

Nutrient Intakes in Prostate Cancer Survivors in the United States: A Nationally Representative Study

Maximilian Andreas Storz, Carla Schmidt & Alvaro Luis Ronco

To cite this article: Maximilian Andreas Storz, Carla Schmidt & Alvaro Luis Ronco (2025) Nutrient Intakes in Prostate Cancer Survivors in the United States: A Nationally Representative Study, *Nutrition and Cancer*, 77:2, 188-199, DOI: [10.1080/01635581.2024.2408766](https://doi.org/10.1080/01635581.2024.2408766)

To link to this article: <https://doi.org/10.1080/01635581.2024.2408766>



© 2024 The Author(s). Published with license by Taylor & Francis Group, LLC



[View supplementary material](#)



Published online: 06 Oct 2024.



[Submit your article to this journal](#)



Article views: 675



[View related articles](#)



[View Crossmark data](#)

Nutrient Intakes in Prostate Cancer Survivors in the United States: A Nationally Representative Study

Maximilian Andreas Storz^a , Carla Schmidt^a and Alvaro Luis Ronco^{b,c}

^aDepartment of Internal Medicine II, Center for Complementary Medicine, Medical Center - University of Freiburg, Faculty of Medicine, University of Freiburg, Germany; ^bUnit of Oncology and Radiotherapy, Pereira Rossell Women's Hospital, Montevideo, Uruguay; ^cBiomedical Sciences Center, University of Montevideo, Montevideo, Uruguay

ABSTRACT

There are currently more than 3.3 million prostate cancer (PC) survivors in the United States. Conformance with national dietary guidelines and a good diet quality may lower the risk for Gleason grade progression in PC patients. Assessing the nutritional status of PC survivors is thus of paramount importance from a public health nutrition perspective. We used 24-h dietary recall data from the National Health and Nutrition Examination Surveys (NHANES) to systematically estimate nutrient intakes in $n=360$ PC survivors (which may be extrapolated to represent $n=1,841,030$ PC survivors) aged 70.69 years on average, and contrasted the results to the daily nutritional goals (DNG) in the 2020–2025 Dietary Guidelines for Americans (DGA). Diet quality in PC survivors was found to be generally poor, and the DNG as specified in the DGA were not met for many micronutrients, including calcium, magnesium and potassium. PC survivors had an insufficient intake of many vitamins (including vitamins A, C, D and E), and did not meet the intake recommendations for dietary fiber. Racial disparities in PC were reflected in the lower overall DQ in Non-Hispanic Black participants. Our results reiterate the need for nutritional assessment and counseling to improve DQ in PC patients.

ARTICLE HISTORY

Received 10 July 2024
Accepted 20 September 2024

Background

Cancer continues to be the second most common cause of death in the United States (US) (1). According to the American Cancer Society (ACS), more than 1.9 million new cancer cases and 609,820 cancer deaths occurred in 2023 in the US alone (1). Following skin cancer, Prostate Cancer (PC) is the most common cancer in American men with 299,010 estimated new cases in 2024 (2). Behind lung cancer, PC is a leading cause of cancer death in American men (3).

PC death rates dropped by about 50% from 1993 to 2013, which can be attributed to advances in treatment and earlier detection. Five-year relative survival rates now exceed 99% for PC patients with a local or regional SEER (Surveillance, Epidemiology, and End Results) stage (4). PC survivorship has thus increased substantially within the last decades, and the ACS estimates that there are currently more than 3.3 million PC survivors in the US (2). As such, PC exerts

a tremendous toll on patients and their families as well as on healthcare systems and society (5).

In addition to stage-dependent classical treatments (active surveillance, prostatectomy, ablative radiotherapy, androgen deprivation therapy, chemotherapy), lifestyle modifications for PC survivors have received increasing attention within recent years (6, 7). The 2022 general ACS nutrition and physical activity guidelines emphasize that “diet, physical activity, and obesity may affect risk for recurrence and overall survival after a cancer diagnosis” (8).

According to the teachable moment heuristic, receiving a cancer diagnosis has the potential to serve as a powerful catalyst for health behavior change (9, 10). This might be of particular importance for PC survivors, who may additionally experience unfavorable side effects of the employed oncological therapies, e.g. androgen deprivation therapy (11). It is now widely accepted that cardiovascular disease, diabetes, as well as muscle and bone loss are important

CONTACT Maximilian Andreas Storz  maximilian.storz@uniklinik-freiburg.de  Department of Internal Medicine II, Centre for Complementary Medicine, Medical Center, University of Freiburg, Freiburg im Breisgau, Germany.

 Supplemental data for this article can be accessed online at <https://doi.org/10.1080/01635581.2024.2408766>.

© 2024 The Author(s). Published with license by Taylor & Francis Group, LLC

This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited. The terms on which this article has been published allow the posting of the Accepted Manuscript in a repository by the author(s) or with their consent.

comorbidities frequently encountered in PC survivors (12–14). Tailoring an individual's diet to address these comorbidities and to reduce cardiovascular risk factors is generally recommended.

Further to that, several studies suggested that nutrition has been directly associated with improved survival rates in selected PC populations (7, 8, 15). Adherence to a Western diet was associated with increased overall mortality (Hazard Ratio (HR)=1.67; 95% confidence interval (CI) 1.16 to 2.42) and prostate cancer-specific mortality (HR = 2.53; 95% CI 1.00 to 6.42) among non-metastatic prostate cancer survivors. Prudent diets, on the other hand, were inversely associated with overall mortality (Relative Risk (RR)=0.64; 95% CI 0.44 to 0.93) (16). Of note, the number of available studies in this particular field is limited, and with the exception of a study by Gregg et al., there is a paucity of data regarding dietary habits in PC survivors (17). The latter revealed that higher Diet Quality (DQ) and conformance with national dietary guidelines may lower the risk of Gleason grade progression in PC survivors – a finding that underscores the potential importance of nutrition and nutritional assessment in this particular population (17).

Considering the increasing number of PC survivors in the US and the associations between DQ and cancer survival, large-scale studies assessing diet quality in PC survivors are warranted. Analyzing data from the National Health and Nutrition Examination Surveys (NHANES), we systematically captured nutrient intake data of PC survivors in the US (18). The NHANES is a continuous program of studies that seeks to assess the health and nutritional status of the non-institutionalized US population (18). The survey's special complex, multistage, probability sampling design enables healthcare professionals to perform nationally-representative nutritional assessments (19).

Focusing on PC survivors, we estimated macro- and micronutrient intakes and used two nutrient-based diet quality scores that particularly focus on under-consumed nutrients (e.g. the Food Nutrient Index (FNI) and the Diet Quality Score (DQS) (20, 21)). The major aim was to contrast DQ in PC survivors to the 2020–2025 Dietary Guidelines for Americans (DGA) and to investigate conformance with national dietary recommendations (22). With this approach, we aimed to identify potential nutrients of concern in PC survivors, thereby raising awareness and pathing the way for targeted dietary recommendations.

Materials and Methods

The NHANES

The herein presented study on nutritional epidemiology in US PC survivors is based on population-based, cross-sectional data from the National Health and Nutrition Examination Surveys (18). The NHANES is an ongoing program which surveys approximately 10,000 people per cycle in 15 different counties across the United States (23). The NHANES includes both interview and examination data, ranging from socio-demographic information to health- and diet-related questions (24). Five consecutive NHANES cycles (2007/2008, 2009/2010, 2011/2012, 2013/2014, and 2015/2016) were appended for this analysis, to increase the potential sample size for analyses stratified by population subgroups (24). The National Center for Health Statistics (NCHS) research ethics review board approved the NHANES and all participants gave written informed consent to participate in the surveys (25).

Prostate Cancer History Assessment

Following the approach from one of our previous studies (24), cancer-related data was obtained from the NHANES medical conditions section. Said section included the question “Have you ever been told by a doctor or other health professional that you had cancer or a malignancy of any kind?”. Those participants replying with “Yes” were subsequently asked the following question: “What kind of cancer was it?”. Participants who reported “Prostate” were considered prostate cancer survivors, whereas those who reported no cancer diseases were considered “non-matched controls”. Prostate cancer survivor status was thus self-reported and not based on a medical record or other data.

Nutrient Intake Data Assessment

Nutrient intake data was obtained from the NHANES nutritional assessment section and based on a 24-h dietary recall interview (24). Dietary recall interviews were conducted face-to-face, in private rooms and with the help of specially trained dietary interviewers fluent in Spanish and English (26). Details on the nutritional assessment component may be found elsewhere (26). For this study, we only considered participants with a reliable dietary recall status, which implied that all relevant variables associated with the 24-h dietary recall contained a value. Apart from daily energy intake (kcal/d), the following macronutrients were

considered for this study: carbohydrate intake (in g/d and expressed as a percentage of the total energy intake), fat intake (in g/d and expressed as a percentage of the total energy intake), protein intake (in g/d and expressed as a percentage of the total energy intake). In addition to that, we estimated fiber intakes (in g/d) and saturated fat intake (in g/d and expressed as a percentage of the total energy intake). Moreover, we included the following minerals: calcium, magnesium, iron, phosphorus, potassium, sodium, and zinc (all reported in mg/d). As for the vitamins, we considered vitamin A (as retinol activity equivalents in mcg/d), vitamin E (as alpha-tocopherol in mg/d), vitamin D (in IU/d), vitamin C, thiamin, riboflavin, niacin, and vitamin B6 (all in mg/d), vitamin B12 (in mcg/d) and folate (as dietary folate equivalents in mcg/d). Other nutrients included were selenium (in mcg/d), choline (in mg/d), lycopene (in mcg/d) and caffeine (in mg/d). Crude and energy-adjusted intakes (nutrient intake/1000kcal) were estimated.

Nutrient intake data in prostate cancer survivors was contrasted to the intake recommendations found in the current DGA (22). Following established procedures (27,28), sex- and age-specific nutrient intake recommendations for males ≥ 51 years were extracted from the DGA appendix (Tables A1–A2 on pages 133–134) (22). All nutrients listed in Tables A1–A2 on pages 133–134 of the DGA were considered. The comparison was performed in a descriptive matter and considered prostate cancer survivors only. The DGA also emphasize several nutrients of public health concern (e.g. fiber, potassium, and calcium) (22), for which we estimated the weighted percentage of prostate cancer survivors who met the respective recommendation. As discussed earlier, the daily nutritional goals (DNG) in the DGA are based on various different sources (22, 27, 28). Source concepts include Adequate Intake (AI), Acceptable Macronutrient Distribution Range (AMDR), Chronic Disease Reduction Level (CDRR), Dietary Guidelines for Americans (DGA), and the Recommended Dietary Allowance (RDA) (22, 27, 28).

Assessment of Under-Consumed Nutrients

Following established procedures, two nutrient-based diet quality scores were used: the Diet Quality Score (DQS) (21), and the Food Nutrient Index (FNI) for the assessment of potentially *under-consumed* nutrients (20). Both scoring systems have been reviewed in detail earlier (20, 21, 29). They were deemed particularly suitable for this analysis since both are nutrient-based (and not food-based) and since the

DQS considers almost all nutrients listed in Tables A1–A2 on pages 133–134 of the DGA (22). The DQS aggregates 17 nutrients into an overall summary measure (21), whereas the FNI considers eight potentially under-consumed nutrients in the US (20). The FNI covers 4 vitamins (vitamins A, C, D, and E) as well as calcium, magnesium, potassium, and choline (20, 30). Eight nutrients are covered in total. The DQS covers the 3 macronutrients and saturated fat, eight vitamins (thiamin, riboflavin, niacin, vitamins A, B6, B12, C, and E) as well as phosphorus, magnesium, iron, zinc, and selenium (21, 29). Seventeen nutrients are covered in total. The DQS assesses the compliance with the Dietary References Intakes (DRIs) for these 17 nutrients (see Supplementary Table 1). Depending on whether the DRIs for a particular nutrient are met or not, a value of 0 or 1 is given. All values are then summed, resulting in an overall score ranging from 0 to 17 points. The higher the total score, the higher the DQ. As for the FNI, the overall score ranges from 0 to 100. FNI components are expressed as a percentage of the RDA or AI found in the DGA (see Supplementary Table 2) (20, 30). The higher the FNI, the higher the alignment with the DGA in terms of the examined *under-consumed* nutrients.

Covariates

Important covariates included sociodemographic data such as age (continuous variable, in years), race/ethnicity (categorical variable with the following categories: Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, Other Race), marital status (categorical variable: married or living with a partner, widowed/divorced/separated, never married), education level (categorical variable: less than 9th grade, 9–11th grade, high school graduate/general education diploma or equivalent, some college or associate degree, college graduate or above) and annual household income (categorical variable: $< \$20,000$ or $\geq \$20,000$). As for anthropometric data, we included the body mass index (BMI, continuous variable). Lifestyle factors included alcohol intake (categorical variable, assessed by the question “In any one year, have you had at least 12 drinks of any type of alcoholic beverage? By a drink, I mean a 12 oz. beer, a 5 oz. glass of wine, or one and half ounces of liquor.”) and smoking status (categorical variable, assessed by the question: “Have you smoked at least 100 cigarettes in your entire life?”). For descriptive purposes, we also obtained self-reported comorbidities from the NHANES medical conditions section.

Inclusion and Exclusion Criteria

Only NHANES participants with a complete dataset were included, implying no missing data on any variable of interest (see above). For a meaningful comparison to the DGA and in light of the typical age of prostate cancer occurrence, only male participants aged ≥ 51 years were considered for this analysis. Participants with missing or incomplete data were excluded from the analysis.

Statistical Analysis

The statistical analysis was performed in STATA 14 statistical software (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP). Appropriate survey commands (svyset and svy) were used with regard to the special NHANES survey design characteristics and population weights. A 10-year weight (2007–2016) for dietary data was constructed to obtain weighted percentages adjusted to the US adult population. While the analysis mainly focused on nutrient intake data in prostate cancer survivors and the comparison to the DGA, we also contrasted the results to the US general population aged 51 years or older without a previous diagnosis of cancer. Participants were not matched in the sense of a case-control study.

The statistical analysis followed previously established procedures [24]. Normally distributed continuous variables were shown with their mean and corresponding 95%-CI. For categorical variables we reported the number of unweighted observations (n) as well as the weighted proportion with its corresponding 95%-CI in parenthesis. The reliability of all estimated proportions was subsequently assessed with regard to the 2017 NCHS guidelines (31). Following previously established procedures [24], the user written Stata command “kg_nchs” was employed as part of the checking process (32). Proportions that did not meet the 2017 NCHS criteria were flagged appropriately.

For the comparison between PC survivors and the general population, we relied on regression analyses followed by adjusted Wald tests. Statistical significance was determined at $\alpha=0.05$. Associations between cancer survivorship status and categorical variables were assessed with Stata’s design-adjusted Rao-Scott test. Finally, we constructed multivariate regression models to predict DQS and FNI scores after adjustment for important covariates. Following regression, we used Stata’s marginsplots function to graph statistics from fitted models. Plots of marginal predicted values for

the FNI and DQS were generated separately. Considering the known racial disparities in prostate cancer burden (33), we also plotted marginal predicted values for both nutrient-based dietary scores depending on race/ethnicity.

Results

The final sample included 5,026 individuals, of which $n=362$ had a history of prostate cancer. Figure 1 displays the reasons for in- and exclusion. Table 1 displays sample characteristics. Prostate cancer survivors were on average 70.69 years old and overweight with a mean BMI of 28.77 kg/m². Significant associations between race/ethnicity and prostate cancer survivor status were observed, with Non-Hispanic Blacks being disproportionately affected by prostate cancer in comparison to the general population. For descriptive purposes, Supplementary Table 3 shows selected self-reported comorbidities in the examined sample.

Table 2 displays macronutrient and fiber intakes in males with a history of prostate cancer in comparison to the DGA. Intakes of all macronutrients were within the acceptable macronutrient distribution range, although fat intake was close to the upper limit of 35% of total energy intake. Mean protein intake in g/kg body weight was 0.98 in PC survivors and 1.04 in the general population (p for the between group difference: 0.100). Likewise, mean energy intake in kcal/kg body weight was 25.15 in PC survivors and 26.78 in the general population (p for the between group difference: 0.018). Mean saturated fat intake expressed as a percentage of total energy intake was higher as recommended by the DGA (11.50% vs <10%). Fiber intakes were well below the recommended intakes. PC survivors consumed on average 9.27 g of fiber/1000 kcal per day, whereas the DGA recommends an intake of at least 14 g/1000 kcal. When compared to the non-matched general population, PC survivors had a significantly lower total energy intake, possible due to the age differences in both groups.

Table 3 shows mineral and vitamin intakes in males with a history of prostate cancer in comparison to the DGA. As for the examined minerals, PC survivors did not meet the intake recommendations for calcium, magnesium and potassium. The chronic disease reduction level for sodium (2300 mg/d) was exceeded by prostate cancer survivors. PC survivors did not meet the daily nutritional goals for the following four vitamins: Vitamin A, vitamin C, vitamin D and vitamin E. When comparing crude nutrient intakes between PC survivors and the general population, statistically significant differences were found for magnesium,

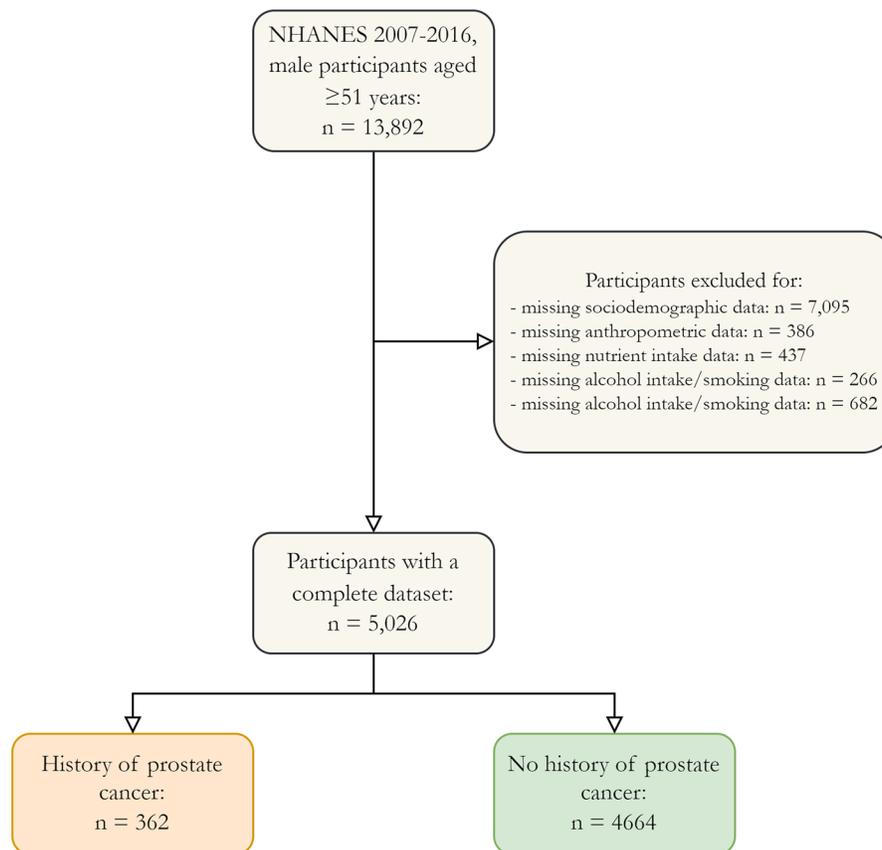


Figure 1. Participant inclusion flowchart.

phosphorus, sodium, niacin, selenium and caffeine. After energy-intake adjustments (nutrient intake/1000 kcal), however, very few differences remained statistically significant with a questionable clinical relevance (see [Supplementary Table 4](#)).

Nutrient-based diet quality scores in PC survivors are shown in [Table 4](#). Participants with a history of prostate cancer had an average DQS of 10.68 points (maximum: 17 points), suggesting a rather poor overall diet quality. The FNI analysis revealed a comparable picture. With 63.80 points on the FNI (maximum: 100 points), the intake of potentially *under-consumed* nutrients was also limited in this cohort. [Supplementary Table 5](#) takes a special look at nutrients of public health concern among prostate cancer survivors, summarizing the percentage of PC survivors who met the daily nutritional goals for calcium, magnesium, potassium and vitamin D. The highest weighted percentage was found for calcium 40.58% (33.73–47.82%), whereas only 12.19% (8.65–16.92%) and 28.32% (22.42–35.06%) of PC survivors met the intake recommendations for fiber and potassium, respectively. [Supplementary Table 6](#) displays weighted intake proportions of other nutrients for which the DNG were not met among prostate

cancer survivors. Of note, less than 25% of PC survivors met the intake recommendations for magnesium, sodium and vitamin E.

Marginal predicted values were graphed from multivariate linear regression models and are displayed in [Figure 2](#). PC survivors had significantly higher predicted FNI scores as compared to general population after adjustment for energy intake (and other covariates including race/ethnicity, age, marital status, iron intake, and caffeine intake). No differences were found for the DQS in a comparable model. [Figure 2](#) also shows marginal predicted values for the DQS and FNI depending on race/ethnicity. In both models, Non-Hispanic Blacks had a significantly lower overall diet quality when compared to Non-Hispanic Whites (reference group) and other races.

Discussion

In the herein presented study, we investigated nutrient intakes in PC survivors in comparison to national dietary guidelines, given that higher adherence to the DGA may be beneficial in PC survivors. Our results suggested an overall poor to moderate diet quality in

Table 1. Sample characteristics.

	General population <i>n</i> = 4664	Prostate cancer survivors <i>n</i> = 362	<i>p</i> Value
Mean age	62.15 [61.83–62.48]	70.69 [69.39–71.98]	<0.001*
Mean BMI	29.20 [28.86–29.53]	28.77 [27.99–29.54]	0.325*
Race/ethnicity			0.002**
Mexican American	<i>n</i> = 716 (6.02% [4.63–7.79%])	<i>n</i> = 19 (2.39% [1.51–3.77%])	<0.001
Other Hispanic	<i>n</i> = 499 (3.98% [3.09–5.10%])	<i>n</i> = 23 (2.47% [1.47–4.13%])	0.003
Non-Hispanic White	<i>n</i> = 2,005 (74.20% [70.92–77.23%])	<i>n</i> = 186 (74.39% [68.46–79.54%])	0.945
Non-Hispanic Black	<i>n</i> = 1,046 (9.70% [8.13–11.52%])	<i>n</i> = 115 (15.62% [12.03–20.05%])	0.001
Other Race ^b	<i>n</i> = 398 (6.11% [5.04–7.39%])	<i>n</i> = 19 (5.13% [2.54–10.09%]) ***	0.587
Education level			0.050**
Less than 9 th grade	<i>n</i> = 766 (7.65% [6.58–8.87%])	<i>n</i> = 39 (5.99% [4.11–8.66%])	0.156
9–11 th grade ^c	<i>n</i> = 682 (10.94% [9.46–12.62%])	<i>n</i> = 44 (8.14% [5.50–11.88%])	0.106
High school graduate ^d	<i>n</i> = 1,062 (23.02% [21.17–24.98%])	<i>n</i> = 70 (17.60% [12.73–23.83%])	0.056
Some college or AA degree	<i>n</i> = 1,115 (27.27% [25.33–29.31%])	<i>n</i> = 98 (29.59% [23.05–37.09%])	0.501
College graduate or above	<i>n</i> = 1,039 (31.12% [28.19–34.21%])	<i>n</i> = 111 (38.68% [31.16–46.79%])	0.045
Marital status			0.007**
Married or living with a partner	<i>n</i> = 3,265 (74.65% [72.53–76.66%])	<i>n</i> = 259 (74.75% [69.00–79.76%])	0.971
Divorced/separated/widowed	<i>n</i> = 1,065 (18.15% [16.39–20.07%])	<i>n</i> = 88 (22.37% [17.47–28.19%])	0.115
Never married	<i>n</i> = 334 (7.20% [5.90–8.76%])	<i>n</i> = 15 (2.87% [1.61–5.06%]) ***	<0.001
Alcohol consumption			0.122**
Yes	<i>n</i> = 843 (14.79% [13.39–16.31%])	<i>n</i> = 80 (18.84% [13.81–25.17%])	0.157
No	<i>n</i> = 3,821 (85.21% [83.69–86.61%])	<i>n</i> = 282 (81.16% [74.83–86.19%])	0.157
Smoking status			0.980**
Yes	<i>n</i> = 2,895 (59.77% [56.97–62.50%])	<i>n</i> = 218 (59.85% [53.58–65.82%])	0.980
No	<i>n</i> = 1,769 (40.23% [37.50–43.03%])	<i>n</i> = 144 (40.14% [34.18–46.42%])	0.980

Sample characteristics of prostate cancer survivors aged ≥ 51 years and the US general population aged ≥ 51 years. Table 1 is based on $n = 5,026$ observations. Categorical data is displayed as: $n = x$ (weighted proportion [95%-confidence interval]). Continuous data displayed as mean [95%-confidence interval]. The category "Other Race" also includes multi-racial. The category 9–11th grade also includes 12th grade with no diploma. * based on post-regression adjusted Wald tests; **based on Stata's Rao-Scott-T-test; *** indicates an unreliable proportion.

PC survivors, who consumed more saturated fatty acids and much less fiber than recommended in the DGA. Daily nutritional goals as specified in the DGA were not met for many important micronutrients, including calcium, magnesium and potassium. As for the examined vitamins, participants with a history of PC did not meet the daily nutritional goals for the following vitamins: Vitamin A, vitamin C, vitamin D and vitamin E.

Recent studies by Gregg et al. and Su et al. emphasized the paramount importance of nutrition in prostate cancer survivors (17, 34, 35). Gregg et al. prospectively investigated diet quality (defined *via* the Healthy Eating Index-2015) in relation to Gleason grade progression in men with newly diagnosed prostate cancer (Gleason score 6 or 7) who were enrolled on a biennial active surveillance monitoring regimen

at MD Anderson Cancer. The study included data from more than $n = 400$ prostate cancer patients. After adjustment for confounders and clinical factors, the authors observed an inverse association between baseline diet quality and Gleason grade progression (17). Consistent with previous investigations reporting associations between the Mediterranean diet and a reduction in cancer morbidity and mortality, the authors also observed a lower risk of Gleason grade progression in men on active surveillance following the Mediterranean diet (34). Su et al. recently provided additional data suggesting that an adequate nutrient intake may alter the risk of Gleason grade upgrading for men with PC on active surveillance (35). Using data from the Johns Hopkins prospective PC active surveillance cohort, the authors investigated said association in $n = 886$ men with a median follow-up of

Table 2. Macronutrient and fiber intake in males with a history of prostate cancer in comparison to the Dietary Guidelines for Americans.

Nutrient	General population <i>n</i> = 4664	Prostate cancer survivors <i>n</i> = 362	<i>p</i> Value	Source of goal	DGA M 51+	DNG met?
Energy intake (kcal/d)	2312.47 [2274.37–2350.58]	2116.53 [2009.14–2223.92]	0.001	DGA	2000	↑
Carbohydrates (%/kcal)	46.89 [46.44–47.35]	47.64 [46.01–49.27]	0.325	AMDR	45–65	
Carbohydrates (g)	267.71 [262.85–272.57]	248.75 [234.91–262.59]	0.011	RDA	130	↑
Carbohydrates (g/1000 kcal)	117.24 [116.09–118.38]	119.10 [115.03–123.18]	0.325			
Protein (%/kcal)	15.948 15.71–16.18	15.879 15.32–16.44	0.818	AMDR	10–35	
Protein (g)	90.10 [88.49–91.72]	83.01 [77.60–88.43]	0.017	RDA	56	↑
Protein (g/1000 kcal)	39.87 [39.29–40.46]	39.70 [38.30–41.10]	0.818			
Total lipid (%/kcal)	34.61 [34.17–35.04]	34.95 [33.66–36.23]	0.615	AMDR	20–35	
Total lipid (g)	90.63 [88.63–92.63]	83.50 [78.04–88.96]	0.018			
Total lipid (g/1000 kcal)	38.45 [37.97–38.94]	38.83 [37.40–40.26]	0.615			
Saturated fat (%/kcal)	11.10 [10.93–11.28]	11.50 [10.99–12.01]		DGA	<10	↑
Saturated fat (g)	29.19 [28.44–29.94]	27.57 [25.72–29.42]	0.111			
Saturated fat (g/1000 kcal)	12.34 [12.14–12.53]	12.78 [12.22–13.34]	0.135			
Fiber (g)	18.72 [18.11–19.32]	18.76 [17.57–19.94]	0.950	DGA	14g/ 1,000 kcal	↓
Fiber (g/1000 kcal)	8.45 [8.21–8.69]	9.27 [8.58–9.96]	0.034	DGA	14g/ 1,000 kcal	↓
18:2	18.16 [17.67–18.66]	16.29 [15.06–17.52]	0.008	AI	14	↑
18:3	1.88 [1.82–1.95]	1.72 [1.56–1.87]	0.050	AI	1.6	↑
Linolenic acid (g)						

Based on *n* = 5,026 observations. Data shown as means with their [95%-confidence interval]. The *p* values refer to differences in the examined nutrients between the general population and prostate cancer survivors; significant *p* values are displayed in bold. AMDR = Acceptable Macronutrient Distribution Range; DGA = Dietary Guidelines for Americans; DNG = Daily Nutritional Goal; RDA: Recommended Dietary Allowance; AI = Adequate Intake (based on DGA). Color legend: red = DGA goal not met; green = DGA goal met.

6.5 years. Hereby, an inverse association between dietary intakes of fiber from grains, grains, carbohydrates and Gleason grade upgrading was found (35).

Data from Su and Gregg independently highlighted that a higher adherence to national American dietary recommendations may reduce the risk of Gleason grade progression. Such data is of paramount importance from a public health nutrition perspective, considering that PC is among the leading causes of cancer deaths in American men (3), and considering the growing population of PC survivors in the US (2). The herein presented data may allow for further insights into the actual DQ of PC survivors in the United States. The low intake of fiber in PC survivors appears to be particularly worrisome. Fiber is a nutrient of public health concern in the US, with many proven benefits for human health (36). An inverse association between fiber intake and prostate cancer risk has been reported more than a decade ago (37,38). A more recent study by Liu et al. reinforced that a regular intake of fiber-rich plant foods may be

beneficial to PC survivors (39). Analyzing longitudinal data from more than *n* = 2062 men diagnosed with non-metastatic prostate cancer from a diet and lifestyle sub-study within the Cancer of the Prostate Strategic Urologic Research Endeavor (CaPSURE) cohort, the authors reported that the consumption of a primarily plant-based diet may be associated with better prostate cancer-specific health outcomes (39). As a consequence, Liu et al. suggested that nutritional assessment and counseling should be recommended to PC patients in order to build the foundation for healthy dietary practices that may contribute to well-being and overall health (39).

Our data reinforce and strengthen this call, emphasizing a low adherence to national dietary guidelines and a low intake of many nutrients of public health concern in most PC survivors (22). Fiber, which can only be found in plant foods, is of high clinical relevance in this context, as a regular intake may not only beneficially affect the prognosis but also the quality of life of PC patients (40, 41). Apart from fiber, many

Table 3. Mineral and vitamin intake in males with a history of prostate cancer in comparison to the Dietary Guidelines for Americans.

Nutrient	General population <i>n</i> = 4664	Prostate cancer survivors <i>n</i> = 362	<i>p</i> Value	Source of goal	DGA M 51+	DNG met?
Minerals						
Calcium (mg)	990.90 [963.34–1081.46]	939.27 [873.57–1004.96]	0.141	RDA	1000	↓
Iron (mg)	16.28 [15.84–16.72]	16.45 [15.59–17.32]	0.710	RDA	8	↑
Magnesium (mg)	333.95 [326.48–341.41]	313.26 [296.55–329.97]	0.030	RDA	420	↓
Phosphorus (mg)	1493.13 [1466.31–1519.95]	1400.75 [1314.37–1487.13]	0.045	RDA	700	↑
Potassium (mg)	3047.49 [2986.35–3108.63]	2889.32 [2729.63–3049.01]	0.066	AI	3400	↓
Sodium (mg)	3830.65 [3756.50–3904.80]	3459.52 [3239.10–3679.93]	0.002	CDRR	2300	↓
Zinc (mg)	12.85 [12.24–13.45]	12.38 [11.54–13.22]	0.388	RDA	11	
Vitamins						
Vitamin A (mcg RAE)	688.19 [637.93–738.46]	756.39 [688.61–824.16]	0.108	RDA	900	↓
Vitamin E (mg ATd)	9.19 [8.89–9.50]	8.86 [8.07–9.65]	0.441	RDA	15	↓
Vitamin D (IU)	212.25 [198.56–225.93]	204.38 [174.56–234.19]	0.623	RDA	600	↓
Vitamin C (mg)	87.50 [82.14–92.86]	88.21 [77.46–98.95]	0.901	RDA	90	↓
Thiamin (mg)	1.78 [1.74–1.82]	1.79 [1.63–1.95]	0.907	RDA	1.2	↑
Riboflavin (mg)	2.42 [2.35–2.48]	2.34 [2.18–2.49]	0.347	RDA	1.3	↑
Niacin (mg)	27.99 [27.43–28.55]	25.03 [23.48–26.58]	<0.001	RDA	16	↑
Vitamin B6 (mg)	2.27 [2.21–2.34]	2.14 [2.00–2.28]	0.120	RDA	1.7	↑
Vitamin B12 (mcg)	5.85 [5.33–6.38]	5.29 [4.84–5.73]	0.108	RDA	2.4	↑
Folate (mcg DFE)	576.23 [558.29–594.18]	558.10 [522.30–593.90]	0.368	RDA	400	↑
Others						
Selenium (mcg)	126.55 [123.69–129.41]	114.48 [106.96–121.99]	0.006			
Choline (mg)	387.65 [379.13–396.17]	372.73 [345.67–399.79]	0.305	AI	550	↓
Lycopene (mcg)	5893.85 [5410.16–6377.55]	4869.15 [3658.81–6079.49]	0.119			
Caffeine (mg)	238.00 [225.42–250.58]	183.48 [153.61–213.35]	0.001	DGA	<400	↓

Based on *n* = 5,026 observations. Data shown as means with the corresponding [95%-confidence interval]. The *p* values refer to differences in the examined nutrients between the general population and prostate cancer survivors; significant *p* values are displayed in bold. AMDR = Acceptable Macronutrient Distribution Range; DGA = Dietary Guidelines for Americans; DNG = Daily Nutritional Goal; RDA: Recommended Dietary Allowance; AI = Adequate Intake (based on DGA). CDRR = chronic disease reduction level. Color legend: red = DNG goal not met; green = DNG goal met.

Table 4. Crude nutrient-based diet quality scores in prostate cancer survivors in comparison to the general population.

Nutrient	General population <i>n</i> = 4664	Prostate cancer survivors <i>n</i> = 362	<i>p</i> value
FNI	62.83 [61.95–63.71]	63.80 [61.42–66.18]	0.437
DQS	10.76 [10.61–10.90]	10.68 [10.25–11.11]	0.730

Based on *n* = 5,026 observations. Data shown as means with the corresponding [95%-confidence interval]. The *p* values refer to differences in the examined nutrients between the general population and prostate cancer survivors; significant *p* values are displayed in bold. FNI = Food Nutrient Index. DQS = Diet Quality Score.

prostate cancer survivors consumed insufficient amounts of calcium and potassium, which can be readily found in plant foods. The low intake of potassium

(only 28.32% of PC survivors met the daily nutritional goal) is particularly concerning, and also suggests a low overall intake of plant foods in this cohort. The low intake of plant foods and conformance with national dietary guidelines is also concerning with regard to other comorbidities frequently encountered in PC survivors. Improving fiber intake and reducing saturated fat intake may also be beneficial for cardiovascular and metabolic health in PC survivors (42).

Further to that, our data may help to identify other nutrients of concern in PC survivors, e.g. when it comes to the intakes of several vitamins. A reservation must be made, however, that our results do not suggest large dietary differences when compared to the general

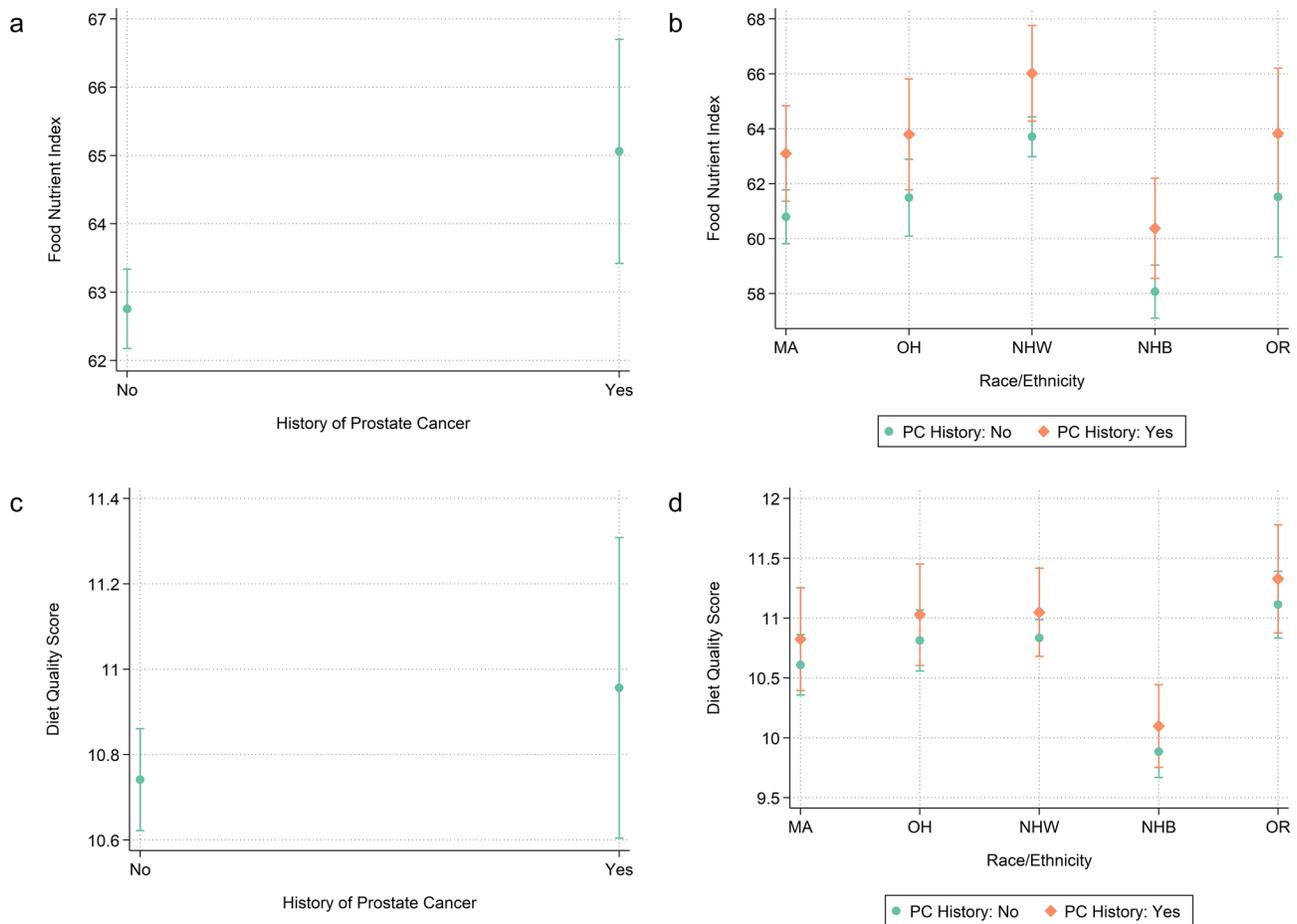


Figure 2. Marginsplots: Predictive margins for the Food Nutrient Index (top row) and Diet Quality Score (bottom row). a = Plot of marginal predicted values for the FNI based on a multivariable regression model adjusting for race/ethnicity (categorical), age (continuous), energy intake (continuous), marital status (categorical), iron intake (continuous), and caffeine intake (continuous). The FNI between both groups differed significantly at a p value of 0.007. b = plot of marginal predicted values for the FNI, illustrating differences in the relationship of the FNI and prostate cancer history (no/yes) depending on race/ethnicity. The FNI of NHB was significantly lower (-5.637 [-6.84--(4.44)]) as compared to NHW at a p value of <0.001. c = Plot of marginal predicted values for the DQS based on a multivariable regression model adjusting for race/ethnicity (categorical), age (continuous), energy intake (continuous), marital status (categorical), and caffeine intake (continuous). d = plot of marginal predicted values for the DQS, illustrating differences in the relationship of the DQS and prostate cancer history (no/yes) depending on race/ethnicity. The DQS of NHB was significantly lower (-0.95 [-1.21--(0.69)]) as compared to NHW at a p value of <0.001. MA = Mexican American; OH = Other Hispanic; NHW = Non-Hispanic White; NHB = Non-Hispanic Black; OR = Other Race.

US population. Minor differences between PC survivors and the general population were only found after (multivariate) energy adjustments. Nutrients which generally fall short on a typical American diet are also the main nutritional topic for PC survivors, who, according to our data, have much room for improvement when it comes to nutrient intakes. While not a primary outcome, our data also reinforce the existing racial disparities in PC (33). Racial/ethnic differences in diet quality may affect Non-Hispanic Blacks disproportionately (43), and our data revealed lower DQS and FNI scores in Non-Hispanic Blacks when compared to other ethnicities. This may reflect a lower intake of critical and under-consumed nutrients in Non-Hispanic Blacks. The lower DQ could have contributed to the higher burden of PC in said population, however, our study design does allow for any causal inferences here.

To a certain degree, our data also suggest some sort of stagnation when it comes to the DQ of PC survivors. Almost 10 years ago, Zhang and colleagues also used NHANES data to evaluate dietary intakes and diet quality in 1,533 US cancer survivors (44). Their analysis was built on NHANES cycles from 1999 to 2010, and also suggested that cancer survivors generally did not meet the daily nutritional goals in the American dietary guidelines (see Figure 2 in the original publication by Zhang et al. (44)). Many nutrients that were deemed critical in our analysis were already *under-consumed* in the older NHANES cycles as suggested by Zhang et al. (44). While differences in the study methodologies do not allow for a 1:1 comparison, one could assume a stagnating intake of many important nutrients from plants (potassium, fiber, magnesium). From a public health nutrition

perspective, a lot of work is to be done. And the call from Liu et al. toward a better and more frequent nutritional assessment and counseling in prostate cancer patients is more topical than ever before (39).

In summary, key findings suggested by our study are as follows: (1) DQ in prostate cancer survivors in the US is improvable, with an overall low alignment with the daily nutritional goals in the DGA. (2) Nutrients of concern in PC survivors do generally not differ from the general male US population, with low intakes of fiber, potassium and magnesium. (3) Racial disparities in PC are reflected in the lower overall DQ in Non-Hispanic Black participants, who have the lowest predicted overall DQ when compared to all other ethnicities.

This investigation has several strengths and limitations that warrant further discussion. Strengths include the large and nationally representative cohort of prostate cancer survivors (NHANES), which may be extrapolated to represent $n = 1,841,030$ PC survivors. The head-to-head comparison with established dietary guidelines and the usage of two validated nutrient-based diet quality scores is an additional plus. The analyzed data is not confined to a single institution (e.g. a specific cancer center) but was drawn from counties all over the US. As for the weaknesses, we acknowledge the lack of PC-specific parameters (e.g. the Gleason grading). This information would have been valuable to allow for a more detailed description of cancer cases, and for potential correlations with DQ. Discussing these parameters in the context of the DGA alignment would have certainly enriched our study. Unfortunately, such specific data was not available in the examined NHANES cycles. Moreover, PC status was self-reported which could theoretically lead to bias. While the absence of matching methods as in the context of a case-control study could also be seen as a limitation, it is important to note that such an approach would be impractical considering the unique NHANES design. Then again, the major aim of this study was to compare nutrient intakes in PC survivors to the DGA. For this reason, we considered nutrients from foods only; supplements were not considered. This may also be interpreted as another drawback. The analysis of food groups contributing to the inadequate intake of certain nutrients (e.g. fiber or saturated fat) will be subject to future work.

Our results suggest a poor conformance with national dietary guidelines in US PC survivors, and reiterate that regular nutritional assessment and counseling in prostate cancer patients could be of utmost importance, particularly in light of the increasing number of PC survivors in the US. From a public

health nutrition perspective DQ in PC survivors aligns poorly with national guidelines, emphasizing the need for additional educational work in this area.

Authors' Contributions

Conceptualization: M.A.S.; data curation: M.A.S.; formal analysis: M.A.S. and C.S.; funding acquisition: M.A.S.; investigation: M.A.S. and A.L.R.; methodology: M.A.S. and A.L.R.; project administration: M.A.S. and A.L.R.; resources: M.A.S.; software: M.A.S.; supervision: M.A.S. and A.L.R.; validation: M.A.S. and A.L.R.; visualization: M.A.S.; writing – original draft: M.A.S.; writing – review & editing: M.A.S. and A.L.R.

Availability of Data and Materials

Data are publicly available online (<https://www.cdc.gov/nchs/nhanes/Default.aspx>). The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Acknowledgments

We would like to thank the Wissenschaftliche Gesellschaft in Freiburg for providing us with the Stata software to perform the analysis.

Disclosure Statement

This work has not been published before; it is not under consideration for publication anywhere else. This work been approved by all coauthors. The authors declare that they have no competing interests.

Ethics Approval and Consent to Participate

NHANES was approved by the National Center for Health Statistics research ethics review board and informed consent was obtained for all participants (<https://www.cdc.gov/nchs/nhanes/irba98.htm>).

Funding

The authors received no financial support/funding. Open access publishing enabled by Project DEAL.

ORCID

Maximilian Andreas Storz  <http://orcid.org/0000-0003-3277-0301>

References

1. American Cancer Society. Cancer facts & figures cancer; 2023 [accessed 2024 Jun 29]. <https://www.cancer.org/research/cancer-facts-statistics/all-cancer-facts-figures/2023-cancer-facts-figures.html>.

2. American Cancer Society. Key statistics for prostate cancer [Internet]; 2024 [accessed 2024 Jun 24]. <https://www.cancer.org/cancer/types/prostate-cancer/about/key-statistics.html>.
3. American Cancer Society. Cancer facts for men | common cancers in men [Internet]; 2024 [accessed 2024 Jul 6]. <https://www.cancer.org/cancer/risk-prevention/understanding-cancer-risk/cancer-facts/cancer-facts-for-men.html>.
4. American Cancer Society. Survival rates for prostate cancer [Internet]; 2024 [accessed 2023 Jun 29]. <https://www.cancer.org/cancer/types/prostate-cancer/detection-diagnosis-staging/survival-rates.html>.
5. Coughlin SS. A review of social determinants of prostate cancer risk, stage, and survival. *Prostate Int*. 2020;8(2):49–54. doi: [10.1016/j.pnil.2019.08.001](https://doi.org/10.1016/j.pnil.2019.08.001)
6. Rebello RJ, Oing C, Knudsen KE, Loeb S, Johnson DC, Reiter RE, Gillesen S, Van der Kwast T, Bristow RG. Prostate cancer. *Nat Rev Dis Primers*. 2021;7(1):9. doi: [10.1038/s41572-020-00243-0](https://doi.org/10.1038/s41572-020-00243-0).
7. Rawla P. Epidemiology of prostate cancer. *World J Oncol*. 2019;10(2):63–89. doi: [10.14740/wjon1191](https://doi.org/10.14740/wjon1191)
8. Rock CL, Thomson CA, Sullivan KR, Howe CL, Kushi LH, Caan BJ, Neuhaus ML, Bandera EV, Wang Y, Robien K, et al. American Cancer Society nutrition and physical activity guideline for cancer survivors. *CA Cancer J Clin*. 2022;72(3):230–62. doi: [10.3322/caac.21719](https://doi.org/10.3322/caac.21719)
9. Puleo GE, Borger T, Bowling WR, Burris JL. The state of the science on cancer diagnosis as a “teachable moment” for smoking cessation: a scoping review. *Nicotine Tob Res*. 2021;24(2):160–8. doi: [10.1093/ntr/ntab139](https://doi.org/10.1093/ntr/ntab139).
10. Lee AS, Ozakinci G, Leung S, Humphris G, Dale H, Hamlet N. Lifestyle change in the cancer setting using ‘the teachable moment’: protocol for a proof-of-concept pilot in a urology service. *Pilot Feasibility Stud*. 2016;2(1):65. doi: [10.1186/s40814-016-0102-y](https://doi.org/10.1186/s40814-016-0102-y).
11. Michaelson MD, Cotter SE, Gargollo PC, Zietman AL, Dahl DM, Smith MR. Management of complications of prostate cancer treatment. *CA Cancer J Clin*. 2008;58(4):196–213. doi: [10.3322/CA.2008.0002](https://doi.org/10.3322/CA.2008.0002).
12. Appukkuttan S, Patel B, Parkin J, Jaffe DH, Wright J, Cyhaniuk A. Physician-reported comorbidities and treatment management in patients with non-metastatic castration-resistant prostate cancer. *J Clin Oncol*. 2020;38(29_suppl):149. doi: [10.1200/JCO.2020.38.29_suppl.149](https://doi.org/10.1200/JCO.2020.38.29_suppl.149).
13. Ng HS, Koczwara B, Roder D, Vitry A. Development of comorbidities in men with prostate cancer treated with androgen deprivation therapy: an Australian population-based cohort study. *Prostate Cancer Prostatic Dis*. 2018;21(3):403–10. doi: [10.1038/s41391-018-0036-y](https://doi.org/10.1038/s41391-018-0036-y).
14. Ahad A, Ejaz A, Fatima E, Sultan W, Ahmad O, Jamil A, Iqbal J, Ullah I, Alraies MC, Minhas AMK. Rising mortality related to cardiovascular disease and prostate cancer amongst older men across the United States. *Curr Probl Cardiol*. 2024;49(11):102785. doi: [10.1016/j.cpcardiol.2024.102785](https://doi.org/10.1016/j.cpcardiol.2024.102785).
15. Jochems SHJ, Van Osch FHM, Bryan RT, Wesselius A, van Schooten FJ, Cheng KK, Zeegers MP. Impact of dietary patterns and the main food groups on mortality and recurrence in cancer survivors: a systematic review of current epidemiological literature. *BMJ Open*. 2018;8(2):e014530. doi: [10.1136/bmjopen-2016-014530](https://doi.org/10.1136/bmjopen-2016-014530)
16. Yang M, Kenfield SA, Van Blarigan EL, Batista JL, Sesso HD, Ma J, Stampfer MJ, Chavarro JE. Dietary patterns after prostate cancer diagnosis in relation to disease-specific and total mortality. *Cancer Prev Res (Phila)*. 2015;8(6):545–51. doi: [10.1158/1940-6207.CAPR-14-0442](https://doi.org/10.1158/1940-6207.CAPR-14-0442)
17. Gregg JR, Zheng J, Lopez DS, Reichard C, Browman G, Chapin B, Kim J, Davis J, Daniel CR. Diet quality and Gleason grade progression among localised prostate cancer patients on active surveillance. *Br J Cancer*. 2019;120(4):466–71. doi: [10.1038/s41416-019-0380-2](https://doi.org/10.1038/s41416-019-0380-2)
18. NHANES – About the National Health and Nutrition Examination Survey [Internet]. 2024. [accessed 2024 Jun 6]. https://www.cdc.gov/nchs/nhanes/about_nhanes.htm.
19. Ahluwalia N, Dwyer J, Terry A, Moshfegh A, Johnson C. Update on NHANES Dietary Data: focus on collection, release, analytical considerations, and uses to inform public policy. *Adv Nutr*. 2016;7(1):121–34. doi: [10.3945/an.115.009258](https://doi.org/10.3945/an.115.009258)
20. Cowan AE, Bailey RL, Jun S, Dodd KW, Gahche JJ, Eicher-Miller HA, Guenther PM, Dwyer JT, Potischman N, Bhadra A, et al. The total Nutrient Index is a useful measure for assessing total micronutrient exposures among US adults. *J Nutr*. 2022;152(3):863–71. doi: [10.1093/jn/nxab428](https://doi.org/10.1093/jn/nxab428)
21. Fitzgerald AL, Dewar RA, Veugelers PJ. Diet quality and cancer incidence in Nova Scotia, Canada. *Nutr Cancer*. 2002;43(2):127–32. doi: [10.1207/S15327914NC432_2](https://doi.org/10.1207/S15327914NC432_2)
22. Dietary Guidelines for Americans [Internet]. [accessed 2024 Jul 6]. <https://www.dietaryguidelines.gov/>.
23. NHANES – Participants – About [Internet]. 2024 [accessed 2024 Jul 6]. <https://www.cdc.gov/nchs/nhanes/participant/participant-about.htm>.
24. Storz MA, Ronco AL. Quantifying dietary acid load in U.S. cancer survivors: an exploratory study using NHANES data. *BMC Nutr*. 2022;8(1):43. doi: [10.1186/s40795-022-00537-4](https://doi.org/10.1186/s40795-022-00537-4).
25. NHANES – NCHS Research Ethics Review Board Approval [Internet]. 2022 [accessed 2024 Jul 6]. <https://www.cdc.gov/nchs/nhanes/irba98.htm>.
26. NHANES – Measuring Guides [Internet]. 2019 [accessed 2024 Jul 6]. https://www.cdc.gov/nchs/nhanes/measuring_guides_dri/measuringguides.htm.
27. Storz MA, Ronco AL. How well do low-PRAL diets fare in comparison to the 2020–2025 dietary guidelines for Americans? *Healthcare (Basel)*. 2023;11(2):180. doi: [10.3390/healthcare11020180](https://doi.org/10.3390/healthcare11020180).
28. Storz MA, Ronco AL. Nutrient intake in low-carbohydrate diets in comparison to the 2020–2025 dietary guidelines for Americans: a cross-sectional study. *Br J Nutr*. 2022;129(6):1–14. doi: [10.1017/S0007114522001908](https://doi.org/10.1017/S0007114522001908).
29. Storz MA. Does self-perceived diet quality align with nutrient intake? A cross-sectional study using the Food Nutrient Index and Diet Quality Score. *Nutrients*. 2023;15(12):2720. doi: [10.3390/nu15122720](https://doi.org/10.3390/nu15122720).
30. Cowan AE, Jun S, Tooze JA, Dodd KW, Gahche JJ, Eicher-Miller HA, Guenther PM, Dwyer JT, Potischman N, Bhadra A, et al. A narrative review of nutrient based indexes to assess diet quality and the proposed total nutrient index that reflects total dietary expo-

- sures. *Crit Rev Food Sci Nutr.* 2023;63(12):1722–32. doi: [10.1080/10408398.2021.1967872](https://doi.org/10.1080/10408398.2021.1967872).
31. Parker JD, Talih M, Malec DJ, Beresovsky V, Carroll M, Gonzalez JF, Hamilton BE, Ingram DD, Kochanek K, McCarty F, et al. National center for health statistics data presentation standards for proportions. *Vital Health Stat 2.* 2017;(175):1–22.
 32. Ward BW. `kg_nchs`: a command for Korn-Graubard confidence intervals and National Center for Health Statistics' Data Presentation Standards for Proportions. *Stata J.* 2019;19(3):510–22. doi: [10.1177/1536867X19874221](https://doi.org/10.1177/1536867X19874221).
 33. Hansen M, Hamieh NM, Markt SC, Vaselkiv JB, Pernar CH, Gonzalez-Feliciano AG, Peisch S, Chowdhury-Paulino IM, Rencsok EM, Rebbeck TR, et al. Racial disparities in prostate cancer: evaluation of diet, lifestyle, family history, and screening patterns. *Cancer Epidemiol Biomark Prev.* 2022;31(5):982–90. doi: [10.1158/1055-9965.EPI-21-1064](https://doi.org/10.1158/1055-9965.EPI-21-1064).
 34. Gregg JR, Zhang X, Chapin BF, Ward JF, Kim J, Davis JW, Daniel CR. Adherence to the Mediterranean diet and grade group progression in localized prostate cancer: an active surveillance cohort. *Cancer.* 2021;127(5):720–8. doi: [10.1002/cncr.33182](https://doi.org/10.1002/cncr.33182).
 35. Su ZT, Mamawala M, Landis PK, De La Calle CM, Shivappa N, Wirth M, Hébert JR, Pavlovich CP, Trock BJ. PD26-06 association between diet and nutrient intake and upgrading in men with prostate cancer on active surveillance. *J Urol [Internet].* 2024;211. doi: [10.1097/01.JU.0001008556.20565.76.06](https://doi.org/10.1097/01.JU.0001008556.20565.76.06).
 36. Storz MA. Nutrition facts labels: who is actually reading them and does it help in meeting intake recommendations for nutrients of public health concern? *BMC Public Health.* 2023;23(1):1947. doi: [10.1186/s12889-023-16859-2](https://doi.org/10.1186/s12889-023-16859-2).
 37. Loeb S, Fu BC, Bauer SR, Pernar CH, Chan JM, Van Blarigan EL, Giovannucci EL, Kenfield SA, Mucci LA. Association of plant-based diet index with prostate cancer risk. *Am J Clin Nutr.* 2022;115(3):662–70. doi: [10.1093/ajcn/nqab365](https://doi.org/10.1093/ajcn/nqab365).
 38. Deschasaux M, Pouchieu C, His M, Hercberg S, Latino-Martel P, Touvier M. Dietary total and insoluble fiber intakes are inversely associated with prostate cancer risk. *J Nutr.* 2014;144(4):504–10. doi: [10.3945/jn.113.189670](https://doi.org/10.3945/jn.113.189670).
 39. Liu VN, Van Blarigan EL, Zhang L, Graff RE, Loeb S, Langlais CS, Cowan JE, Carroll PR, Chan JM, Kenfield SA. Plant-based diets and disease progression in men with prostate cancer. *JAMA Netw Open.* 2024;7(5):e249053. doi: [10.1001/jamanetworkopen.2024.9053](https://doi.org/10.1001/jamanetworkopen.2024.9053).
 40. Ornish D, Weidner G, Fair WR, Marlin R, Pettengill EB, Raisin CJ, Dunn-Emke S, Crutchfield L, Jacobs FN, Barnard RJ, et al. Intensive lifestyle changes may affect the progression of prostate cancer. *J Urol.* 2005;174(3):1065–70. doi: [10.1097/01.ju.0000169487.49018.73](https://doi.org/10.1097/01.ju.0000169487.49018.73).
 41. Loeb S, Hua Q, Bauer SR, Kenfield SA, Morgans AK, Chan JM, Van Blarigan EL, Shreves AH, Mucci LA. Plant-based diet associated with better quality of life in prostate cancer survivors. *Cancer.* 2024;130(9):1618–28. doi: [10.1002/cncr.35172](https://doi.org/10.1002/cncr.35172).
 42. Satija A, Hu FB. Plant-based diets and cardiovascular health. *Trends Cardiovasc Med.* 2018;28(7):437–41. doi: [10.1016/j.tcm.2018.02.004](https://doi.org/10.1016/j.tcm.2018.02.004).
 43. Wang Y, Chen X. How much of racial/ethnic disparities in dietary intakes, exercise, and weight status can be explained by nutrition- and health-related psychosocial factors and socioeconomic status among US adults? *J Am Diet Assoc.* 2011;111(12):1904–11. doi: [10.1016/j.jada.2011.09.036](https://doi.org/10.1016/j.jada.2011.09.036).
 44. Zhang FF, Liu S, John E, Must A, Demark-Wahnefried W. Diet quality of cancer survivors and non-cancer individuals: results from a national survey. *Cancer.* 2015;121(23):4212–21. doi: [10.1002/cncr.29488](https://doi.org/10.1002/cncr.29488).