Racial Differences in Serum Selenium Concentration: Analysis of US Population Data from the Third National Health and Nutrition Examination Survey

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Lower intake of the essential trace element selenium may be a risk factor for prostate cancer and other cancers. In the United States, many racial disparities in cancer incidence, such as the 61% higher incidence of prostate cancer among Blacks relative to Whites, remain unexplained. Using data from a large, nationally representative survey, the authors explored Black/White differences in serum selenium concentration. Mean serum selenium concentrations, both crude and adjusted for known predictors of serum selenium, were determined for 10,779 Black and White males and females aged ≥12 years who participated in the Third National Health and Nutrition Examination Survey (1988–1994). Crude mean serum selenium concentrations were 126.35 ng/ml for Whites and 118.76 ng/ml (~6% lower) for Blacks. Adjustment for known serum selenium predictors, including a proxy for residence at the county level, reduced the racial disparity, although concentrations remained approximately 3% lower in Blacks than in Whites of both sexes (p < 0.0001). The observation that Blacks had lower unadjusted and adjusted serum selenium concentrations relative to Whites is intriguing, given the racial disparity in incidence of prostate cancer and other cancers.

African Americans; biological markers; neoplasms; nutrition surveys; selenium

Abbreviations: NHANES III, Third National Health and Nutrition Examination Survey; PIR, poverty index ratio; PSU, primary sampling unit.

The essential trace element selenium has been the focus of a number of recent scientific investigations because of its anticarcinogenic potential (1–3). Selenium is essential to the functioning of several enzymes, including the antioxidant enzyme glutathione peroxidase; it helps maintain a healthy immune system and plays a role in many other aspects of human health (2).

Selenium is found throughout the food supply. The richest sources are cereal grains, meats, and fish, although concentrations in food vary considerably according to the soil content of the geographic region where the food was produced (4). In China, two endemic diseases, a type of cardiomyopathy called Keshan disease and a type of deforming arthritis called Kashin-Bek disease, have been attributed to selenium deficiency (2). Selenium intake that is sufficient to prevent these diseases may nevertheless be inadequate to reduce the risk of other diseases, most notably cancer (1, 5–8).

In ecologic studies conducted in the 1960s and 1970s, investigators reported moderately strong inverse associations between low regional levels of selenium and increased cancer incidence or mortality (9–11). Subsequently, observational epidemiologic studies and clinical trials have provided mixed but encouraging evidence that higher exposure to selenium, as measured in the blood, toenails, or diet, is associated with a decreased risk of cancer, particularly cancer of the prostate but also lung and colorectal cancer (1, 12–16).
Racial differences in cancer rates, including those cancers hypothesized to be associated with low selenium levels, are striking and largely unexplained. Relative to men of other racial/ethnic groups in the United States, Black men experience the highest total cancer incidence and mortality rates (17). The greatest disparity is for prostate cancer, with incidence and mortality rates being 61 percent and 146 percent higher in Blacks than in Whites, respectively. Among women, cancer incidence is highest in Whites, mostly because of higher breast cancer rates, whereas Black women lead other racial/ethnic groups in cancer mortality (17).

Racial variation in serum selenium concentration may explain some of the Black/White disparity in cancer rates. Such variation has been previously reported, most notably in an analysis of data from the Third National Health and Nutrition Examination Survey (NHANES III) that focused on the association between serum selenium levels and demographic factors (18). Although those authors reported that Blacks had significantly lower serum selenium levels relative to Whites, they did not present results adjusted for the influence of important predictors of serum selenium that could potentially confound the racial differences. It was our objective in this study to further investigate the Black/White disparity in serum selenium levels using NHANES III data and adjusting for known predictors of serum selenium concentration, including location of residence at approximately the county level (4, 18–25).

MATERIALS AND METHODS

Study design and sampling technique

In this study, we used serologic and interview data from NHANES III, a national survey conducted by the National Center for Health Statistics (Centers for Disease Control and Prevention) between 1988 and 1994 (26–30). The survey was designed to assess the health and nutritional status of the civilian, noninstitutionalized US population aged 2 months or older. Although certain groups, such as Blacks, were oversampled in order to permit subgroup analyses, the use of sample weights in the analysis allows for generalization of the results to the US population. In-person interviews were conducted in sampled households, and all subjects were invited to participate in medical examinations conducted at a nearby NHANES III mobile examination center. Details of the survey design and examination procedures have been previously published (31, 32).

Of 39,695 eligible NHANES III participants, 30,818 (78 percent) completed a home interview and were examined in the mobile examination center. Serum selenium concentration was measured in 18,292 participants aged 12 years or older. Racial/ethnic groups other than non-Hispanic Blacks and non-Hispanic Whites (hereafter referred to as “Blacks” and “Whites”) were excluded, leaving 12,321 participants. Subsequent exclusions were made for participants who either were currently pregnant \( n = 183 \) or were missing data on predictor variables used to adjust for potential confounding \( n = 1,359 \). Therefore, the current study included 10,779 participants (4,369 Blacks and 6,410 Whites).

Data collection

Blood specimens were obtained from participants by venipuncture. Selenium was measured in serum samples using atomic absorption spectrometry at 196 nm; details of this procedure have been published elsewhere (33–35).

As noted above, for our sample, race was self-reported as Black or White. We categorized age at interview into 10-year groups, except for ages 12–14 years and 15–19 years. Region of residence (Northeast, Midwest, South, or West) was used as a proxy for geographic location. Cigarette smoking was quantified as the average number of cigarettes smoked per day among current smokers. Never smokers were defined as persons who had smoked fewer than 100 cigarettes in their lifetime, while former smokers were persons who had smoked at least 100 cigarettes in their lifetime but reported no current smoking. Alcohol intake was quantified as the average number of alcoholic drinks (i.e., a 12-ounce (0.4-liter) beer, a 4-ounce (118-ml) glass of wine, or a 1-ounce (30-ml) shot of liquor) consumed per week among current drinkers. Never drinkers were defined as persons who had consumed fewer than 12 drinks in their lifetime, while former drinkers were defined as those who had consumed at least 12 drinks in their lifetime but reported no drinking within the past 12 months.

Body mass index, a measure of obesity defined as weight in kilograms divided by height in meters squared, was categorized according to clinical guidelines set by the National Institutes of Health (36). The poverty index ratio (PIR) was used as a proxy for socioeconomic status. The PIR represents reported total combined family income over the past 12 months divided by the current federal poverty threshold for a family of that size; a PIR of less than 1 is considered poverty (37). Dietary intake of selenium was derived from the 24-hour dietary recall that was administered to participants who underwent examination at a mobile examination center. The nutrient database of the University of Minnesota Nutrition Coordinating Center was used to quantify selenium intake, which excluded supplementary selenium (38, 39); selenium intake can be interpreted as the total amount of selenium consumed on any given day.

Statistical analysis

The statistical analyses for this study were performed using SAS, version 9.1 (SAS Institute, Inc., Cary, North Carolina) and the SAS-callable version (version 9.0.0) of SUDAAN (Research Triangle Institute, Research Triangle Park, North Carolina), a statistical software package that takes into account sample weighting and the complex, multistage probability sample design of NHANES III. Demographic characteristics were compared by race using chi-squared tests. For each sex separately and for both sexes combined, crude mean serum selenium concentrations were calculated for persons who reported their race as either Black or White.

In order to assess the degree to which various factors explained the Black/White disparity in serum selenium concentration, four linear regression models were constructed which included known predictors of serum selenium concentration.
concentration (4, 18–25). For each sex separately and for both sexes combined, the first model was adjusted for age only; the second was additionally adjusted for current smoking status, current alcohol consumption, body mass index, and PIR. Region of residence was added to the third model. Because geographic location of residence is an important predictor of selenium intake (4), a fourth model was constructed that adjusted for NHANES III primary sampling unit (PSU) in addition to all of the variables used in the second model. The PSUs are sampled areas where the participant resided and represent, in most cases, individual counties or portions of large metropolitan areas, although a few PSUs include adjacent counties. There were 98 PSUs in NHANES III. In our data set, each PSU contained, on average, 110 participants (range, 1–236). To adjust for PSU in the regression analyses, we included a separate dummy variable for each PSU. All p values were two-sided and were considered statistically significant if they were less than 0.05.

We also assessed the associations between total dietary selenium intake and race and region, as well as the association between serum selenium concentration and selenium intake. Kernel density smoothing (40), weighted by the appropriate NHANES III sample weights, was used to graph the race-specific distributions of serum selenium concentration. For purposes of graphic presentation, the selenium range was restricted to 70–200 ng/ml.

RESULTS

Characteristics of the study population, weighted to represent the US noninstitutionalized population, are presented in table 1. Whites had a higher male:female ratio and were older than Blacks. The majority of Blacks lived in the South, whereas Whites were more evenly dispersed throughout the regions. Blacks more often reported living in poverty relative to Whites.

Population density estimates (figures 1 and 2) illustrate that, for both sexes, serum selenium concentrations were noticeably shifted to lower concentrations in Blacks relative to Whites. This pattern was observed across most of the United States, as illustrated in figure 3, which includes unadjusted mean values for Blacks and Whites in each of the 67 PSUs that contained at least 10 members of each race. Mean values are plotted on the x-axis for Blacks and on the y-axis for Whites. The points for a majority (93 percent) of PSUs fall above a 45° line, indicating that Whites have higher mean serum selenium concentrations than Blacks in most of the PSUs. This figure also shows a strong positive correlation (\( r = 0.74, p < 0.0001 \)) between the Black and White serum selenium levels in the various PSUs.

Prior to constructing statistical models to examine the association between serum selenium and race, we assessed the association between serum selenium and potential confounders. Age, sex, current smoking status, body mass index, PIR, region of residence, and current alcohol consumption were found to significantly predict serum selenium levels when entered into a model one at a time (\( p < 0.05 \)). In the fully adjusted model that included PSU but not region, all of these variables remained significantly associated with serum selenium concentration, with the exception of current alcohol consumption (\( p = 0.44 \)) and PIR (\( p = 0.22 \)).

Overall crude (unadjusted) mean serum selenium concentrations were lower among Blacks (118.76 ng/ml) than among Whites (126.35 ng/ml); this difference was approximately

### Table 1. Percentage distribution† of sample-weighted characteristics of the study population, Third National Health and Nutrition Examination Survey, 1988–1994

<table>
<thead>
<tr>
<th></th>
<th>Total (n = 10,779)</th>
<th>Whites (n = 6,410)</th>
<th>Blacks (n = 4,369)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>49</td>
<td>49</td>
<td>46</td>
</tr>
<tr>
<td>Female</td>
<td>51</td>
<td>51</td>
<td>54*</td>
</tr>
<tr>
<td><strong>Age group (years)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12–14</td>
<td>5</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>15–19</td>
<td>7</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>20–29</td>
<td>18</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>30–39</td>
<td>21</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>40–49</td>
<td>17</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>50–59</td>
<td>11</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>60–69</td>
<td>10</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>70–79</td>
<td>7</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>≥80</td>
<td>3</td>
<td>3</td>
<td>1**</td>
</tr>
<tr>
<td><strong>Region of residence</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>21</td>
<td>22</td>
<td>15</td>
</tr>
<tr>
<td>Midwest</td>
<td>26</td>
<td>27</td>
<td>20</td>
</tr>
<tr>
<td>South</td>
<td>35</td>
<td>33</td>
<td>56</td>
</tr>
<tr>
<td>West</td>
<td>17</td>
<td>18</td>
<td>9***</td>
</tr>
<tr>
<td><strong>Current alcohol consumption</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never drinker</td>
<td>17</td>
<td>15</td>
<td>27</td>
</tr>
<tr>
<td>Former drinker</td>
<td>31</td>
<td>31</td>
<td>33</td>
</tr>
<tr>
<td>Current drinker</td>
<td>52</td>
<td>54</td>
<td>40***</td>
</tr>
<tr>
<td><strong>Current smoking status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never smoker</td>
<td>48</td>
<td>47</td>
<td>59</td>
</tr>
<tr>
<td>Former smoker</td>
<td>24</td>
<td>25</td>
<td>13</td>
</tr>
<tr>
<td>Current smoker</td>
<td>28</td>
<td>28</td>
<td>29***</td>
</tr>
<tr>
<td><strong>Poverty income ratio</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1 (indicating poverty)</td>
<td>11</td>
<td>8</td>
<td>31</td>
</tr>
<tr>
<td>≥1 (indicating nonpoverty)</td>
<td>89</td>
<td>92</td>
<td>69***</td>
</tr>
<tr>
<td><strong>Body mass index‡</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underweight (&lt;18.5)</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Normal weight (18.5–24.9)</td>
<td>45</td>
<td>46</td>
<td>40</td>
</tr>
<tr>
<td>Overweight (≥25)</td>
<td>51</td>
<td>50</td>
<td>56**</td>
</tr>
</tbody>
</table>

* \( p < 0.01 \); ** \( p < 0.001 \); *** \( p < 0.0001 \) (Blacks vs. Whites).
† Percentages may not sum to 100 because of rounding.
‡ Weight (kg)/height (m)².
7–8 ng/ml (~6 percent) and was statistically significant \( p < 0.0001 \) (table 2). In age-adjusted models and in models adjusted for all of these factors except region of residence, the racial differences diminished progressively but remained statistically significant \( p < 0.0001 \) for both sexes (table 2).

The influence of geographic location of residence was evaluated by first incorporating into the models region of residence (Northeast, Midwest, South, or West). Then we replaced region with PSU to more finely adjust for the geographic location of residence. For both sexes, the

FIGURE 1. Population density estimates of serum selenium concentration (ng/ml) for Black and White males in the Third National Health and Nutrition Examination Survey, 1988–1994. The solid-line curve represents the density for Blacks and the dotted-line curve represents the density for Whites. The area under each curve above an interval represents the estimated population relative frequency. In this graph, serum selenium levels were restricted to values between 70 ng/ml and 200 ng/ml. A kernel density estimator was used to produce the curves.

FIGURE 2. Population density estimates of serum selenium concentration (ng/ml) for Black and White females in the Third National Health and Nutrition Examination Survey, 1988–1994. The solid-line curve represents the density for Blacks and the dotted-line curve represents the density for Whites. The area under each curve above an interval represents the estimated population relative frequency. In this graph, serum selenium levels were restricted to values between 70 ng/ml and 200 ng/ml. A kernel density estimator was used to produce the curves.
FIGURE 3. Scatterplot of primary sampling unit (PSU)-level crude mean serum selenium concentrations (ng/ml) for Blacks versus Whites in the Third National Health and Nutrition Examination Survey, 1988–1994. The plot shows the mean values for Blacks and Whites in each of the 67 PSUs that contained at least 10 members of each race. The solid line represents equality of the mean selenium levels for Blacks and Whites.

### TABLE 2. Sample-weighted crude mean serum selenium concentration (ng/ml) and unadjusted and adjusted mean differences in selenium concentration, by sex and race, Third National Health and Nutrition Examination Survey, 1988–1994†

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Mean (SE)</td>
<td>No.</td>
</tr>
<tr>
<td><strong>Unadjusted</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whites</td>
<td>6,410</td>
<td>126.35 (1.08)</td>
<td>3,025</td>
</tr>
<tr>
<td>Blacks</td>
<td>4,369</td>
<td>118.76 (0.60)</td>
<td>2,011</td>
</tr>
<tr>
<td>Difference*</td>
<td></td>
<td>7.59 (1.07)</td>
<td></td>
</tr>
<tr>
<td><strong>Adjusted for age</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference*</td>
<td></td>
<td>7.43 (1.08)</td>
<td></td>
</tr>
<tr>
<td><strong>Adjusted for age, sex, current smoking status, current alcohol consumption, body mass index§, and poverty income ratio</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference*</td>
<td></td>
<td>6.92 (1.17)</td>
<td></td>
</tr>
<tr>
<td><strong>Adjusted for age, sex, current smoking status, current alcohol consumption, body mass index, poverty income ratio, and region</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference*</td>
<td></td>
<td>5.73 (0.92)</td>
<td></td>
</tr>
<tr>
<td><strong>Adjusted for age, sex, current smoking status, current alcohol consumption, body mass index, poverty income ratio, and primary sampling unit</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference*</td>
<td></td>
<td>4.02 (0.46)</td>
<td></td>
</tr>
</tbody>
</table>

* * p < 0.0001.
† Observations were excluded for all analyses if values were missing for any of the following variables: age, sex, region of residence, current smoking status, current alcohol consumption, body mass index, or poverty income ratio.
‡ SE, standard error.
§ Weight (kg)/height (m)².
Black/White difference was moderately diminished with the addition of region of residence (table 2). The substitution of PSU approximately halved the crude Black/White difference, but mean serum selenium concentration remained significantly lower in Blacks than in Whites in all models and for both sexes.

Using total dietary intake of selenium from the NHANES III 24-hour recall, we examined racial differences in reported selenium intake and evaluated the association between serum selenium concentration and selenium intake. For these analyses, 291 additional participants were excluded because of missing values for selenium intake, leaving 10,488 participants. Although selenium intake was higher among Whites (120.81 μg/day) than among Blacks (118.27 μg/day), this difference did not achieve statistical significance in either the crude model or the fully adjusted model that included PSU (p > 0.05). Dietary selenium was also not associated with serum selenium in the crude models or in the models fully adjusted for all selenium predictors, including PSU, nor was it associated with region of residence in the crude or fully adjusted (but without PSU) models (p > 0.05).

**DISCUSSION**

Selenium has been hypothesized to play a role in preventing cancer (1–3). Epidemiologic studies have demonstrated an inverse association between circulating selenium levels and cancers of the prostate (12, 16), lung (14), and colorectum (13, 15). To date, the strongest evidence for a protective effect comes from the Nutritional Prevention of Cancer Trial, a randomized, placebo-controlled clinical trial designed to test the ability of selenium supplements (200 μg/day) to reduce skin cancer incidence among 1,312 males and females living in a US region with low soil levels of selenium (5, 7, 8, 41–43). With respect to the skin cancer hypothesis, recent analyses suggest that selenium supplementation actually increases the risk of nonmelanoma skin cancer, particularly squamous cell carcinoma, among participants with higher baseline serum selenium levels (44). However, secondary analyses showed reductions in risk of other cancers, especially prostate cancer; after approximately 4.5 years of treatment and 7.5 years of follow-up, prostate cancer incidence among persons receiving selenium supplements was half that experienced by the placebo group (p < 0.05). The Selenium and Vitamin E Cancer Prevention Trial (SELECT), another large-scale randomized, placebo-controlled clinical trial, recruited approximately 35,500 North American males, approximately 15 percent of whom are Black. This trial is designed to determine whether supplemental selenium and/or vitamin E decreases the risk of prostate cancer in healthy males and is expected to yield results by 2013 (45, 46).

The mechanisms by which selenium may decrease cancer risk were summarized by Rayman (47). Traditionally, it has been thought that the capacity of the selenoenzyme glutathione peroxidase to inactivate peroxides that can cause cellular damage may explain the importance of selenium in human carcinogenesis. However, glutathione peroxidase activity is maximized at an intake of 55 μg/day, far below both the average plasma selenium levels in the United States and the 200 μg/day given in the Nutritional Prevention of Cancer Trial (41). A role in oxidant defense for a second selenoprotein, selenoprotein-P, has been suggested (48). However, a human supplementation trial demonstrated that selenoprotein-P levels did not increase after 16 weeks of selenium supplementation at levels of 200 μg/day, 400 μg/day, and 600 μg/day, indicating that selenoprotein-P was optimized in selenium-replete persons (49).

A third potential cancer prevention agent is selenium-methylenecysteine, which has been shown to have low toxicity and to be the most effective seleno-compound in the prevention of mammary cancer in rats; selenium-methylenecysteine is the predominant form of selenium in selenium-enriched broccoli and garlic (3, 50–52). Ip et al. (53) reported on studies showing that methylenenic acid, a simplified version of selenium-methylenecysteine (without the amino acid), inhibited cell proliferation and induced apoptosis in a mouse mammary model.

If selenium does reduce cancer risk, racial differences in circulating selenium levels might partially explain why cancer incidence rates are higher among US Blacks than among US Whites. Compared with White men, age-standardized incidence rates among Black men are substantially higher for the three most commonly diagnosed cancers (lung, colon, and prostate); particularly striking is the fact that prostate cancer incidence rates are 61 percent higher in Black men (17). Cancers of the colorectum and lung/bronchus are 24 percent and 8 percent higher in Black women than in White women, respectively, but breast cancer incidence is lower (by 15 percent) in Black women compared with White women (17).

In our analysis of approximately 11,000 male and female NHANES III participants aged 12 years or older, Blacks had mean serum selenium values that were approximately 6 percent lower than those of Whites. Adjustment for lifestyle factors identified in the literature to be predictors of selenium status only slightly attenuated this racial disparity. Geography, an indicator of local food and water supplies, was a strong predictor. Adjustment for broad regional location of residence (Northeast, Midwest, South, or West) significantly reduced racial disparity. Additional adjustment by the NHANES III sampling variable, PSU, which more finely adjusts for geography at approximately the county level, reduced the crude Black/White disparity in mean serum selenium concentration by approximately half. Besides adjusting for possible geographic differences in the selenium content of foods, PSU also adjusts for the month/season of the year in which the serum samples were taken, since most subjects from the same PSU were examined within a few weeks of each other. Adjusting for geography may also control for unmeasured, locally determined lifestyle variables that are related to both race and serum selenium level (e.g., local cultural and social differences that relate to dietary patterns) (54).

Racial variation in selenium status has been reported previously (18, 19, 55–58). Apart from the previous NHANES III analysis that presented unadjusted serum selenium values by race and other demographic factors (18), other studies examining racial differences in selenium status have been...
limited by the inclusion of relatively few Blacks; most have reported blood selenium concentrations that were 5–10 percent lower in Blacks than in Whites (19, 56–58).

An explanation for the racial disparities observed in this analysis is not readily apparent. Selenium intake, based on the NHANES III 24-hour dietary recall, was slightly higher among Whites than among Blacks, but this difference did not achieve statistical significance. Lewis et al. (33) found no racial differences in selenium intake in a sample of approximately 250 southern US Blacks and Whites. It is possible that we were not able to demonstrate that differential intake of selenium-rich foods plays an important role in racial variation of serum selenium concentration because intakes were derived from a single 24-hour dietary recall, which probably contained significant measurement error. Thus, dietary influences cannot be ruled out and should be investigated in future studies. Differential intake of selenium-containing dietary supplements may also be relevant, although Niskar et al. (18) found that only 11 percent of NHANES III participants reported taking such supplements; furthermore, this behavior was not a predictor of serum selenium concentrations. Although we adjusted for the potentially confounding effect of many known and suspected predictors of serum selenium, it is possible that an unknown factor could explain the variation. Finally, genetic factors that may correlate with race could differentially affect selenium absorption and metabolism and thus serum selenium bioavailability/concentration (47, 59).

While the absolute difference between racial groups is relatively small, it may nonetheless be of public health significance. An earlier NHANES III analysis indicated that the US population does not appear to be at risk of selenium deficiency or toxicity (24). Our analysis also revealed that nearly all (>99.5 percent) of our study population had serum selenium concentrations that were considered nutritionally optimal (>80 ng/ml) (60). However, selenium levels that do not produce signs of clinical deficiency could be suboptimal and could adversely affect cancer risk (1, 5–8).

For example, updated reports from the Nutritional Prevention of Cancer Trial (5, 7, 8, 43) indicate that only participants entering the trial with baseline serum selenium levels below either approximately 106 ng/ml or approximately 120 ng/ml experienced a protective effect from selenium supplementation. Participants with higher baseline values showed no benefit from supplementation, and some subanalyses even indicated increased cancer risk among such selenium-replete persons, suggesting the existence of a threshold level of benefit and perhaps safety (47). Among our subjects, a larger proportion of Blacks (56 percent) than of Whites (36 percent) had serum selenium concentrations below 120 ng/ml ($p < 0.0001$).

Our study had several strengths and limitations. The unusually large number of participants drawn from a representative sample of noninstitutionalized US Blacks and Whites enabled us to generate stable and generalizable estimates of mean serum selenium concentration. Additionally, many lifestyle factors known to predict serum selenium levels were measured in NHANES III, allowing us to adjust for their potentially confounding influences. In particular, because of the geographically clustered sample design of NHANES III, we had the rare opportunity to adjust for location of residence at approximately the county level. Limitations include the potential misclassification that may result from the use of a single measurement of serum selenium. However, it has been demonstrated that a single measurement can reasonably rank subjects according to long-term dietary intake of selenium (61). We also had to rely on a single 24-hour recall to estimate dietary intake of selenium. This method of dietary assessment is known to have large day-to-day within-person variability, which results in attenuated associations and reduced statistical power (62). Additionally, the use of standard recipe and food composition databases adds to the measurement error in determining selenium intake from dietary instruments such as a 24-hour dietary recall (62). In addition to potential validity issues regarding the instrument itself, the measurement of dietary selenium is known to be challenging, because the selenium content in food varies according to the selenium content of the soil where the food originated (4). We were also unable to evaluate certain subtleties related to selenium intake, such as the fact that different sources of selenium (e.g., plant sources vs. animal sources) vary in physiologic relevance and also result in different serum selenium concentrations (63).

In conclusion, using nationally representative data from NHANES III, we observed substantial variation in circulating selenium levels in Black men and women versus White men and women. Crude and adjusted mean serum selenium concentrations were significantly lower among Blacks than among Whites, with differences being apparent for both sexes. Low intake of selenium has been suggested as a potential risk factor for several major cancers. It is provocative that, relative to US Whites, US Blacks have both lower concentrations of serum selenium and higher incidence rates of cancer overall and cancers of the prostate, colorectum, and lung. Particularly intriguing are the high prostate cancer incidence rates observed among Blacks and the relatively strong evidence for an inverse association between prostate cancer and selenium exposure. Although the absolute difference in serum selenium concentrations between Blacks and Whites was small, this observation deserves further investigation, since it could potentially translate into a cancer prevention strategy.

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