Title
Lower Urinary Tract Symptoms and Diet Quality: Findings From the 2000-2001 National Health and Nutrition Examination Survey

Journal
Urology, 79(6)

ISSN
0090-4295

Authors
Erickson, Bradley A
Vaughan-Sarrazin, Mary
Liu, Xin
et al.

Publication Date
2012-06-01

DOI
10.1016/j.urology.2012.03.004

Peer reviewed

Lower Urinary Tract Symptoms and Diet Quality: Findings From the 2000-2001 National Health and Nutrition Examination Survey

Bradley A. Erickson, Mary Vaughan-Sarrazin, Xin Liu, Benjamin N. Breyer, Karl J. Kreder, and Peter Cram

OBJECTIVE To evaluate the association between dietary quality and the prevalence of lower urinary tract symptoms (LUTS).

METHODS We used urinary symptom and dietary data obtained from the 2000-2001 National Health and Nutrition Examination Survey (NHANES) for the study. Dietary quality was assessed using the 10-component United States Department of Agriculture (USDA) Healthy Eating Index (HEI). We used bivariate methods to examine rates of LUTS among men with poor versus good diets. Multivariable logistic regression was used to calculate odds ratios after applying sample weights and controlling for age, race/ethnicity, smoking status, diabetes, alcohol intake, and exercise.

RESULTS Our study cohort consisted of 1385 men aged ≥40 years, of whom 279 (21.1%) reported LUTS. We found higher rates of LUTS among men with poor dietary intake of dairy (22.4% vs 16.4%, P = .013) and among men with poor intake of protein (24.6% vs 17.9%, P = .012) as well as among those with overall poor diet (25.8 vs 17.8%, P = .018) with little dietary variety (26.1 vs 17.6%, P = .001). On multivariate analysis, an unhealthy diet (odds ratios [OR] = 1.7; 95% confidence interval [CI] = 1.05-2.90) was associated with more LUTS, whereas alcohol intake was protective from LUTS (OR = 0.67; 95% CI = 0.48-0.93).

CONCLUSION In an analysis of NHANES data, we found that poor diet quality was independently associated with patient-reported LUTS. UROLOGY 79: 1262–1267, 2012. Published by Elsevier Inc.

Investigators are increasingly interested in the relationship between environmental/lifestyle factors and urinary symptoms. For example, obesity, stress,[1] and type II diabetes, all linked to lifestyle, also appear to be associated with an increased the risk of developing lower urinary tract symptoms (LUTS).[2] Conversely, a healthier lifestyle with higher levels of exercise and moderate drinking, appear to decrease the risk of lower urinary tract symptoms (LUTS[3]). Although the causal pathway remains uncertain, it has been hypothesized that a healthier lifestyle may lower the incidence of LUTS through the effect on sympathetic tone,[4] androgen levels,[5,6] and inflammation.[7]

The relationship between our individual diets, perhaps our most modifiable and unique lifestyle factor, and urinary symptoms remains ill defined. Although clinicians commonly hypothesize an association between the typical American diet and LUTS,[8] empirical data are limited, with most of the existing studies reaching inconclusive or contradictory findings.[8-10] The goal of this study was to examine the relationship between diet and LUTS using data from the 2001-2002 National Health and Nutrition Examination Survey (NHANES). We hypothesized that a healthy balanced diet would be associated with fewer urinary symptoms.

MATERIAL AND METHODS

NHANES 2000-2001

The NHANES is an annual cross-sectional survey of the US population designed to collect information on the overall health status of Americans. The survey uses a clustered probability sample design, and deliberately oversamples Mexican Americans, non-Hispanic blacks, and elderly persons.[4] NHANES data are subsequently de-identified and made publicly available for analysis. The 2000-2001 dataset was chosen

Financial Disclosure: *The authors declare that they have no relevant financial interests.*

From the Department of Urology, Roy J. and Lucille A. Carver College of Medicine, University of Iowa, Iowa City, Iowa; Division of General Internal Medicine, Department of Internal Medicine, Roy J. and Lucille A. Carver College of Medicine, University of Iowa, Iowa City, Iowa; and Department of Urology, University of California–San Francisco, San Francisco, California

Reprint requests: Bradley A. Erickson, M.D., Department of Urology, University of Iowa, 200 Hawkins Drive, 3 Royal College of Physicians (RCP), Iowa City, IA 52246. E-mail: Brad-erickson@uiowa.edu

Submitted: December 22, 2011, accepted (with revisions): March 2, 2012

0090-4295/12/$36.00
http://dx.doi.org/10.1016/j.urology.2012.03.004

because of the ability to easily link subject data to the USDA Healthy Eating Index (HEI) data described below.

Urinary Symptoms. Information on our outcome of interest, patient reported LUTS, was obtained from two questions used in NHANES that was asked to all men aged 40 and older: (1) "Do you usually have trouble trying to urinate?" and (2) "Does your bladder feel empty after urinating?" Women were not asked these questions in the NHANES and were therefore excluded from analysis. Data from a third question, "Have you ever been diagnosed with enlargement of your prostate due to benign prostatic hyperplasia (BPH)?" was analyzed independently, but was not included in the LUTS definition because an "enlarged prostate diagnosis" does not always equate with LUTS. Possible answers to these questions included yes, no, refuse to answer, or do not know.

NHANES Dietary Questionnaire/Health Eating Index. Each NHANES respondent completed a 24-hour dietary recall questionnaire, which provides detailed information on each respondent's previous day's food intake; these data are broken down into nutrient components (ie, protein, carbohydrate, fat). Specifically, the United States Department of Agriculture (USDA) uses the raw data reported by each subject to produce HEI scores for all participants using an NHANES specific formula.[11] We combined the NHANES and USDA data to allow for the current analyses.

The HEI evaluates the degree of each respondent's conformance to federal dietary guidelines.[12] The overall HEI score represents the sum of 10 separate dietary component scores; each component is equally weighted and scored from 0 (poorest dietary compliance) to 10 (highest dietary compliance), with the maximum overall score being 100 (perfect USDA diet). Of the 10 components, 5 measure the degree to which participants conform to serving recommendations of the 5 major food groups, including grains, vegetables, fruits, dairy, and meat (protein) relative to ideal body weight. Four components are based on the percentage of the total daily calories attributable to fat, saturated fat, and total cholesterol as well as sodium intake and a measure of overall variety found in the diet. The final component evaluates the variety in the diet. The criteria for scoring can be found in Appendix 1 and 2.

Patient Population. All men over the age of 40 years who had completed both the prostate/urinary symptoms and dietary sections of the survey were included in the study. We excluded men who reported a history of prostate cancer because such a diagnosis (and associated treatment) could mirror the symptoms of LUTS, thus confounding our analysis. NHANES data did not allow for exclusion of men that may have had LUTS because of conditions, such as interstitial cystitis or chronic prostatitis.

Data Analysis. We used bivariate methods (*t* test for continuous measures, analysis of variance [ANOVA] for categorical) to compare the demographics and diet among patients who did and did not report any LUTS. For the purposes of these analyses, a patient was considered to have LUTS if he answered "yes" to either of the symptom questions described previously (difficulty voiding and/or bladder feels empty).

To evaluate dietary data, we first compared the mean HEI dietary score for each of the 10 individual subscales and the overall HEI score among respondents with and without LUTS. We then stratified respondents into 3 HEI dietary categories based on a method that has been used previously[12]: poor (total score <50; component score <5); need improvement (total score 50-80; component score 5-8); and good (total score >80, component score ≥8). We again used bivariate methods to compare the prevalence of LUTS in each of the three dietary groups with an expectation of a reduced rate of symptoms with progressively improved diet.

We used logistic regression models to examine the relationship between having LUTS and diet while accounting for previously described nondietary LUTS risk factors.[13,14] In these models, the outcome of interest was a patient-level variable (LUTS yes/no), whereas the independent variable of interest was diet. Dietary data were evaluated as tertile of dietary quality (tertile 1 = lowest score, tertile 3 = highest score); all odds ratios were reported relative to tertile 3 (those patients with the best diet). Factors used in risk adjustment included age (<60, ≥60), body mass index (below/above median), smoking status (nonsmoker, current smoker), alcohol intake (≥1 drink per week, <1 drink per week), exercise (moderate/vigorous, sedentary) and diabetes (yes/no). Each HEI diet variable was analyzed in our models individually because of variable collinearity.

Because each observation in the NHANES is weighted differently, sample weights were applied in all analyses. This study received institutional review board exempt status. We used SAS versus 9.2 (SAS Institute, Cary, NC) for all analysis. Statistical significance was set at $P < .05$ and all tests were 2-sided.

RESULTS

Demographic and Comorbid Disease

The NHANES survey included 1718 men age of 40 years or older, of which 1448 (84.3%) completed the prostate questionnaire. After exclusion of 63 men with prostate cancer, our cohort consisted of 1385 men (mean age 59.1 years; standard deviation [SD] 13.2 years). At least 1 symptom suggestive of LUTS was reported in 279 (21.1%) men, of whom 126 had "trouble urinating" and 212 "did not feel their bladder was empty." There were 59 men reporting both symptoms. Comparison of weighted demographic information between those with and without symptoms is shown in Table 1. Men with LUTS were more likely to be either black or Hispanic (vs white, $P < .0001$), nonsmokers ($P < .0001$), to have diabetes ($P < .0001$), to be older ($P < .0001$), to have a higher prostate specific antigen ($P < .0001$), and to have a diagnosis of "enlarged prostate" ($P < .0001$). Moderate and vigorous physical activity and alcohol intake were significantly more common in men without LUTS ($P < .0001$).

Dietary Results

Bivariate analysis of HEI categories and symptoms is shown in Table 2. Men with LUTS consumed less dairy products ($P = .005$) and had less variety in their diets ($P = .02$) and overall, had significantly less nutritious diets by USDA standards (lower overall HEI, $P = .03$). Table 3 shows the prevalence of LUTS according to USDA HEI categories. We observed a significantly higher prevalence of LUTS among respondents with poor overall diet, poor protein intake, and poor dietary variety.

Multivariate analysis is shown in Table 4. After controlling for age, race/ethnicity, diabetes, alcohol

Table 1. Characteristics of patients with and without LUTS*

	No LUTS* (n = 1106)	LUTS (n = 279)	*P* Value
Age (Mean, SD)	58.2 ± 12.9	63.0 ± 13.4	<.0001
Race/ethnicity (%)			<.0001†
White(%)	81.8	64.05	
Black(%)	7.7	16.3	
Hispanic(%)	3.95	7.97	
Current smoker (%)	31.17	28.29	<.0001
Diabetes (%)	9.79	18.26	<.0001
Alcohol (> 1 drink per week) (%)	73.86	58.95	<.0001
BMI (mean, SD)	28.1 ± 5.0	28.4 ± 5.4	.16
PSA (mean, SD)	1.70 ± 2.54	2.98 ± 7.0	<.0001
Enlarged prostate diagnosis (%)	11.3	24.4	<.0001
Moderate exercise (%)	38.1	26.7	<.0001
Vigorous exercise (%)	54.5	44.74	<.0001

* All percentages and means are calculated using sampling weights and age-adjustment. Sample sizes are unweighted.
* n is unadjusted.
† ANOVA. Significant for white vs black and Hispanic. Nonsignificant for black vs Hispanic.
LUTS, lower urinary tract symptoms; PSA, prostate specific antigen; BMI, body mass index (kg/m^2).

Table 2. Healthy Eating Index (HEI) scores in men with and without LUTS: Bivariate Analysis

	No Urinary Symptoms (Mean, 95% CI)	One or More Urinary Symptoms (Mean, 95% CI)	*P* Value*
Overall HEI	63.0 (62.2-63.7)	60.8 (59.1-62.4)	.03
Cholesterol	6.8 (6.5-7.1)	6.3 (5.8-6.9)	.18
Dairy	5.8 (5.5-6.0)	4.9 (4.4-5.4)	.005
Fat	6.2 (6.0-6.4)	6.1 (5.6-6.5)	.59
Fruit	3.9 (3.7-4.2)	3.7 (3.2-4.1)	.37
Grain	6.4 (6.3-6.6)	6.5 (6.1-6.8)	.78
Protein	7.6 (7.4-7.8)	7.3 (6.9-7.7)	.17
Saturated fat	6.9 (6.7-7.1)	6.6 (6.2-7.1)	.42
Sodium	5.1 (4.8-5.3)	5.8 (5.3-6.3)	.02
Variety	8.0 (7.8-8.1)	7.4 (7.0-7.8)	.02
Vegetable	6.3 (6.1-6.5)	6.1 (5.7-6.5)	.48

All results are calculated using sampling weights.
* *P* values calculated using unpaired *t* tests. $P \leq .05$ indicated statistical significance.

Table 3. Prevalence of LUTS by USDA dietary category*

	Poor (%)	Needs Improvement (%)	Good (%)	*P* Value (for Trend)*
Overall HEI	25.8	18.6	17.8	.018
Cholesterol	22.3	18.0	18.8	.14
Dairy	22.4	19.2	16.4	.013
Fat	20.9	18.9	19.6	.62
Fruit	20.7	20.7	17.3	.21
Grain	21.8	18.0	19.8	.43
Protein	24.6	19.8	17.9	.012
Saturated fat	22.7	14.8	19.8	.34
Sodium	18.2	18.6	22.4	.17
Variety	26.1	21.2	17.6	.001
Vegetable	20.9	22.3	17.8	.20

All percentages were calculated using sampling weights.
* USDA dietary categories: poor (total score <50; component score <5); needs improvement (total score 50-80; component score 5-8); and good (total score >80, component score ≥8).
* Mantel-Haenszel extension χ^2 test for trend ($P \leq .05$ indicated statistical significance).

intake, body mass index (BMI) (kg/m^2), exercise and smoking, the odds ratios (OR) of LUTS in those with the least healthy diet was 1.7 (95% CI condidence interval [CI] = 1.05-2.90). Alternatively, in our adjusted analyses, there was no statistically significant association between any of the 10 dietary subscales and LUTS. We also found greater odds of LUTS among blacks and Hispanics (vs whites), older patients (vs younger), and decreased odds in alcohol drinkers even after controlling for diet (Table 4).

COMMENT

In this cross-sectional study of the United States population, we found that a healthier diet, as determined by the USDA HEI, was associated with lower self-reported LUTS in men over the age of 40 years. Alternatively, we found no evidence that any individual food group appeared to be protective from LUTS. We also found evidence of greater self-reported LUTS in blacks and Hispanics and reduced LUTS in patients who consumed alcohol.

There is a relative paucity of literature evaluating the association between diet and LUTS, and the findings of these studies are heterogeneous and conflicting. A 2008 study by Kristal et al that analyzed the incident cases of BPH among patients assigned to the placebo arm of the prostate cancer prevention trial found that a diet that included moderate alcohol intake and was high in pro-

Table 4. Multivariable logistic regression

Model Variables	OR (95% CI)*	*P* Value
Age >60 years	2.4 (1.6-3.5)	<.0001
Race/ethnicity		
African American	2.8 (2.0-4.0)	<.0001
Hispanic	2.9 (1.8-4.8)	<.0001
Diabetes	1.4 (0.8-2.5)	.24
Alcohol	0.67 (0.48-0.93)	.015
Smoking (current)	0.95 (0.66-1.36)	.77
Exercise	0.76 (0.46-1.25)	.28
BMI	1.1 (0.71-1.70)	.67
Overall HEI	1.74 (1.05-2.90)	.031
HEI categories†		
Cholesterol	1.36 (1.00-1.83)	.051
Dairy	1.31 (0.78-2.20)	.31
Fat	1.11 (0.66-1.88)	.69
Fruit	1.39 (0.78-2.50)	.27
Grain	1.02 (0.61-1.70)	.94
Meat	1.10 (0.75-1.59)	.63
Saturated fat	1.18 (0.74-1.87)	.49
Sodium	0.72 (0.44-1.18)	.19
Variety	1.34 (0.89-2.02)	.16
Vegetable	1.13 (0.72-1.78)	.59

* Logistic regression model odds ratios (OR) represent ORs with all confounding variables included it the model: age >60 years relative to age ≤60; race/ethnicity relative to reporting white race; diabetes relative to no patient report of diabetes; alcohol consumption relative to <1 drink consumed per week; smoking relative to no current smoking; exercise relative to sedentary activity in past month; BMI relative to BMI below the median.
† HEI categories were analyzed separately in the full model described above because of variable collinearity.

tein and vegetables and low in fat and red meat was protective for LUTS.[8] A study by Chyou et al found that beef intake slightly increased the risk of LUTS, although analysis of 32 other food groups found no increased risk.[9] Analysis of the Health Professionals Follow-up Study found that vegetable intake was inversely correlated with LUTS, but other food groups showed no strong association.[10] In other studies, starch, vegetable consumption, fat consumption, and poultry have shown to increase the risk of BPH and LUTS,[15-17] whereas others have shown vegetables and unsaturated fats to be protective from LUTS. The heterogeneous patient populations, definitions used for LUTS, and analytic methods used make it difficult to draw any clear conclusions.

We used the HEI scores generated from the NHANES 24-hour dietary data. Use of the HEI has many advantages. First, the HEI uses an easily interpretable scoring system based on adherence to USDA dietary recommendations that precorrects for such factors as total caloric intake, body size, age, and individual recommended serving amount.[12] This makes comparison of the numbers between subgroups potentially easier. Second, the scores have been shown in other studies to correlate with the development of chronic diseases, most importantly cardiovascular disease.[18] Third, unlike other dietary studies that analyze individual components of diet for correlation with disease, the HEI is intended to analyze the overall healthiness of the study participant's diet. Although this can be viewed as a weakness of using the HEI, as it does not easily allow one to study the effects of manipulating 1 dietary variable to lower LUTS (ie, studying the increase in vegetable consumption), use of the overall HEI may represent a more real-world dietary situation, in which increasing or decreasing a single dietary component may not be expected to influence disease processes if the overall diet remains poor.

How diet affects the development of LUTS is unclear, but there are potential mechanisms that have been proposed. Oxidative stress within the prostate has been shown to increase the development of BPH[19]; thus healthier foods with higher levels of antioxidants may decrease LUTS. This relationship has been described in a previous observational study where diets rich in the antioxidants obtained from vegetables, namely β-carotene, lutein, and vitamin C, protected participants from LUTS.[20] The autonomic nervous system can also be influenced by diet,[21] and increased sympathetic tone has been linked to the development of LUTS. A study by McVary et al showed that sympathetic tone directly correlated with increasing American Urological Association Symptoms scores.[4] A similar link between catecholamines and life stress as it relates to urinary symptoms has been described.[1] Finally, androgens, which are necessary for prostate growth and likely play a role in BPH development through influences of prostatic growth factors,[22] are another possible dietary mechanism for LUTS development. Androgen levels can be influenced by diet, likely by dietary affects on the circulating sex hormone binding globulins,[23] which alter the bioavailability of circulating androgens. A decrease in the bioavailability of testosterone relative to estrogen levels has been shown to influence prostate growth.[5]

The findings of an inverse correlation between both alcohol intake and exercise and LUTS have been reported previously in similar study populations.[8] Only alcohol intake was significant on multivariate analysis, but both exercise and alcohol intake were highly correlated with a healthy diet.[9] Overall, these findings support a theory that a lifestyle that includes a healthy diet, exercise, and moderate alcohol intake, may decrease the risk of LUTS. Further study of how these three variables work together in the individual to decrease LUTS is certainly warranted.

The relationship between race and LUTS was an intriguing finding from the study that has been suggested before.[24,25] Confounding variables that were not included in this analysis but have been shown to effect LUTS, including socioeconomic status and education, may explain some of the differences we found between races.[26] A further consideration, however, might be that the differences in LUTS reported between levels of socioeconomic status and education may be in part influenced by known differences in diet, although this theory requires further investigation.

Our analysis has several limitations that warrant brief mention. Our data are cross-sectional in nature, and although they can demonstrate associations between diet and LUTS, they cannot show conclusively a causal relationship between diet and LUTS. Our definition of LUTS was based on only 2 self-reported questions that have not been validated to describe all LUTS/BPH patients. Having a more precise questionnaire, such as the American Urological Association Symptom Index, would certainly allow a better understand of the relationship between diet and LUTS. In addition, with such few men reporting 2 symptoms (n = 59), we were unable to demonstrate a dose-dependent relationship between LUTS and diet that should exist if diet is truly causal.

The HEI scores used NHANES 24-hour dietary recall data that, although excellent at accurately capturing the individual's previous day's food intake, are not as accurate when used to extrapolate dietary intake over the entire year. However, with large populations such as those used in the NHANES, a valid description of average intake for the entire cohort has been shown to be possible.[27] Finally, the overall HEI score represents 10 dietary components, determined by the USDA to be important aspects of diet that are all equally weighted. However, this weighting may not accurately reflect what represents the components of a truly healthy diet and may be culturally biased.[26]

Despite these limitations, our analysis is noteworthy for its methodological rigor and use of contemporary and highly generalizable US data. Our finding of a nearly 70% reduction in the odds of LUTS among patients with the healthiest diet needs further confirmation, but suggests that diet alteration may be a potential option in the management of this common and bothersome symptom.

CONCLUSIONS

In an analysis of NHANES and HEI data, we found an association between consuming a less healthy diet and LUTS after controlling for other known modifiable risk factors. Further investigation into the mechanism(s) of dietary LUTS prevention is warranted.

References

1. Ullrich PM, Lutgendorf SK, Leserman J, et al. Stress, hostility, and disease parameters of benign prostatic hyperplasia. *Psychosom Med*. 2005;67:476-482.
2. Rohrmann S, Smit E, Giovannucci E, et al. Association between markers of the metabolic syndrome and lower urinary tract symptoms in the Third National Health and Nutrition Examination Survey (NHANES III). *Int J Obes*. 2005;29:310-316.
3. Orsini N, RashidKhani B, Andersson SO, et al. Long-term physical activity and lower urinary tract symptoms in men. *J Urol*. 2006; 176:2546-2550; discussion 2550.
4. McVary KT, Rademaker A, Lloyd GL, et al. Autonomic nervous system overactivity in men with lower urinary tract symptoms secondary to benign prostatic hyperplasia. *J Urol*. 2005;174:1327-1333.
5. St. Sauver JL, Jacobson DJ, McGree ME, et al. Associations between longitudinal changes in serum estrogen, testosterone, and bioavailable testosterone and changes in benign urologic outcomes. *Am J Epidemiol*. 2011;173:787-796.
6. Rohrmann S, Nelson WG, Rifai N, et al. Serum sex steroid hormones and lower urinary tract symptoms in Third National Health and Nutrition Examination Survey (NHANES III). *Urology*. 2007;69:708-713.
7. St. Sauver JL, Sarma AV, Jacobson DJ, et al. Associations between C-reactive protein and benign prostatic hyperplasia/lower urinary tract symptom outcomes in a population-based cohort. *Am J Epidemiol*. 2009;1;169:1281-1290.
8. Kristal AR, Arnold KB, Schenk JM, et al. Dietary patterns, supplement use, and the risk of symptomatic benign prostatic hyperplasia: results from the prostate cancer prevention trial. *Am J Epidemiol*. 2008;167:925-934.
9. Chyou PH, Nomura AM, Stemmermann GN, et al. A prospective study of alcohol, diet, and other lifestyle factors in relation to obstructive uropathy. *Prostate*. 1993;22:253-264.
10. Rohrmann S, Giovannucci E, Willett WC, et al. Fruit and vegetable consumption, intake of micronutrients, and benign prostatic hyperplasia in US men. *Am J Clin Nutr*. 2007;85:523-529.
11. USDA. Healthy eating index SAS code; 2011. Available at: http://www.cnpp.usda.gov/Publications/HEI/HEI-2005/HEI2005_NHANES0102.txt. Accessed August 30, 2011.
12. Index HE; 2011. Available at: http://www.cnpp.usda.gov/HealthyEatingIndex-Archive.htm. Accessed September 1, 2011.
13. Rohrmann S, Crespo CJ, Weber JR, et al. Association of cigarette smoking, alcohol consumption and physical activity with lower urinary tract symptoms in older American men: findings from the Third National Health and Nutrition Examination Survey. *BJU Int*. 2005;96:77-82.
14. Parsons JK. Lifestyle factors, benign prostatic hyperplasia, and lower urinary tract symptoms. *Curr Opin Urol*. 2011;21:1-4.
15. Bravi F, Bosetti C, Dal Maso L, et al. Macronutrients, fatty acids, cholesterol, and risk of benign prostatic hyperplasia. *Urology*. 2006; 67:1205-1211.
16. Ambrosini GL, de Klerk NH, Mackerras D, et al. Dietary patterns and surgically treated benign prostatic hyperplasia: a case control study in western Australia. *BJU Int*. 2008;101:853-860.
17. Bravi F, Bosetti C, Dal Maso L, et al. Food groups and risk of benign prostatic hyperplasia. *Urology*. 2006;67:73-79.
18. McCullough ML, Feskanich D, Rimm EB, et al. Adherence to the dietary guidelines for Americans and risk of major chronic disease in men. *Am J Clin Nutr*. 2000;72:1223-1231.
19. De Marzo AM, Coffey DS, Nelson WG. New concepts in tissue specificity for prostate cancer and benign prostatic hyperplasia. *Urology*. 1999;53(Suppl 3a):29-39; discussion 39-42.
20. Suzuki S, Platz EA, Kawachi I, et al. Intakes of energy and macronutrients and the risk of benign prostatic hyperplasia. *Am J Clin Nutr*. 2002;75:689-697.
21. Appel LJ, Champagne CM, Harsha DW, et al. Effects of comprehensive lifestyle modification on blood pressure control: main results of the PREMIER clinical trial. *JAMA*. 2003;289:2083-2093.
22. Weihua Z, Makela S, Andersson LC, et al. A role for estrogen receptor beta in the regulation of growth of the ventral prostate. *Proc Natl Acad Sci U S A*. 2001;98:6330-6335.
23. Nayeem F, Nagamani M, Anderson KE, et al. Dietary beta-tocopherol and linoleic acid, serum insulin, and waist circumference predict circulating sex hormone-binding globulin in premenopausal women. *J Nutr*. 2009;139:1135-1142.
24. Fowke JH, Munro H, Signorello LB, et al. Association between socioeconomic status (SES) and lower urinary tract symptom (LUTS) severity among black and white men. *J Gen Intern Med*. 2011;26(11):1305-1310.
25. Sarma AV, Wei JT, Jacobson DJ, et al. Comparison of lower urinary tract symptom severity and associated bother between community-dwelling black and white men: the Olmsted County study of urinary symptoms and health status and the Flint men's health study. *Urology*. 2003;61:1086-1091.
26. Darmon N, Drewnowski A. Does social class predict diet quality? *Am J Clin Nutr*. 2008;87:1107-1117.
27. Basiotis PP, Welsh SO, Cronin FJ, et al. Number of days of food intake records required to estimate individual and group nutrient intakes with defined confidence. *J Nutr*. 1987;117:1638-1641.

Appendix 1. Components of the Healthy Eating Index and scoring system*

	Score Ranges*	Criteria for Maximum Score of 10	Criteria for Minimum Score of 0
Grain consumption	0-10	6-11 servings†	0 servings
Vegetable consumption	0-10	3-5 servings†	0 servings
Fruit consumption	0-10	2-4 servings†	0 servings
Milk consumption	0-10	2-3 servings†	0 servings
Meat consumption	0-10	2-3 servings†	0 servings
Total fat intake	0-10	30% or less energy from fat	45% or more energy from fat
Saturated fat intake	0-10	Less than 10% energy from saturated fat	15% or more energy from saturated fat
Cholesterol intake	0-10	300 mg or less	450 mg or more
Sodium intake	0-10	2400 mg or less	4800 mg or more
Variety	0-10	8 or more different items in a day	3 or fewer different items in a day

* Adapted from the Healthy Eating Index 1999-2000. Available at: http://www.cnpp.usda.gov/publications/hei/hei99-00report.pdf.
* Persons with consumption or intakes between the maximum and minimum ranges or amounts were assigned scores proportionately.
† Number of servings depends on Recommended Energy Allowance (see Table 2). All amounts are on a per-day basis.

Appendix 2. Recommended number of Food Guide Pyramid servings per day, by age/gender categories

Age (y)/Gender Category	Energy (Kilocalories)	Grains	Vegetables	Fruits	Milk	Meat*
Children, 2-3†	1300	6	3	2	2	2
Ψ	1600	6	3	2	2	2
Children, 4-6	1800	7	3.3	2.3	2	2.1
Females, 51+	1900	7.4	3.5	2.5	2	2.2
Children, 7-10	2000	7.8	3.7	2.7	2	2.3
Females, 11-24	2200	9	4	3	3	2.4
Ψ	2200	9	4	3	2	2.4
Females, 25-50	2200	9	4	3	2	2.4
Males, 51+	2300	9.1	4.2	3.2	2	2.5
Males, 11-14	2500	9.9	4.5	3.5	3	2.6
Ψ	2800	11	5	4	2	2.8
Males, 19-24	2900	11	5	4	3	2.8
Males, 25-50	2900	11	5	4	2	2.8
Males, 15-18	3000	11	5	4	3	2.8

* Adapted from the Healthy Eating Index 1999-2000. Available at: http://www.cnpp.usda.gov/publications/hei/hei99-00report.pdf.
* One serving of meat equals 2.5 oz of lean meat.
† Portion sizes were reduces to two-thirds of adult servings except for mild for children aged 2-3 years.