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Prevalence of Advanced Colorectal Neoplasia in Whites and Blacks Undergoing Screening Colonoscopy in a Safety Net Hospital

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Abstract

Background—Blacks are more likely than whites to be diagnosed with colorectal cancer and die of their disease. The extent to which genetic or biologic factors versus disparities in screening rates explain this variance remains controversial.

Objective—To define the prevalence and location of presymptomatic advanced colorectal neoplasia (ACN) among whites and blacks undergoing screening colonoscopy controlling for other epidemiologic determinants of risk.

Design—Cross-sectional survey between March 22, 2005 and January 31, 2012.

Setting—Urban, open-access, academic, safety net hospital in Massachusetts.

Participants—Asymptomatic, average-risk whites (n=1172) and blacks (n=1681) 50 to 79 years of age presenting for screening colonoscopy.

Measurements—Adjusted prevalence and location of ACN, defined as a tubular adenoma 10 mm in size, any adenoma with villous features or high-grade dysplasia, any dysplastic serrated lesion, or invasive cancer.

Results—The prevalence of ACN was higher among whites than blacks (6.8% vs. 5.0%; $P=0.039$) but varied by sex (white versus black men, 9.3% vs. 5.7%; white vs. black women, 3.5% vs. 4.3%; P for interaction =0.034). After controlling for exposure to multiple risk factors, black

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men were 41% less likely than white men (adjusted odds ratio [aOR], 0.59; 95% confidence intervals [CI], 0.39–0.89) to have ACN; conversely, no significant differences were observed for women (aOR, 1.32; 95% CI, 0.73–2.40). Among individuals with ACN, blacks a higher percentage of proximal disease (52% vs. 39%) after adjustment for age and sex ($P=0.055$).

Limitations—Single institution study; inadequate statistical power for subgroup analyses; recall bias.

Conclusions—Black men are less likely than white men to have ACN at screening colonoscopy in a safety net health care setting. These findings suggest that disparities in access to screening and differential exposure to modifiable risk factors rather than genetic or biologic factors are largely responsible for the higher incidence of CRC among black men. Genetic or biologic factors, however may explain the predilection for proximal disease.

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Introduction

Colorectal cancer (CRC) currently ranks as the third most common cancer and second leading cause of cancer-related death among men and women in the United States (1). Despite recent declines in overall incidence and mortality, black men and women are both more likely to be both diagnosed with CRC and die of their disease than their white counterparts (2). A clear understanding of the factors contributing to these disparities has been elusive. Although differential access to and/or uptake of care, particularly with respect to screening (3–5), have been identified as potential contributors, there is also evidence to suggest that biologic and genetic factors may play an important role (6, 7). Differences in the molecular composition of tumors (8, 9), age of onset (10, 11) and anatomic distribution of disease within the colon (10) lend credence to the putative role of these factors. Nevertheless, U.S. age-adjusted incidence rates were consistently lower among blacks men and comparable for black women in the 1980s (12), thus suggesting that lack of appropriate screening may be the more important cause (13).

An understanding of the age-adjusted prevalence and distribution of presymptomatic advanced colorectal neoplasia (ACN) would shed light on this controversy. Studies to date, however, have provided conflicting results, with some studies finding a higher prevalence among blacks and others finding no difference (14–17). Possible explanations include differences in the primary endpoint (e.g. polyp size vs. histopathology) or selection criteria, racial misclassification, ethnic mix, and differential exposure to modifiable risk factors for ACN. Findings regarding the anatomic location of ACN are also conflicting (14–17). Therefore, the overall objective of this study was to compare the prevalence and distribution of ACN among average-risk whites and blacks undergoing screening colonoscopy in a safety net health care system controlling for exposure to other epidemiologic determinants of risk.

Methods

Study Design

We conducted a cross-sectional study of consecutive asymptomatic, average-risk patients presenting for open access screening colonoscopy between March 22, 2005 and January 31, 2012. Potential study participants were identified from daily appointment logs and assessed for eligibility by a study coordinator in the endoscopy unit just prior to their scheduled procedure. The study protocol was approved by the Boston University Medical Campus Institutional Review Board.

Setting and Participants

Boston Medical Center is a private, not-for-profit, community-based, academic medical center. It is the largest safety net hospital in New England with 18 affiliated community health center partners and a legislative mandate to provide care to low-income persons and other vulnerable populations regardless of their ability to pay. Approximately 70% of the center's patients are from racial (44% black) and ethnic minority groups and more than 95% have some form of health care insurance. During the time frame of this study, cumulative screening rates for whites and blacks were approximately 55% and 58%, respectively, with colonoscopy accounting for 89% of completed tests for both groups.

Participants were 50 to 79 years of age, due for CRC screening in accordance with current guidelines and categorized themselves as non-Hispanic whites or non-Hispanic blacks. Patients with indications other than screening, such as the presence of lower gastrointestinal symptoms, iron deficiency anemia, positive fecal occult blood testing or surveillance because of a personal history of colorectal neoplasia or chronic inflammatory bowel disease, were ineligible. Patients undergoing screening because of a family history of CRC affecting a first-degree relative of any age or colorectal polyps affecting a first-degree relative before age 60 were also ineligible.

Survey Methodology

The risk assessment questionnaire was self-administered to consenting patients with adequate literacy skills using a coded, scannable, paper-based collection form devoid of identifiable patient information. A trained interviewer technique was used for patients with low literacy skills. The survey took ~ 5 minutes to complete.

The questionnaire itself was initially comprised of 38 items that included all 21 items of the original *YourDiseaseRisk* (*YDR*) risk assessment tool for CRC and 17 additional items related to putative risk factors not included in the *YDR* Index (Supplement 1). The original *YDR* index was a web-based adaptation of the Harvard Cancer Risk Index (18), which had been validated for CRC using data from the Nurses Health Study and the Health Professionals Follow-up Study (19). The questionnaire was modified in July 2007 (Supplement 2) to reflect changes in the *YDR* index based on an updated review of the literature (20). Relevant changes included omission of the vegetable intake item and addition of a dairy intake item. Prior screening behavior was also expanded to include virtual colonoscopy and stool-based DNA testing. The 17 additional items not included in the *YDR*

index related to race/ethnicity, smoking (21), dose/duration of aspirin and other non-steroidal anti-inflammatory drug (NSAID) use (22, 23), personal history of diabetes mellitus (24), and family history of colorectal polyps (25). Items related to a family history, inflammatory bowel disease and prior screening behavior provided an internal check of eligibility status. The age, height and weight items used a fill-in-the-blank format; all other items used a single best answer tick box format.

Colonoscopy findings and histology

All screening colonoscopies were performed by board-certified attending gastroenterologists alone or assisted by a gastroenterology fellow. Endoscopic data, including the size and location of any polyps or masses, depth of scope insertion, and quality of the bowel preparation were abstracted from the computerized colonoscopy reports. Polyps or masses located in the rectum, sigmoid, descending colon or splenic flexure were classified as “distal”, whereas those located in the transverse colon, hepatic flexure, ascending colon or cecum were classified as “proximal”. All retrieved polypoid lesions or biopsy specimens were reviewed initially by board-certified pathologists and classified according to World Health Organization histologic criteria as normal mucosa, serrated lesions, conventional adenomas or invasive cancer (26); each also underwent a second review by a gastrointestinal pathologist with expertise in colorectal neoplasia. Adenomas were subclassified as tubular, tubulovillous or villous with or without high grade dysplasia; conversely, serrated lesions were subclassified as hyperplastic polyps, sessile serrated adenomas/polyps with or without cytological dysplasia and traditional serrated adenomas (26). An advanced colorectal neoplasm (ACN) was defined as a tubular adenoma ≥ 10 mm in size, an adenoma of any size with villous features or high-grade dysplasia, a dysplastic serrated lesion of any size, or invasive cancer (27). Patients with multiple polyps submitted individually or collectively in a single specimen container were classified on the basis of their most advanced histology.

Statistical Analyses

The primary analysis examined racial differences in the overall prevalence of ACN after adjustment for other determinants of risk in a multivariate analysis. The key secondary analysis examined racial differences in the distribution of proximal vs. distal ACN, among those with ACN. Patients with incomplete examinations due to poor bowel preparation or failure to reach the cecum for reasons other than a poor bowel preparation or an obstructing neoplasm were excluded from analysis if they did not undergo a complete examination within 1 year. Patients with unretrieved polyp specimens were also excluded. Based on the results of a prior retrospective analyses (28), we estimated that a target sample of 1156 patients in each group provided 80% power of detecting a 6.2% vs.3.6% difference in ACN prevalence at the two-tailed, $P<0.05$ level.

Blacks and whites were compared on demographic factors and findings at colonoscopy through the two-sample t-test for continuous variables and the chi-square test or Fisher's exact test for categorical variables. Differences in the prevalence of ACN between whites and blacks were examined through chi-square analyses or Fisher's exact tests after stratification by age and gender. Multiple logistic regression analysis was used to obtain adjusted odds ratios and 95% confidence intervals to describe the associations between race

and ACN, controlling first for age and sex, and then for the risk factors listed in Table 1. Age, body mass index (BMI), and height were treated as continuous covariates in these regressions; data on other risk factors were collected based on categorical responses and dichotomized for analysis. Racial differences in CRC differed for men and women, and so interaction terms examined whether differences in the odds of ACN between blacks and whites varied by sex and age. Secondary analyses examined racial differences in the prevalence of proximal ACN among patients with ACN, through logistic regression models controlling for age and sex. Sensitivity analyses were also performed to determine whether the exclusion of patients with poor bowel preparation or the presence of an unmeasured dichotomous confounder impacted on the robustness of our results (29)

Modifications to the risk assessment questionnaire during the course of the study led to missing data on dairy intake and diabetes for the first 772 participants. We therefore employed multiple imputation to include all patients in the adjusted analysis, using PROC MI and PROC MIANALYZE in SAS to generate and analyze 5 imputed data sets. Markov Chain Monte Carlo methods were used to first impute continuous missing BMI (n=65), and then binary and ordinal logistic regression models were used to impute missing risk factor data, based on demographic and other risk factors. Because of the number of covariates included in the adjusted analyses, we examined Variance Inflation Factors (VIFs) to assess collinearity between covariates. No problems with collinearity were identified; sex had the highest VIF of 2.0, which dropped to 1.4 if height was excluded, and all other variables had VIFs below 1.5.

All statistical calculations were performed using SAS® Windows, Version 9.2 (Cary, NC) with significance being defined at the two-tailed $P < 0.05$ level for all analyses.

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Results

Study Population

A total of 3321 potentially eligible patients presumed to be of average risk were referred for screening colonoscopy, including 1385 whites and 1936 blacks. Figure 1 depicts the number of pre-screen eligible patients who declined to participate, were deemed ineligible based on inclusion/exclusion criteria, or excluded, because of inadequate bowel preparation, incomplete colonoscopy, or failed polyp retrieval for each group. The evaluable study population was comprised of 1172 whites and 1681 blacks. As shown in Table 1, both groups had a mean age of approximately 56 years. The two groups were also comparable with respect to age distribution and colonoscopy experience, with 92% of patients in both groups completing their initial examination. The two groups differed, however, with respect to sex ($P < 0.001$), with a predominance of men in the white cohort (57%) and women in the black cohort (52%), which is similar to the racial distribution of whites (54% male) and blacks (56% women) at Boston Medical Center. Differences were also observed for

education, insurance, and most epidemiologic determinants of risk. The racial distribution of patients among the 22 participating endoscopists was roughly balanced with each examining a mean (standard deviation) of 42(15)% whites and 58(14)% blacks (data not shown). Characteristics of the two study groups stratified by sex are provided in Appendix Tables 1 and 2.

Unadjusted Prevalence and Location of ACN

As shown in Table 2, the prevalence ACN was significantly higher among whites than blacks, with an observed rate of ACN of 6.8% for whites versus 5.0% for blacks ($P=0.039$). Whites were also more likely to present with multiple (≥ 3) non-advanced adenomas, a marker for metachronous ACN (30, 31), and non-advanced adenomas 6–9 mm in size. Although the difference in ACN between whites and blacks overall was largely attributable to tubular adenomas ≥ 10 mm in size (4.3% vs. 2.7%, $P=0.020$), there were no significant differences in the distribution of histologic subtypes among those with ACN ($P=0.55$). With respect to anatomic location, whites were more likely to present with distal ACN (4.2% vs. 2.4%; $P=0.007$) whereas the prevalence of proximal ACN was comparable for the two groups (2.6% vs. 2.6%, $P=0.96$). Among patients with ACN, however, there was a predilection for proximal disease among blacks but the difference was not statistically significant (52% vs. 39%; $P=0.080$).

Similar analyses were performed after stratification by age and sex (Table 3). These analyses suggested that the prevalence of ACN was higher among whites than blacks 50 to 59, 60 to 69 and 70 to 79 years of age, though estimates were imprecise due to small numbers by subgroup. After stratification by sex, the prevalence of ACN was significantly higher for white men than black men overall (9.3% vs. 5.7%), and in particular, white men <60 years of age (9.0% vs. 5.2%). Differences between white and black women, overall and by age, were inconclusive, likely due to the low prevalence of ACN in these subgroups.

Adjusted Prevalence of ACN

Results from a logistic regression model with terms for race, age and sex supported inclusion of an interaction term for race by sex ($P=0.034$) but not race by age ($P=0.20$). After controlling for the risk factors presented in Table 1, black men remained at lower odds of ACN than white men (aOR, 0.59; 95% CI, 0.39–0.89), whereas differences between black and white women remained non-significant (aOR, 1.32; 95% CI, 0.73–2.40); (Table 4). These analyses also identified smoking for 20+ years (aOR, 2.90; 95% CI 2.08–4.04), consumption of 2+ servings of alcoholic daily (aOR, 1.86; 95% CI, 1.20–2.88) and NSAID use (aOR, 0.65; 95% CI, 0.47–0.91) as independent determinants of risk (Appendix Table 3)

Among individuals with ACN, a higher percentage of blacks had proximal disease (52% vs. 39%) after adjustment for age and sex ($P=0.055$). This predilection for proximal location was observed for both men (54.3% vs. 40.3%) and women (50.0% vs. 33.3%).

Sensitivity Analysis

A sensitivity analysis was conducted to explore the impact of excluding the 135 patients (51 black and 25 white men; 42 black and 17 white women) with poor bowel preparation. If

these patients had 3 times the odds of ACN as those with adequate preparation, their inclusion would increase the unadjusted odds of ACN for black men from the observed 0.59 to 0.61 (95% CI, 0.42 – 0.89) and for black women from 1.23 to 1.26 (95% CI, 0.73 – 2.17). We also explored the impact of an unmeasured covariate on the lower adjusted OR for black men. Results would remain significant unless the association between the confounder and ACN is moderately strong (OR = 2.0), and the risk factor was substantially more prevalent in whites than blacks (e.g., 30% vs. 10%, or 40% vs. 20%) (Appendix Table 4).

Discussion

Our study affirms the importance of race as an independent determinant of risk. However, contrary to the results of several previously published studies (14–17), we found that the prevalence of ACN was higher among whites than blacks overall, and in particular, white men compared to black men after adjustment for other known CRC risk factors. Although no significant differences were observed between white and black women, our findings are inclusive, presumably due to the low prevalence of ACN in this subgroup. Like others (14, 15, 17), however, we did observe a predilection for proximal disease among blacks compared to whites with ACN. The findings related to differences in the overall prevalence of ACN are noteworthy since similar sex-specific relationships were observed for CRC incidence rates among whites and blacks prior to the rise in screening rates (12). These findings are also consistent with results from a MISCAN microsimulation modeling study that estimated that 51% of the disparity in CRC incidence rate for men and 32% for women could be explained by differences in screening (13).

Previous studies comparing the prevalence and location of ACN among whites and blacks have provided conflicting results. The largest such study reported by Lieberman et al. used pooled data from the Clinical Outcomes Research Initiative (CORI) consortium and found that the prevalence of polyps > 9 mm in size, a surrogate for ACN, was higher among both black men and women after adjustment for age, sex and family history (14). Lebwohl and colleagues also observed a higher rate of ACN for both black men and women, using conventional histopathologic criteria, after adjustments for age, sex, family history, insurance status and trainee participation (17). Conversely, the Prostate, Lung, Colorectal and Ovarian (PLCO) Cancer Screening Trial (15) and a study by Friedenberg et al. (16) both found no association between race and ACN. The four studies also exhibited disparate results with respect to location of disease with two studies finding a higher prevalence of proximal ACN among blacks overall (15, 17), one study finding a higher prevalence among blacks older than age 60 but not overall (14), and one finding no difference (16). We speculate that differences in the primary endpoint (e.g., polyp size vs. histopathology), racial misclassification, ethnic mix, and differential exposure to modifiable risk factors for ACN (e.g., smoking or prior colonoscopy) may explain this variance.

Our study has several noteworthy strengths that lend credence to our findings. First, the prospective enrollment of patients enabled us to control for prior exposure to colonoscopy and other epidemiologic determinants of risk thus minimizing confounding. Second, the safety net health care setting provided a unique opportunity to assess the prevalence of ACN among a patient population devoid of many of the financial barriers to access to CRC

screening present in other health care settings. Third, we employed a more valid measure of ACN than polyp size alone to define our outcome of interest, since 10–20% of polyps ≥ 10 mm will be non-neoplastic and 2–10% of polyps < 10 mm in size will have advanced histology (32–35). Lastly, we also restricted our analyses to patients with complete examinations with adequate bowel preparations and complete retrieval of all polyp specimens to minimize misclassification.

Our study also had several important limitations. First, the study was conducted at a single urban, academic medical center and thus our findings may not be generalizable to other health care settings in other geographic regions where ethnic mix or exposure rates to modifiable risk factors may differ. Because of the widespread disparities in access to colonoscopy in most other health settings, however, we believe that the internal validity of our findings may be more relevant than their external validity. Second, the use of a convenience sample also raises concern about potential selection bias. This concern, however, is offset by the fact that blacks and whites had equal access to screening colonoscopy, patients were recruited consecutively and enrollment was high. Third, our study lacked sufficient statistical power for many of our subgroup analyses, particularly women, because of the relatively low prevalence of disease. Fourth, our study design does not preclude the possibility of length time bias as a possible explanation for the higher cancer incidence observed among blacks. Nevertheless, cancer registry data for the state of Massachusetts for 2000–2009 (36, 37), which has among the highest CRC screening rates in the nation for both whites and blacks, reveals lower age-adjusted CRC incidence rates among blacks than whites of both sexes, thus reducing the likelihood of length time bias (2). Fifth, although patients were recruited prospectively, our response data from the questionnaire is subject to recall bias. Sixth, although our data on race and ethnicity were determined by self-report, misclassification remains a possibility because mixed ancestry, acculturation and/or assimilation. Seventh, the reliance on subjective estimates of polyp size at endoscopy may have resulted in misclassification. The observation that whites were also more likely than blacks to present with non-advanced adenomas 6–9 mm in size lessens this concern. Lastly, our selection criteria precluded a comparison of ACN prevalence in individuals under age 50 and thus cannot shed light on recommendations by some professional groups to initiate screening for blacks at age 45 (38, 39).

Despite these limitations, our findings have important public health implications since they highlight the need for targeted strategies aimed at increasing screening rates among blacks in settings where disparities exist. These strategies must not only address barriers to access (e.g., lack of health care insurance) but also patient and physician level barriers to acceptance, adherence and utilization. Despite the predilection for proximal disease among blacks with ACN, the relatively high proportion of patients with proximal disease in both groups supports the use of colonoscopy over flexible sigmoidoscopy for whites and blacks undergoing endoscopic screening. Our study also reinforces the importance of risk-reducing lifestyle changes (e.g., smoking cessation), which may account for another 34–46% of the variation in risk (13).

In conclusion, our study finds that race is an independent determinant of ACN at screening colonoscopy, but in contradistinction to several previously published studies, we find that

risk is higher among white than blacks overall and, in particular, white men compared to black men, after adjustment for prior exposure to screening colonoscopy and other known epidemiologic determinants of risk. Our findings provide new evidence suggesting that disparities in access to screening and differential exposure to modifiable risk factors rather than genetic differences are largely responsible for the higher overall incidence of CRC among blacks, especially black men. Future studies, however, are warranted to better define the extent to which genetic or biologic factors might explain the predilection for proximal disease among blacks.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Appendix

Appendix Table 1

Characteristics of the White and Black Study Cohorts – MEN ONLY

Characteristic	n (%) Patients		P value *
	Whites (n=663)	Blacks (n=802)	
<i>Sociodemographic factors</i>			
Mean age (SD), years	55.9 (6.3)	56.5 (6.5)	0.054
Categorical age, years			0.44
50–59	499 (75.3)	580 (72.3)	
60–69	132 (19.9)	177 (22.1)	
70–79	32 (4.8)	45 (5.6)	
Sex			N/A
Male	663 (56.6)	802 (47.7)	
Female			
Education			<0.001
High school	277 (55.6)	514 (70.7)	
> High school	221 (44.4)	213 (29.3)	

Characteristic	n (%) Patients		P value *
	Whites (n=663)	Blacks (n=802)	
Insurance			<0.001
Commercial/Private	343 (51.7)	228 (28.4)	
Medicare	110 (16.6)	154 (19.2)	
Medicaid	169 (25.5)	308 (38.4)	
Free care	34 (5.1)	100 (12.5)	
Military	0	1 (0.1)	
Self-pay/Uninsured	7 (1.1)	11 (1.4)	
<i>Risk Factors (besides age and sex)</i>			
Body mass index			0.35
< 30	455 (70.2)	533 (67.9)	
> 30	193 (29.8)	252 (32.1)	
Mean body mass index (SD)	28.3 (5.4)	28.2 (4.9)	0.61
Height			0.001
Men 5'10", Women 5'7"	368 (57.0)	518 (65.9)	
Men > 5'10", Women > 5'7"	278 (43.0)	268 (34.1)	
Mean height (SD)	69.8 (3.2)	69.1 (3.3)	<0.001
Smoking,			0.50
Never/<20 years	413 (62.8)	514 (64.5)	
20 years	245 (37.2)	283 (35.5)	
Daily servings of alcohol			0.001
< 2	543 (82.5)	710 (88.6)	
2	115 (17.5)	91 (11.4)	
Aspirin use, most days > 15 years			0.007
No	642 (97.3)	788 (99.1)	
Yes	18 (2.7)	7 (0.9)	
NSAID use			<0.001
Never	296 (45.5)	470 (59.4)	
Ever	354 (54.5)	321 (40.6)	
Birth control pill use			N/A
Never/< 5 years			
5 years			
Hormone replacement therapy			N/A
Never/< 5 years			
5 years			
Red meat intake			<0.001
< 3 servings a week	364 (55.1)	556 (69.3)	
3 servings a week	297 (44.9)	246 (30.7)	
Multivitamin use, 4 days a week			0.008
No	413 (62.4)	553 (69.0)	
Yes	249 (37.6)	248 (31.0)	

Characteristic	n (%) Patients		P value *
	Whites (n=663)	Blacks (n=802)	
Calcium “sufficient” [†] , [‡]			<0.001
No	539 (81.3)	716 (89.3)	
Yes	124 (18.7)	86 (10.7)	
Daily vitamin D supplement ± calcium use [§]			0.72
No	581 (88.6)	693 (87.9)	
Yes	75 (11.4)	95 (12.1)	
Moderate physical activity 30 minutes daily			0.146
No	162 (24.5)	223 (27.9)	
Yes	499 (75.5)	577 (72.1)	
Diabetes mellitus			<0.001
No	607 (91.5)	630 (78.5)	
Yes	56 (8.5)	172 (21.5)	
Prior colonoscopy (> 10 years)			0.38
No	437 (92.2)	554 (93.6)	
Yes	37 (7.8)	38 (6.4)	

NSAID, non-steroidal anti-inflammatory drugs; OR, odds ratio; CI, confidence interval

* Chi-square analysis for categorical variables and t-tests for continuous variables

[†] Calcium “sufficient” defined by daily use of a calcium supplement or daily intake of 3 servings of milk/dairy.

[‡] Multiple imputation was used to account for missing data for dairy intake and diabetes mellitus for those enrolled prior to 2007 because of changes in our risk assessment questionnaire (189 whites, 209 blacks)

[§] Daily vitamin D group includes patients who took a multivitamin

Appendix Table 2

Characteristics of the White and Black Study Cohorts – WOMEN ONLY

Characteristic	n (%) Patients		P value *
	Whites (n=509)	Blacks (n=879)	
<i>Sociodemographic factors</i>			
Mean age (SD), years	56.2 (6.2)	56.2 (6.2)	0.98
Categorical age, years			0.68
50–59	375 (73.7)	635 (72.2)	
60–69	109 (21.4)	205 (23.3)	
70–79	25 (4.9)	39 (4.4)	
Sex			N/A
Male			
Female	509 (43.4)	879 (52.3)	
Education			<0.001
High school	205 (54.0)	633 (77.4)	
> High school	175 (46.0)	185 (22.6)	
Insurance			<0.001
Commercial/Private	294 (57.8)	281 (32.0)	
Medicare	62 (12.2)	129 (14.7)	
Medicaid	112 (22.0)	316 (36.0)	
Free care	36 (7.1)	141 (16.0)	
Military	0	0	
Self-pay/Uninsured	5 (1.0)	12 (1.4)	
<i>Risk Factors (besides age and sex)</i>			
Body mass index			<0.001
< 30	346 (68.8)	375 (44.0)	
> 30	157 (31.2)	477 (56.0)	
Mean body mass index (SD)	28.2 (6.5)	31.7 (6.2)	<0.001
Height			0.62
Men 5'10", Women 5'7"	435 (86.6)	754 (87.6)	
Men > 5'10", Women > 5'7"	67 (13.4)	107 (12.4)	
Mean height (SD)	64.4 (2.7)	64.4 (3.0)	0.94
Smoking,			<0.001
Never/<20 years	375 (74.1)	720 (82.4)	
20 years	131 (25.9)	154 (17.6)	
Daily servings of alcohol			<0.001
< 2	460 (90.7)	855 (97.4)	
2	47 (9.3)	23 (2.6)	
Aspirin use, most days > 15 years			0.031
No	495 (98.0)	865 (99.3)	
Yes	10 (2.0)	6 (0.7)	
NSAID use			<0.001

Characteristic	n (%) Patients		P value *
	Whites (n=509)	Blacks (n=879)	
Never	338 (67.2)	451 (52.1)	
Ever	165 (32.8)	415 (47.9)	
Birth control pill use			0.048
Never/< 5 years	353 (70.0)	655 (74.9)	
5 years	151 (30.0)	219 (25.1)	
Hormone replacement therapy			<0.001
Never/< 5 years	467 (92.1)	852 (97.3)	
5 years	40 (7.9)	24 (2.7)	
Red meat intake			0.004
< 3 servings a week	361 (70.9)	683 (77.8)	
3 servings a week	148 (29.1)	195 (22.2)	
Multivitamin use, 4 days a week			<0.001
No	263 (51.7)	544 (62.0)	
Yes	246 (48.3)	334 (38.0)	
Calcium "sufficient" [†] , [‡]			<0.001
No	264 (51.9)	298 (33.9)	
Yes	245 (48.1)	581 (66.1)	
Daily vitamin D supplement ± calcium use [§]			0.006
No	309 (61.2)	599 (68.5)	
Yes	196 (38.8)	275 (31.5)	
Moderate physical activity 30 minutes daily			0.032
No	135 (26.6)	282 (32.1)	
Yes	372 (73.4)	596 (67.9)	
Diabetes mellitus			<0.001
No	473 (92.9)	674 (76.7)	
Yes	36 (7.1)	205 (23.3)	
Prior colonoscopy (> 10 years)			0.71
No	345 (91.8)	581 (91.1)	
Yes	31 (8.2)	57 (8.9)	

NSAID, non-steroidal anti-inflammatory drugs; OR, odds ratio; CI, confidence interval

* Chi-square analysis for categorical variables and t-tests for continuous variables

[†] Calcium "sufficient" defined by daily use of a calcium supplement or daily intake of 3 servings of milk/dairy.

[‡] Multiple imputation was used to account for missing data for dairy intake and diabetes mellitus for those enrolled prior to 2007 because of changes in our risk assessment questionnaire (133 whites, 241 blacks)

[§] Daily vitamin D group includes patients who took a multivitamin.

Appendix Table 3

Unadjusted Prevalence of Advanced Colorectal Neoplasia Among Average Risk Whites and Blacks Undergoing Screening Colonoscopy

Characteristics	ACN, n/N (%)		OR (95 % CI) *
	Whites	Blacks	
<i>Overall</i>	80/1172 (6.8)	84/1681 (5.0)	0.72 (0.52–0.98)
<i>Age, years</i>			
50 – 59	55/874 (6.3)	59/1215 (4.9)	0.76 (0.52–1.11)
60 – 69	20/241 (8.3)	19/382 (5.0)	0.58 (0.30–1.11)
70 –79	5/57 (8.8)	6/84 (7.1)	0.80 (0.23–2.76)
<i>Sex</i>			
Men	62/663 (9.3)	46/802 (5.7)	0.59 (0.40–0.88)
Women	18/509 (3.5)	38/879 (4.3)	1.23 (0.70–2.18)
<i>Age/Sex</i>			
Men < age 60	45/499 (9.0)	30/580 (5.2)	0.55 (0.34–0.89)
Men age 60	17/164 (10.4)	16/222 (7.2)	0.67 (0.33–1.37)
Women < age 60	10/375 (2.7)	29/635 (4.6)	1.75 (0.84–3.63)
Women age 60	8/134 (6.0)	9/244 (3.7)	0.60 (0.23–1.60)

ACN, advanced colorectal neoplasia; OR, odds ratio; CI, confidence intervals

* Logistic regression analysis

Appendix Table 4

Sensitivity Analysis to Examine the Potential Impact of an Unmeasured Covariate on the Association Between Race for Men and Advanced Colorectal Neoplasia

		OR between confounder and ACN			
Prevalence of Confounder in Blacks	Prevalence of Confounder in Whites	1.5	2.0	2.5	3.0
10%	20%	0.62 (0.42 – 0.92)	0.64 (0.43 – 0.96)	0.67 (0.45 – 0.99)	0.69 (0.45 – 1.03)
	30%	0.66 (0.43 – 0.96)	0.70 (0.47 – 1.04)	0.74 (0.50 – 1.11)	0.79 (0.52 – 1.18)
	40%	0.67 (0.45 – 1.00)	0.75 (0.50 – 1.13)	0.82 (0.55 – 1.24)	0.88 (0.59 – 1.34)
	50%	0.70 (0.47 – 1.05)	0.80 (0.53 – 1.21)	0.90 (0.59 – 1.36)	0.98 (0.65 – 1.49)
20%	30%	0.62 (0.42 – 0.92)	0.64 (0.43 – 0.95)	0.66 (0.44 – 0.98)	0.67 (0.45 – 1.01)
	40%	0.64 (0.43 – 0.96)	0.69 (0.46 – 1.03)	0.73 (0.48 – 1.09)	0.76 (0.50 – 1.14)
	50%	0.67 (0.45 – 1.00)	0.74 (0.49 – 1.11)	0.79 (0.53 – 1.20)	0.84 (0.56 – 1.28)
30%	40%	0.62 (0.41 – 0.91)	0.64 (0.43 – 0.95)	0.65 (0.43 – 0.98)	0.66 (0.44 – 1.00)

ACN, advanced colorectal neoplasia; OR, odds ratio; CI, confidence interval

* Values are the adjusted OR and 95% CI for ACN in black vs. white men, controlling for an unmeasured confounder, indexed by the prevalence of the confounder in the black and white samples and the odds ratio between the confounder and ACN. The observed unadjusted odds ratio for ACN in blacks vs. whites was 0.59.

Fig. 1.
Study flow diagram

Table 1

Characteristics of the White and Black Study Cohorts

Characteristic	No. (%) Patients		<i>P</i> value *
	Whites (n=1172)	Blacks (n=1681)	
<i>Sociodemographic factors</i>			
Mean age (SD), years	56.0 (6.2)	56.4 (6.3)	0.16
Categorical age, years			0.37
50–59	874 (74.6)	1215 (72.3)	
60–69	241 (20.6)	382 (22.7)	
70–79	57 (4.9)	84 (5.0)	
Sex			<0.001
Male	663 (56.6)	802 (47.7)	
Female	509 (43.4)	879 (52.3)	
Education			<0.001
High school	482 (54.9)	1147 (74.2)	
> High school	396 (45.1)	398 (25.8)	
Insurance			<0.001
Commercial/Private	638 (54.4)	511 (30.4)	
Medicare	172 (14.7)	283 (16.8)	
Medicaid	281 (24.0)	624 (37.1)	
Free care	69 (5.9)	239 (14.2)	
Military	0	1 (0.1)	
Self-pay/Uninsured	12 (1.0)	23 (1.4)	
<i>Risk Factors (besides age and sex)</i>			
Body mass index			<0.001
< 30	801 (69.6)	908 (55.5)	
> 30	350 (30.4)	729 (44.5)	
Mean body mass index (SD)	28.3 (5.9)	30.1 (6.5)	<0.001
Height			<0.001
Men 5'10", Women 5'7"	803 (70.0)	1272 (77.2)	
Men > 5'10", Women > 5'7"	345 (30.0)	375 (22.8)	
Mean height (SD)	67.4 (4.1)	66.7 (3.9)	<0.001
Smoking,			<0.001
Never/<20 years	788 (67.7)	1234 (73.8)	
20 years	376 (32.3)	437 (26.2)	
Daily servings of alcohol			<0.001
< 2	1003 (86.1)	1565 (93.2)	
2	162 (13.9)	114 (6.8)	
Aspirin use, most days > 15 years			<0.001
No	1137 (97.6)	1653 (99.2)	
Yes	28 (2.4)	13 (0.8)	
NSAID use			<0.001

Characteristic	No. (%) Patients		P value *
	Whites (n=1172)	Blacks (n=1681)	
Never	692 (60.0)	772 (46.6)	
Ever	461 (40.0)	885 (53.4)	
Birth control pill use			<0.05
Never/< 5 years	353 (70.0)	655 (74.9)	
5 years	151 (30.0)	219 (25.1)	
Hormone replacement therapy			<0.001
Never/< 5 years	467 (92.1)	852 (97.3)	
5 years	40 (7.9)	24 (2.7)	
Red meat intake			<0.001
< 3 servings a week	725 (62.0)	1239 (73.8)	
3 servings a week	445 (38.0)	441 (26.2)	
Multivitamin use, 4 days a week			<0.001
No	676 (57.7)	1097 (65.3)	
Yes	495 (42.3)	582 (34.7)	
Calcium “sufficient” [†] , [‡]			<0.001
No	783 (66.8)	1298 (77.2)	
Yes	486 (33.2)	383 (22.8)	
Daily vitamin D supplement ± calcium use [§]			0.50
No	890 (76.7)	1292 (77.7)	
Yes	271 (23.3)	370 (22.3)	
Moderate physical activity 30 minutes daily			<0.01
No	297 (25.4)	505 (30.1)	
Yes	871 (74.6)	1173 (69.9)	
Diabetes mellitus [‡]			<0.001
No	1080 (92.1)	1304 (77.3)	
Yes	92 (7.9)	377 (22.4)	
Prior colonoscopy (> 10 years)			0.82
No	782 (92.0)	1135 (92.3)	
Yes	68 (8.0)	95 (7.7)	

NSAID, non-steroidal anti-inflammatory drugs; OR, odds ratio; CI, confidence interval

* Chi-square analysis for categorical variables and t-tests for continuous variables

[†] Calcium “sufficient” defined by daily use of a calcium supplement or daily intake of 3 servings of milk/dairy.

[‡] Multiple imputation was used to account for missing data for dairy intake and diabetes mellitus for those enrolled prior to 2007 because of changes in our risk assessment questionnaire (322 whites, 450 blacks).

[§] Daily vitamin D group includes patients who took a multivitamin.

Table 2

Colonoscopy Findings by Race/Ethnicity *

Variable	No. (%) of Total Patients			No. (%) Patient with ACN		
	Whites (n = 1172)	Blacks (n = 1681)	P value ¶	Whites (n = 80)	Blacks (n = 84)	P value ¶
<i>Overall Findings</i>						
Normal	619 (52.8)	1006 (59.8)	<0.001			
Non-dysplastic serrated lesions †	170 (14.5)	208 (12.4)	0.099			
Non-advanced tubular adenomas	303 (25.8)	383 (22.8)	0.059			
Multiplicity (n = 3)	48 (4.1)	35 (2.1)	0.002			
Size 6-9 mm	76 (6.5)	78 (4.6)	0.032			
ACN	80 (6.8)	84 (5.0)	0.039			
<i>Histologic subtype and anatomic location of ACN</i>						
<i>Histologic Subtypes</i>						
Tubular adenomas 10 mm	50 (4.3)	45 (2.7)	0.020	50 (62.5)	45 (53.6)	0.55
Villous features/high-grade dysplasia	23 (2.0)	27 (1.6)	0.47	23 (28.8)	27 (32.1)	
Dysplastic serrated lesions †	2 (0.2)	5 (0.3)	0.71	2 (2.5)	5 (6.0)	
Invasive cancer	5 (0.4)	7 (0.4)	0.99	5 (6.2)	7 (8.3)	
<i>Anatomic location†</i>						
Distal	49 (4.2)	40 (2.4)	0.007	49 (61.3)	40 (47.6)	0.080
Proximal §	31 (2.6)	44 (2.6)	0.96	31 (38.8)	44 (52.4)	

* Colonoscopy findings defined by most advanced histology

† Non-dysplastic serrated lesions include hyperplastic polyps and sessile serrated adenomas/polyps without cytological dysplasia; dysplastic serrated lesions include sessile serrated adenomas/polyps with cytological dysplasia and include sessile serrated adenomas/polyps with cytological dysplasia and traditional serrated adenomas.

‡ Distal refers to rectum, sigmoid colon and descending colon; proximal refers to neoplastic lesions arising in the splenic flexure, transverse colon, hepatic flexure, ascending colon or cecum.

§ Proximal group includes five white patients and six black patients had both distal and proximal neoplasia.

¶ Chi-square analysis or Fisher's exact test comparing percent of all patients

|| Chi-square analysis comparing percent of patients with CAN

Table 3

Adjusted Associations Between Race and Advanced Colorectal Neoplasia.

Risk factor	Unadjusted OR (95% CI)	Adjusted OR (95% CI) [‡]
Race		
Men		
Black vs. White	0.59 (0.40–0.88)	0.59 (0.39–0.89)
Women		
Black vs. White	1.23 (0.70–2.18)	1.32 (0.73 – 2.40)
Age, per year increase (50 to 79)	1.02 (1.00–1.05)	1.02 (1.00–1.05)
Body Mass Index, per unit increase	1.00 (0.97–1.02)	1.01 (0.98–1.05)
Height, per inch increase	1.06 (1.02–1.10)	1.01 (0.96–1.07)
Smoking,		
< 20 years	Reference	Reference
20 years	3.24 (2.35–4.46)	2.90 (2.08–4.04)
Daily servings of alcohol		
< 2	Reference	Reference
2	2.34 (1.55–3.53)	1.86 (1.20–2.88)
NSAID use		
Never	Reference	Reference
Ever	0.63 (0.46–0.87)	0.65 (0.47–0.91)
Use of birth control pills		
Never/< 5 years	Reference	Reference
5 years	0.84 (0.44–1.58)	0.93 (0.50–1.74)
Use of hormone replacement therapy		
Never/< 5 years	Reference	Reference
5 years	0.77 (0.18–3.24)	0.73 (0.17–3.15)
Red meat intake		
< 3 servings per week	Reference	Reference
3 servings a week	1.23 (0.88–1.71)	0.97 (0.69 –1.38)
Multivitamin use		
< 4 days a week	Reference	Reference
4 days a week	1.15 (0.83–1.58)	1.13 (0.72–1.77)
Calcium “sufficient” [*]		
Yes	Reference	Reference
No	1.06 (0.73–1.53)	0.92 (0.60–1.43)
Daily vitamin D supplement [±]		
calcium [‡]		
No	Reference	Reference
Yes	0.92 (0.63–1.35)	1.13 (0.72–1.77)
Moderate physical activity 30 minutes daily		

Risk factor	Unadjusted OR (95% CI)	Adjusted OR (95% CI) [‡]
No	Reference	Reference
Yes	0.94 (0.66–1.32)	0.96 (0.67–1.37)
Diabetes mellitus		
No	Reference	Reference
Yes	0.94 (0.59–1.50)	1.01 (0.60–1.71)

* Calcium “sufficient” defined by daily use of a calcium supplement or daily intake of ≥ 3 servings of milk/dairy.

[†] Daily vitamin D group includes patients who took a multivitamin.

[‡] Logistic regression with adjustment for age and risk factors listed in Table 1, with use of multiple imputation to account for missing data for dairy intake and diabetes mellitus. The model included an interaction term for race by sex ($P=0.034$)