Prevalence and Risk Factors For Lower Selenium Status Among Adult White Males in the USA

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Abstract

Objectives: To establish the prevalence of lower serum selenium status (<106 ng/mL) among the adult white American male population, to determine whether certain social, economic, geographic, physical, and dietary characteristics are risk factors for lower selenium status, and to identify and evaluate potential selenium fortification vehicles that target men with lower selenium status.

Design: A cross-sectional study using nationally representative data from the National Health and Nutrition Examination Survey III, 1988-1994 (NHANES III).

Methods: 2989 white men, aged 20 or greater in the NHANES III dataset had recorded serum selenium values. These men were divided in two groups based on selenium status, those with values of less than 106 ng/mL (n=288) and those with a status greater than or equal to 106 ng/mL(n=2701). Various demographic, physical, and dietary variables were then compared between the two selenium status groups in a bivariate analysis. Multiple logistic regression was then performed to assess possible risk factors for lower selenium status.

Results: This study estimated 7.7% of White Americans adult men aged 20 years and older, a total of 4,751,618 individuals, had a selenium status of below 106 ng/mL. Several of the more than forty, social, economic, geographic, physical, and dietary characteristics examined were shown to be significantly associated a lower selenium status. Risk factors for lower selenium status (106 ng/mL) were; smoking, living in the South, an age of 60 years or older, exercising less than your peers, and having a lower income.

Conclusion: It would appear certain physical, geographic, dietary and demographic characteristics present a significant risk for lower selenium status. While, this work was unable to identify a suitable selenium fortification vehicle to reduce the prevalence of lower selenium status, it did identify risk factors that may contribute to this condition. The findings of this work could be helpful in designing a selenium augmentation/fortification program that target men with lower levels of the mineral.

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Introduction

Recently, a large scale clinical trial demonstrated that selenium supplementation significantly reduced the risk of prostate cancer. The Nutritional Prevention of Cancer (NPC) trial in the United States began in 1983 in order to test whether supplementing individuals with selenium could play a role in preventing the development of cancer. Individuals were given either 200 μg of selenium per day in the form of selenized yeast or a placebo.[1]

After 13 years, the NPC trial demonstrated that, although selenium supplementation did not seem to have any statistically significant effect on primary endpoint of non-melanoma skin cancer, it did provide protection against other forms of cancer. Selenium supplementation, for example, was found to significantly reduce total cancer mortality (41%) and total cancer incidence (25%).[1] The strongest inverse association between selenium supplementation was with prostate cancer. The supplemented group was 52% less likely to develop prostate cancer than the placebo group.[1] Subsequent analysis of the NPC data by Duffield-Lillico and

colleagues showed that this inverse association between selenium supplementation and prostate cancer incidence was confined mainly to those men with blood plasma selenium levels in the lowest tertile (≤ 106.4 ng/mL).[2]

Prostate cancer has both large human and financial consequences in the United States. For example, in 2002, 34,446 men died as a result of prostate cancer and it was estimated that health care costs to treat the disease exceed $1.5 billion per year.[3] While not all men who develop prostate cancer have low selenium status and conversely, not all men with low selenium intake develop prostate cancer, certainly there must be some positive relationship. Given that it has been demonstrated that men with low selenium status, who are supplemented with Se, significantly reduce their risk of developing the disease, it seems very likely that some of these prostate cancer deaths could be prevented by increasing dietary intake of this trace element.

The three major objectives of this study were to estimate the prevalence of low selenium status among adults white American men, to examine the associations, if any, between a range of biological, environmental and lifestyle factors and depressed male selenium status, and lastly, to evaluate a potential dietary intervention that might be used to reduce the incidence of prostate cancer.

Methods and Materials

Data from the third National Health and Nutrition Examination Survey, 1988-1994 (NHANES III) are employed to develop comparative profiles of lower selenium status vs. higher selenium status among white adult men in the United States and to conduct multivariate analyses examining risk factors for lower selenium status. The NHANES III survey uses complex stratified multistage probability design to examine a nationally representative sample of the United States civilian non-institutionalized population. NHANES III collected data on body measurements, demographics, physical function, dietary intake, health condition, lifestyle behaviors, and biochemical measurements of blood and urine from 39,695 individuals which were considered representative of the US population as a whole.[4] This cross-sectional survey includes data from 2989 white men aged 20 or greater, which represented a weighted total of 61,776,414. In this study an unweighted total of 288 men had a selenium status less than 106 ng/mL, while 2701 had selenium status values greater than or equal to 106 ng/mL. (Definitions of variables used in the analysis are available from the author upon request).

Chi-square tests and confidence intervals were created for all categorical dependent variables, while T-tests were used to evaluate the differences between the low and high selenium status groups for continuous normally distributed independent variables for the bivariate comparisons. Multiple logistic regression was performed to evaluate the relationship between lower selenium status and the significant independent variables from the bivariate analysis.

Statistical analysis undertaken during this study were performed using a Statistical Analysis System software (SAS) callable version of SUDAAN, which is able to account for the complex survey design and sampling weights of NHANES III.[5,6]

Results

The overall prevalence of selenium status below 106 ng/mL among white American adults 20 years of age and older is 7.7% (95% CI 6.5-8.8) with a weighted estimate of 4,751,618 individuals. Compared with other western countries, the prevalence with men with lower selenium is quite small since several nations have mean selenium status values below 106

ng/mL. It has been estimated, for example, that greater than 50% of the adult population of Austria, Germany, Spain, and Poland have serum selenium levels below 70 ng/mL.[7]

Bivariate Analysis

Tables 1 through 5 reveal significant differences exist between adult men with lower and higher selenium status on a range of variables including; geographic location, age, level of education, health, diet, and physical measures. Low selenium status differs significantly along geographic lines. For example, the highest prevalence of white men with lower selenium status occurs in the South, with 12.6% of the total white adult male population exhibiting this characteristic. This rate is nearly twice that of the Northeast and Midwest at 6.3% and 6.6% respectively, and almost 4 times greater than the prevalence in West region at 3.2% (see **Table 1**, p.164). In the United States as a whole, the majority of men with a selenium status below 106 ng/L, live in the South (54.3%), 20.0% are in the Midwest, 18.4% live in the Northeast, while 7.3% are in West With regard to age it would appear as though low selenium status is more prevalent among older men, i.e., in the low selenium status group 31.7% (95% C.I. 25.8-37.6) are above the age of 60, whereas in the higher selenium group on 21.31% (95% C.I. 20.7-23.6) are in the oldest age category (see **Table 1**, p.164).

There were significant differences between the two selenium status groups in the case of income. The prevalence of poverty was significantly greater in the low selenium status group than in the higher one (28.6%, 95% C.I. 21.6-34.6 vs. 19.4%, 95% C.I. 17.6-21.2). A significant difference also occurred in the high income group, with men with lower selenium status being less likely to have a high income than those with a higher selenium status (29.06%, 95% C.I. 21.6-36.6 vs. 45.6%, 95% C.I. 43.1-48.0). In the middle income category, prevalence rates were not significantly different between the two selenium status groups.

In terms of education, there were significant differences between the two selenium status groups. The lower selenium status group contained a significantly higher prevalence of individuals that did not graduate from high school compared to those in the higher selenium status group (30.3% vs. 20.1%).

Of the 12 health status variables examined only four; smoking status, self-reported health status, self-reported physical activity level, and a cataract diagnosis differed significantly between the two selenium status groups. **Table 2** (p.165) presents the results from the analysis performed with the health status variables. While statistically not significant, the prevalence rates of many chronic diseases, including congestive heart failure, arthritis, cancer, skin cancer, and diabetes were more common within the lower selenium status group.

The prevalence of men who state that there health was fair or poor was significantly higher, 17.2% vs. 11.4% ($p \leq 0.01$) in the lower selenium status group than in the higher selenium status group. Of the variables studied, smoking status presented the most striking difference between the two selenium status groups. Using serum cotinine levels as a surrogate measure for smoking status, it was found that the majority (59.9%, 95% CI 51-68) of those in the lower selenium group were smokers, while less than 40% were smokers in the higher selenium status group. This study found that men with lower selenium are generally less active than those with higher selenium. This is not a finding that has been documented in previous studies. It is likely that exercise is a covariate of other factors which have been demonstrated to affect selenium status such as smoking, income, and educa-

Table 1. Demographic bivariate results.

Selenium Status (ng/mL) (White US Males age >=20years)

	<106 ng/mL		≥106 ng/mL	
Characteristic	**Number**	**%(95% C.I.)**	**Number**	**%(95% C.I.)**
Overall Prevalence	4,751,618	7.7 (7.1-9.3)	57,024,796	92.3 (91.2-93.41)
Age**				
20-39	1,974,553	41.55 (33.68-49.42)	25,381,585	44.5 (41.9-46.6)
40-59	1,269,727	26.72 (20.06-33.37)	19,449,637	34.1 (31.3-35.7)
60+	1,507,733	31.72 (25.83-37.61)	12,193,573	21.3 (20.7-23.6)
Income**				
Low (poverty index ratio <= 1.85)	1,265,099	28.06 (21.6-34.6)	10,542,907	19.4 (17.6-21.2)
Medium (poverty index ratio 1.851-3.5)	1,931,989	42.9 (35.1-50.56)	19,039,406	35.0 (32.7-37.7)
High (poverty index ratio => 3.501)	1,310,131	29.06 (21.6-36.6)	24,763,722	45.6 (43.1-48.0)
Education (years attended) **				
≥ 12	1,512,733	69.9 (63.3-75.9)	45,484,599	79.9 (78.1-81.6)
< 12	3,475,348	30.3 (24.0-36.6)	11,445,280	20.1 (18.3-21.8)
Live in a Metropolitan Area				
Yes	1,848,906	38.9 (31.7-46.1)	25,508,144	44.7 (43.3-46.2)
No	2,902,712	61.1 (53.9-68.3)	31,516,651	55.3 (53.8-56.7)
Geography (% living in)**				
North East	875,556	18.4 (12.5-24.3)		
Mid West	952,311	20.0 (14.4-25.6)		
South	2,579,221	54.3 (47.0-61.5)		
West	344,530	7.3 (2.68-11.82)~		
Geography (within region prevalence) **				
North East	875,556	6.3 (4.0-8.6)		
Mid West	952,311	6.6 (3.9-7.3)		
South	2,579,221	12.6 (10.3-15.0)		
West	344,530	3.2 (1.0-5.3)~		

Source: The National Health and Nutrition Examination Survey NHANES III (1988-1994)

Notes: All reported values represent weighted estimates using Final Exam Weight: WTPFEX6.
As per NHANES III analytical guidelines all coefficients of variation above 30% are flagged with~

* stastically significant chi-square test results (95%)
** statistically significant chi-square test result (99%)

Table 2. Health variables bivariate results.

Selenium Status (ng/mL) (White US Males age >=20years)				
	<106 ng/mL		≥106 ng/mL	
Characteristic	**Number**	**%(95% C.I.)**	**Number**	**%(95% C.I.)**
Self Report Health Status**				
Fair or poor	865,542	17.2 (13.1-21.4)	6,500,634	11.4 (10.0-12.7)
Excellent, very good or good	4,144,031	82.7 (78.5-86.8)	50,504,170	88.6 (87.25-89.9)
Exercise Activity Level*				
less than peers	1,150,331	24.6 (18.15-31.0)	9,947,108	17.7 (15.8-19.6)
more or same as peers	3,520,129	75.4 (68.8-81.8)	46,141,661	82.3 (80.3-84.10
Smoker (Serum Corinne >= 14 ng/mL = smoker)**				
yes	1,673,114	59.91 (51.24-68.58)	10,407,624	38.5 (35.5-41.6)
no	1,119,379	40.08 (31.41-48.75)	16,572,751	61.5 (58.3-64.4)
Doctor ever told: cataracts**				
Yes	532,128	11.1 (7.8-14.5)	3,222,438	5.6 (4.8-6.4)
No	4,477,445	89.3 (86.3-92.3)	53,802,357	94.4 (93.5-95.1)
Doctor ever told: congestive heart failure				
Yes	170,927	3.6 (1.2-5.9)	1,071,007	1.9 (1.4-2.4)
No	4,580,690	96.4 (94.1-98.740	55,953,789	98.1 (97.6-98.6)
Doctor ever told: stroke				
Yes	170,927	3.6 (1.2-5.9)	1,071,007	1.9 (1.4-2.4)
No	4,580,690	96.4 (94.1-98.8)	55,953,789	98.1 (97.6-98.6)
Doctor ever told: arthritis				
Yes	925,984	19.5 (14.8-24.2)	8,813,552	15.5 (13.8-17.1)
No	3,825,634	80.5 (75.8-85.2)	48,204,415	84.5 (82.9-86.2)
Doctor ever told: asthma				
Yes	309,333	6.5 (3.2-9.7)	4,524,339	7.9 (6.6-9.3)
No	4,442,285	93.5 (90.3-96.8)	52,500,457	92.1 (90.7-93.4)
Doctor ever told: emphysema				
Yes	234,714	4.9 (2.5-7.4)	1,579,760	2.8 (2.2-3.4)
No	4,516,904	95.1 (92.6-97.5)	55,423,214	97.2 (96.4-97.8)
Doctor ever told: gout				
Yes	264,187	5.6 (3.0-8.0)	2,412,023	4.2 (3.3-5.1)
No	4,487,431	94.4 (91.9-96.9)	54,612,773	95.8 (94.9-96.7)
Doctor ever told: skin cancer				
Yes	285,855	6.0 (3.6-8.42)	3,189,124	5.6 (4.8-6.4)
No	4,465,763	94.0 (91.6-96.4)	53,835,671	94.4 (93.6-95.2)
Doctor ever told: other type of cancer				
Yes	162,970	3.4 (1.6-5.3)	1,656,493	2.9 (2.3-3.6)
No	4,588,647	96.6 (94.7-98.4)	55,368,303	97.1 (96.4-97.7)
Doctor ever told: sugar diabetes				
Yes	278,784	5.9 (3.4-8.3)	2,754,481	4.3 (3.9-5.8)
No	4,472,834	94.1 (91.7-96.6)	54,248,907	95.7 (94.2-96.1)

Notes: All reported values represent weighted estimates using Final Exam Weight: WTPFEX6.
As per NHANES III analytical guidelines all coefficients of variation above 30% are flagged with ~.

* stastically significant chi-square test results (95%)
** statistically significant chi-square test result (99%)

tion. Of the health conditions examined, the prevalence of only one, cataracts, differed statically significantly amongst the two selenium status groups (5.6% in the higher SS group vs. 11.1 in lower SS group, p= 0.02).

Of the 13 individual foods and food groups examined, only two differed significantly among the selenium status groups (see **Table 3**, p.167). More men in the higher selenium status group take a vitamin and eat dark bread.

The only significant difference between the two serum selenium groups with regard to specific food, or food group involved the consumption of dark bread. In the lower selenium group, 29.6% (95% C.I. 22.6-36.1) of respondents said they ate ten or more serving of dark bread per month vs. 38.3%(95% C,I. 36.7-40.6) in the higher selenium status group.

The two selenium status groups also differed in their stated use of vitamin supplements. Perhaps not surprisingly, the prevalence rate of those that took a supplement was greater in the higher selenium status group than the lower selenium status group (38.2% vs. 29.5%). Unfortunately, the NHANES survey does not specify what types of vitamins or minerals an individual takes, and therefore there is no way of knowing whether an individual's supplement contained selenium, and if it did, how much.

On a number of different physical measures men, with lower selenium status differ significantly from men with higher levels of the mineral (**Table 4**, p.168 and **Table 5**, p.169). When looking at measures of cholesterol and at body mass index, the prevalence rates of men who are considered obese or overweight, or who have high cholesterol, do not differ significantly between the two selenium status groups see Table 4.

Of the five micronutrients examined, the mean levels of three; lycopene, calcium, and beta-carotene were significantly lower in the low selenium group (see Table 5). The levels of the other two micronutrients, vitamins C and E, were also lower in this group, though not significantly. Mean lead levels were significantly higher in the low selenium group (4.81 ug/dL vs. 4.18 ug/dL, p≤ 0.05).

Multivariate Analysis

A multiple logistic regression was performed to evaluate the relationship between the dependent variable (i.e., selenium status < 106 ng/mL) and the significant independent variables from the bivariate analysis. Micronutrients and toxins were not added to the model as they have not been shown in the literature to have a causal relationship to selenium status. The results of the multivariate analysis are presented in **Table 6,** p.169.

Multiple logistic regression analysis indicated that all but one of the explanatory variables in the model were significantly associated with a selenium status below <106 mg/mL.

The results of this analysis showed that those in the age cohorts below the age of 60 were less likely to have lower selenium status (i.e., age 20-39; OR= 0.63 CI 0.54-0.73 and age 40-59; OR= 0.49 CI 0.43-0.56). In addition, living in the South appears to be significant risk factor for lower selenium status when compared with the other three regions (i.e. Midwest vs. South; OR= 0.45; CI= 0.41-0.50, Northeast vs. South; OR= 0.32 CI= 0.29-0.35, West vs. South; 0.38; CI= 0.29-0.50). As well, higher/medium income reduces the likelihood of having lower selenium status (i.e. higher/medium income vs. lower income; OR=0.82; CI= 0.74-0.91) and as does being a non- smoker (i.e. non-smoker vs. smoker OR=0.45; CI= 0.37-0.54). With regard to the lone dietary variable, those that consume dark breads are less likely to have lower selenium status than those who do not (i.e. high consumption vs. no consumption; OR= 0.45; CI= 0.53-0.77,

Table 3. Dietary variable summary.

Selenium Status (ng/mL) (White US Males age >=20years)				
	<106 ng/mL		≥106 ng/mL	
Characteristic	**Number**	**%(95% C.I.)**	**Number**	**%(95% C.I.)**
Have you taken vitamins/minerals in past month*				
Yes	1,276,112	29.5 (22.6-36.4)	23,136,412	38.2 (35.9-40.5)
No	3,048,381	70.5 (63.6-77.4)	37,440,535	61.8 (59.5-64.1)
Dairy Servings Per Month				
<30				
30-59	1,124,706	26.0 (18.8-33.2)	12,423,909	20.5 (18.7-22.4)
>60	1,688,109	39.0 (31.3-46.8)	24,788,272	40.9 (38.6-43.3)
	1,511,679	35.0 (27.5-42.4)	23,334,133	38.5 (36.3-40.8)
Meat Servings Per Month				
<30				
30-59	840,923	19.4 (13.4-25.5)	13,826,558	22.8 (20.9-24.8)
≥60	2,330,544	53.9 (46.1-61.7)	30,937,235	51.1 (48.8-53.4)
	1,153,026	26.7 (20.1-33.2)	15,777,575	26.1 (24.0-28.1)
Fruit and Vegetable Servings Per Month				
<60				
60-119	1,386,639	32.1 (24.3-39.8)	16,891,090	27.9 (25.8-30.0)
≥120	1,819,827	42.1 (34.2-50.0)	25,389,361	41.9 (39.6-44.3)
	1,118,026	25.8 (19.6-32.1)	18,265,864	30.2 (28.1-32.2)
Cereals Servings Per Month				
<10				
10-29	2,316,019	53.6 (45.7-61.44)	32,499,575	53.6 (51.3-56.0)
≥30	1,211,444	28.0 (21.0-35.0)	17,180,364	28.4 (26.2-30.5)
	797,030	18.4 (13.2-23.7)	10,907,633	18.0 (16.3-19.7)
Serving of Dark Bread Per Month*				
0				
1-9	1,751,833	40.5 (32.8-48.2)	18,343,404	30.3 (28.2-32.4)
≥10	1,291,724	29.9(22.4-37.4)	18,984,227	31.4 (29.1-33.6)
	1,280,936	29.6 (22.6-36.1)	23,196,566	38.3 (36.7-40.6)
Servings of White Bread Per Month				
>9				
10-29	1,200,664	27.8 (30.4-35.2)	19,498,801	32.2 (30.0-34.4)
≥30	963,941	22.3 (15.5-29.1)	14,164,832	23.4 (21.3-25.6)

medium consumption vs. no consumption; OR= 0.78; CI= 0.69-0.91). Also, men that say they exercise the same or more than their peers are less likely to have a selenium status below 106 mgl/mL (OR= 0.79; CI= 0.69-0.91). Finally, after controlling for the other explanatory variables, education level (i.e. graduated high school vs. did not graduate from high school) was not shown to be a significant predictor of a selenium status below 106 mg/mL (OR 1.02; CI=0.92-1.12).

Discussion

This is the first study that has identified various factors which may contribute

Table 4. Prevalence of selected health characteristics of American men age 20 and over with higher and lower selenium status.

Selenium Status (ng/mL) (White US Males age >=20years)

	<106.4 ng/mL		>106.4 ng/mL	
Characteristic	**Number**	**%(95% C.I.)**	**Number**	**%(95% C.I.)**
LDL Cholesterol				
Normal	1,582,032	83.9 (74.3-93.4)	19,114,719	80.0 (77.2-82.8)
High or Very High	304,453	16.1(6.6-25.7)	4,769,294	20.0 (17.2-22.7)
Serum Triglycerides				
Normal	2,693,802	77.5 (70.2-84.8)	35,012,979	78.6 (76.4-80.9)
High or Very High	782,187	22.5 (15.2-29.8)	9,509,224	21.4 (19.1-23.6)
Total Cholesterol				
Normal	4,049,366	85.2 (79.4-91.0)	46,695,648	81.9 (80.1-83.7)
High or Very High	702,252	14.8 (9.0-20.6)	10,324,385	18.1 (16.3-19.9)
Body Mass Index				
Normal Weight	1,514,447	32.7 (25.9-39.5)	21,860,526	38.7 (36.3-41.1)
Obese or Overweight	3,112,878	67.3 (60.7-74.1)	34,600,849	61.3 (58.9-63.6)

Source: The National Health and Nutrition Examination Survey NHANES III (1988-1994)

Notes: All reported values represent weighted estimates using Final Exam Weight: WTPFEX6.
As per NHANES III analytical guidelines all coefficients of variation above 30% are flagged with ~.

* stastically significant chi-square test results (95%)
** statistically significant chi-square test result (99%)

to a selenium status below 106 ng/mL in a nationally representative sample of White American men. The importance of this group comes from previous research that has demonstrated that men with a selenium status less than 106 ng/mL, supplemented with 200 μg of selenium, significantly reduce their risk of developing prostate cancer.[2]

Using the NHANES III survey this study estimated that between the years 1988-1994, 7.7% of White American adult men aged 20 years and older, a total of 4,751,618 individuals, had a selenium status of below 106 ng/mL.

Several of the more than forty, social, economic, geographic, physical, and dietary characteristics examined by this study were shown to be significantly associated a lower selenium status. Risk factors for lower selenium status (106 ng/mL) identified by this study were; smoking, living in the South, an age of 60 years or older, exercising less than your peers, and having a lower income.

Based on the findings of this study it is difficult to identify an intervention strategy to increase the selenium status among men with lower levels of the mineral for a number of different reasons. In the past, micronutrient deficiencies and their associated illnesses were suc-

Table 5. Selected mean blood micronutrient and toxin levels of American men age 20 and over with higher and lower selenium status.

Selenium Status (ng/mL) (White US Males age >=20years)				
	<106.4 ng/mL		>106.4 ng/mL	
Characteristic	**Number**	**Mean (95% C.I.)**	**Number**	**Mean (95% C.I.)**
Serum Vitamine E (ug/dL)	4,728,599	1076.3 (995.8-1156.8)	56,783,214	1171.0 (1147.2-1196.5)
Serum Beta Carotene (ud/dL)*	4,728,599	14.55 (13.14-16.0)	56,783,214	17.5 (16.6-18.4)
Serum Vitamin C (ug/dL)	4,717,095	0.61 (0.54-0.68)	56,353,064	0.69 (0.67-0.71)
Serum Lycopene (ud/dL)*	4,728,599	22.4 (20.2-24.6)	56,783,214	25.5 (25.0-26.1)
Serum Calcium (mmol/L)*	4,678,005	2.26 (2.25-2.28)	56,248,603	2.31 (2.30-2.32)
Serum Lead (ug/dL)*	4,751,617	4.81 (4.37-5.24)	56,992,361	4.18 (4.05-4.32)

* statistically significant t-test results (95%)

Table 6. Multiple Logistic Regression Results for Selenium Status <106 ng/mL.

Dependent Variable Selenium Status <106 ng/ml	**P value**	**Odds Ratio**	**95%**	**C.I.**
Significant Explanatory Variables				
Age (20-39 vs >60)	<.0001	0.63	0.54	0.73
Age (40-59 vs >60)	<.0001	0.49	0.43	0.56
Region (Midwest vs South)	<.0001	0.45	0.41	0.50
Region (Northeast vs South)	<.0001	0.32	0.29	0.35
Region (West vs South)	<.0001	0.38	0.29	0.50
Income (higher/medium income vs lower income)	0.0003	0.82	0.74	0.91
Smoking Status (non smoker vs smoker)	<.0001	0.45	0.37	0.54
Dark Bread Consumption (high consumption vs no consumtpion)	<.0001	0.64	0.53	0.77
Dark Bread Consumption (medium consumption vs no consumtpion)	0.0169	0.78	0.64	0.96
Exercise (more or the same active vs less active)	0.0014	0.79	0.69	0.91
Insignificant Explanatory Variable				
Education (graduated vs. not graduated)	0.7239	1.02	0.92	1.12

cessfully overcome with large scale food fortification, such was the case with iodized salt to prevent goiter, vitamin D fortified milk to prevent rickets, and folic acid supplemented grains to reduce the incidence of spina-bifida. With regard to making a case for supplementing a specific food in order to augment the selenium intake of those men with lower selenium status this study provides little guidance. The ideal food candidate for supplementation would be one that was consumed significantly more by men in the lower selenium status than in the higher group. With such a food, you would have the best chance of augmenting the selenium of status of those with lower serum levels of this mineral and minimize the odds (however small) of providing those with already higher levels of the with too much. However, of the 13 individual foods and food groups examined by this study, none were significantly consumed more by the lower selenium status group than by the higher status group.

Furthermore, the need to identify and perhaps implement a specific intervention aimed at augmenting selenium status is perhaps redundant. The modifiable factors for lower selenium status identified by this study were smoking, exercising less, and poverty, all of which are risk factors for many other diseases and are currently being addressed by several public health agencies in the United States.

There are two points are important to consider when interpreting the results from this study. First, the NHANES III survey examined the non-institutionalized civilian population of the United States, thus it does not include persons in institutions such as hospitals, nursing homes, or prisons. Second, it should be noted that the conclusions of this study are based upon a survey that was conducted from 1988-1994, as a result applying the results to today's (2007) population should be done with caution.

Conclusion

This study concludes that lower selenium status is significantly associated with various socio-economic, demographic, physical, and dietary factors. The factors reported in this study are consistent with risk factors for many diseases. Determinants of lower selenium status include modifiable lifestyle factors such as cigarette smoking and exercise which, if changed, could not only have a positive effect upon selenium status but decrease the risk of developing other diseases.

Cigarette smoking was one of the most striking determinants of low selenium status. However, it is unclear whether fortifying tobacco with selenium would be a good strategy to increase selenium status among men with depressed levels of the mineral. Laboratory experiments which have added selenium to tobacco show the mineral reduces the mutagenicity and toxicity of cigarette smoke.[7,8] Yates and colleagues suggest that the mechanism by which selenium generates relief in cigarette smoke induced toxicity is to react with the constituents in the smoke itself and not by stimulating a protective mechanism in the cell. Thus, the action of adding selenium to tobacco appears to reduce the toxicity of the smoke as opposed to having a supplemental effect. In any case, the effects fortified tobacco with regard to selenium status in humans has not been studied. While this may be a good strategy to reduce the harmful effects of tobacco smoke, further research is needed to determine whether adding selenium to tobacco would have a positive effect upon selenium status.

This study was unable to identify a suitable food fortification vehicle in order to augment the selenium status of men low levels of the mineral using the monthly recall survey in NHANES III. A problem with the NHANES survey it that it simply asks for the number of servings of a certain food or food group that a

person consumes per month. This type of survey is problematic for a number of reasons. First, NHANES does not define a standard serving size for each food or food group, so one person may consider a serving of dark bread to be one slice, whereas another would consider it to be two slices. Second, NHANES does not account for different nutrient levels in the same type of food. For example, various types of dark bread may contain different concentrations of nutrients, including selenium. Other problems include memory lapses and the desire to appear more concerned about health than the interviewee really is. Future research could use a different dietary survey, such as a 24 hour dietary recall to perhaps gain a better perspective as to the eating habits of men with lower selenium status

Despite not identifying a clear fortification vehicle, increasing the selenium content of common food stuff, in order to augment selenium status on a population level, is a practice that should be considered and merits further investigation. As mentioned earlier, selenium supplementation has been shown to decrease the incidence rates of various types of illness from cancer to viral infections. The only dietary variable shown reduce the probability of depressed selenium status was the consumption of dark bread. While, dark bread consumption maybe a surrogate measure for a healthy diet in general, it has been shown to contain more than twice the amount of selenium per 100g (36.6 μg vs. 17.3 μg).[10] Therefore, augmenting the selenium of white bread to the same level of dark bread could have a positive effect with regard to reducing the prevalence of lower selenium status. This type of fortification has being attempted before. In 2005, Waitrose launched selenium-fortified bread in Great Britain which contained approximately 40 μg of selenium per 100g.[11] Sales of this bread were slow and the product was later pulled from the selves. The company blamed a lack of public awareness of the benefits of selenium for the sluggish sales of the product.[12]

Large scale fortification of foods with selenium, by means of widespread fertilization, has been safely conducted in Finland since 1984. Further research in this area could include estimating the impact of various levels of selenium in fertilizers and subsequent impacts on national and global (because of food exports) selenium status.

The findings of this study may have a further significance should the ongoing SELECT trial demonstrate that selenium supplementation has a protective effect against prostate cancer among men with lower selenium status. Should this be the case, the results of this study could be used to identify a target population that would benefit most from selenium supplementation. In the event that chemoprevention of prostate cancer with selenium is demonstrated to be effective among men with low levels of the mineral, this work could also be used as a screening tool to by physicians. Patients presenting with risk factors for low selenium status could be blood tested to determine if this was the case and if so, prescribed a daily selenium supplement. Though conservative, this approach would eliminate the possibility, however small of toxicity, and deliver the mineral in a controlled dose.

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