.003 (1.001–1.005)	0.010
BMI	1.030 (0.996–1.066)	0.087
CRP $\geq$ 1 mg/dL (n = 39)		
Dietary fibre	0.945 (0.832–1.074)	0.388
Vitamin B6 / PLP	0.988 (0.968–1.008)	0.232
RBC folate	0.998 (0.995–1.001)	0.172
Dietary vitamin B12	0.771 (0.513–1.158)	0.210
Triglycerides	1.010 (1.001–1.020)	0.030
BMI	1.062 (0.991–1.139)	0.091

OR, odds ratio; CI, confidence interval; PLP, pyridoxal 5'-phosphate; RBC, red blood cell; BMI, body-mass index; CRP, C-reactive protein. Models are mutually adjusted for all six nutritional indicators listed. OR < 1 indicates that higher values of the indicator are associated with lower odds of being in a self-rated health category (protective); OR > 1 indicates higher odds of poorer health.

3.4. Stratified subgroup analyses

Subgroup analyses by CRP status showed that the favorable associations of fiber, vitamin B6 and vitamin B12 were confined largely to survivors with low systemic inflammation (CRP < 1 mg/dL; n = 269): fiber OR 0.950 ($p < 0.001$), vitamin B6 OR 0.994 ($p = 0.001$), vitamin B12 OR 0.922 ($p = 0.025$). In the elevated-CRP subgroup (n = 39), confidence intervals were wide, and the only indicator retaining significance was triglycerides (OR 1.010 per mg/dL; $p = 0.030$), consistent with inflammation acting as both a marker and a mediator of perceived health.

4. Discussion

In this nationally representative cross-sectional analysis of U.S. adult cancer survivors, we found that a more favorable nutritional profile, higher dietary fiber, higher circulating vitamin B6, higher dietary vitamin B12 (and a consistent protective trend for higher RBC folate), lower serum triglycerides and healthier BMI, was independently associated with better self-rated health. The associations were robust to mutual adjustment, exhibited monotonic dose-response relationships without obvious thresholds, and showed biologically plausible patterns of effect modification by sex and systemic inflammation. To our knowledge, this is among the first studies to jointly model dietary and circulating nutritional biomarkers against a patient-centered ordinal health outcome in cancer survivors using a population-representative sample.

Our findings are broadly consistent with, and extend, the existing literature. Higher dietary fiber intake has been associated with lower all-cause mortality and better quality of life, plausibly through modulation of the gut microbiome, attenuation of chronic low-grade inflammation and improved insulin sensitivity^[5]. The B vitamins share a common mechanistic axis, one-carbon metabolism, governing DNA synthesis, repair and methylation, and their deficiencies are well documented in cancer populations and linked to fatigue, anemia and neuropathy^[6,7]. Elevated triglycerides and higher BMI, in turn, are established correlates of metabolic syndrome and cardiovascular comorbidity. The independent association of overall nutritional status with cancer survivors' wellbeing and prognosis is further supported by guideline-based recommendations^[3]. Notably, the protective association of dietary fiber and vitamin B6 was statistically robust in female but not male survivors, which may reflect differences in dietary reporting, body composition and statistical power (fewer males were included), whereas the stronger inverse association of vitamin B12 in males may relate to sex differences in B12 absorption. These observations are hypothesis-generating and merit exploration in larger, sex-stratified cohorts.

The CRP subgroup analyses provide additional mechanistic insight. The favorable associations of fiber and B vitamins were most evident among survivors with low systemic inflammation (CRP < 1 mg/dL), whereas in the presence of elevated inflammation the nutritional signal was attenuated and only hypertriglyceridemia remained significantly associated with poorer health. This pattern is consistent with the well-established crosstalk between malnutrition and inflammation: systemic inflammation both drives anorexia and catabolism ("inflammation-mediated malnutrition") and blunts the health benefits of adequate nutrient intake, and aligns with the broader concept that CRP stratifies cancer survivors into biologically distinct prognostic phenotypes. From a clinical perspective, this suggests that inflammation

control may be a prerequisite for nutritional interventions to translate into perceived health benefits fully.

From a clinical and public-health perspective, our results reinforce the importance of routine nutritional assessment and counseling in cancer survivorship care. The identification of modifiable, easily measured indicators- fiber intake, B-vitamin status, triglycerides, and BMI- offers actionable targets for dietary and metabolic optimization, and integration of such nutritional strategies into survivorship care plans represents a low-cost, scalable complement to disease-directed therapy. Future research should confirm these cross-sectional observations in large, longitudinal cohorts with detailed clinical phenotyping, examine whether nutritional interventions can causally improve SRH and survival, and explore the mediating roles of the gut microbiome, one-carbon metabolism and systemic inflammation.

5. Conclusion

Among U.S. adult cancer survivors, higher dietary fiber, circulating vitamin B6 and dietary vitamin B12 (with a consistent protective trend for red-blood-cell folate), together with lower serum triglycerides and healthier body-mass index, were independently associated with better self-rated health in a dose-response manner. The associations were most robust in female survivors and in those with low systemic inflammation. These findings support nutritional and metabolic optimization as a pragmatic, modifiable strategy to improve perceived health in cancer survivorship and warrant confirmation in longitudinal and interventional studies.

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Disclosure statement

The authors declare no conflict of interest.

References

- [1] Idler E, Benyamini Y, 1997, Self-Rated Health and Mortality: A Review of Twenty-Seven Community Studies. *Journal of Health and Social Behavior*, 38(1): 21–37.
- [2] DeSalvo K, Bloser N, Reynolds K, et al., 2006, Mortality Prediction with a Single General Self-Rated Health Question: A Meta-Analysis. *Journal of General Internal Medicine*, 21(3): 267–275.
- [3] Arends J, Baracos V, Bertz H, et al., 2017, ESPEN Expert Group Recommendations for Action Against Cancer-Related Malnutrition. *Clinical Nutrition*, 36(5): 1187–1196.
- [4] Robison L, Demark-Wahnefried W, 2011, Cancer Survivorship: Focusing on Future Research Opportunities. *Cancer Epidemiology, Biomarkers & Prevention*, 20(10): 1994–1995.
- [5] Liu L, Wang S, Liu J, 2015, Fiber Consumption and All-Cause, Cardiovascular, and Cancer Mortalities: A Systematic Review and Meta-Analysis of Cohort Studies. *Molecular Nutrition & Food Research*, 59(1): 139–146.
- [6] Stabler S, 2013, Vitamin B12 Deficiency. *New England Journal of Medicine*, 368: 149–160.
- [7] Lyon P, Strippoli V, Fang B, et al., 2020, B Vitamins and One-Carbon Metabolism: Implications in Human Health and Disease. *Nutrients*, 12(9): 2867.
- [8] Centers for Disease Control and Prevention, National Center for Health Statistics, 2023, National Health and Nutrition Examination Survey.
- [9] Harrell F, 2015, Regression Modeling Strategies: With Applications to Linear Models, Logistic Regression, and Survival Analysis. 2nd ed. Springer.

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