

Confounders in Adenoma Detection at Initial Screening Colonoscopy: A Factor in the Assessment of Racial Disparities as a Risk for Colon Cancer

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Abstract

Background and Aims: The incidence and mortality of colorectal cancer is persistently highest in Black/African-Americans in the United States. While access to care, barriers to screening, and poverty might explain these findings, there is increased interest in examining biological factors that impact the colonic environment. Our group is examining biologic factors that contribute to disparities in development of adenomas prospectively. In preparation for this and to characterize a potential patient population, we conducted a retrospective review of initial screening colonoscopies in a cohort of patients. **Methods:** A retrospective review was performed on initial average risk screening colonoscopies on patients (age 45 - 75 years) during 2012 at three institutions. Descriptive statistics and multivariable logistic regression models were used to examine the relationship between potential risk factors and the detection of adenomas. **Results:** Of the 2225 initial screening colonoscopies 1495 (67.2%) were performed on Black/African-Americans and 566 (25.4%) on Caucasians. Multivariable logistic regression revealed that older age, male sex, current smoking and teaching gastroenterologists were associated with higher detection of adenomas and these were less prevalent among Black/African-Americans except for age. Neither race, ethnicity, BMI, diabetes mellitus, HIV

nor insurance was associated with adenoma detection. **Conclusion:** In this sample, there was no association between race and adenoma detection. While this may be due to a lower prevalence of risk factors for adenomas in this sample, our findings were confounded by a lower detection rate by consultant gastroenterologists at one institution. The study allowed us to rectify the problem and characterize patients for future trials.

Keywords

Colorectal, Cancer, Screening, Adenoma, Quality

1. Introduction

Colorectal Cancer (CRC) is the fourth most common cancer in the United States (US) and second most lethal [1]. Most colon cancers develop via a multistep process involving a series of somatic genetic mutations and histopathologic changes that accumulate over time that is estimated to take approximately 10 - 15 years [2] [3] [4]. Consequently, screening with removal of adenomas and early detection of colorectal cancers has contributed to substantial decreases in the incidence and mortality of colorectal cancer in the United States over the past 10 years [5] [6] [7] [8].

Multiple studies have reported increased risk of colon cancer regardless of racial group to be associated with age, male sex, family history in a first degree relative, smoking, as well as diabetes mellitus and BMI which can be a reflection of diet and activity level [9] [10]. At the molecular level, inflammatory processes are associated with colon tumorigenesis [11]. We hypothesize that these factors also contribute to a higher incidence of precancerous colon polyps and sought to characterize the impact of these factors in our patients.

The incidence and mortality of colon cancer remains significantly higher in Blacks/African-Americans than all other races and ethnicities in this US [1] [12]. This persistent disparity is likely multifactorial in etiology. The incidence and risk of colon cancer is thought to be low in Africa. This may be a reflection of lower rates of detection due to lower screening rates. However investigators have suggested that the higher incidence in US Blacks/African-Americans may be due to biological risk factors as a result of gene-environment interactions [13] [14] [15] [16]. Additionally, disparities in socioeconomic status could contribute to unequal access to colon cancer screening here and abroad [17] [18]. We hypothesize that African-Americans have more risk factors for colorectal cancer and are also more likely to have a higher prevalence of adenomas.

To test these hypotheses, we conducted a retrospective chart review of initial screening colonoscopies performed at three collaborating institutions: SUNY Downstate Medical Center (DMC), New York City Health and Hospitals/Kings County (Kings County), and Stony Brook University Hospital (SBUMC). DMC and SBUMC are funded by New York State while Kings County is supported by

the New York Health and Hospital Corporation. DMC and Kings County are in central Brooklyn and SBUMC is in Long Island, New York. All three institutions educate residents and fellows and all three employ consultant gastroenterologists from time to time.

2. Methods

Collection of clinical data from initial screening colonoscopies performed in 2012

This study was approved by the Institutional Review Boards for all three institutions (IRB # 802718 for DMC and Kings County, approved 07/21/2017; IRB # 966231 for SBUMC, approved 03/21/2017). Patients who underwent screening colonoscopies between January 1 and December 31, 2012, were identified using the endoscopy reporting software at each of the three institutions.

Patients age < 45 y or >75 y, a history of previous colonoscopy, a history of inflammatory bowel diseases, known hereditary colorectal syndromes, detection of microscopic or macroscopic blood in stool and other alarm symptoms, detection of colonic masses or polyps on previous studies, were excluded from this analysis. We excluded colonoscopies that were incomplete (did not reach the cecum) and those associated with poor bowel preparation.

The clinical metadata was collected using the same data vocabulary at the three institutions and included: 1) age (y) at time of initial screening colonoscopy; 2) sex (male/female); 3) race (Black/Caucasian/Other); 4) ethnicity (Hispanic/non-Hispanic); 5) BMI (kg/m²); 6) diabetes mellitus (diagnosed, not diagnosed); 7) smoking (current/ not current); 8) HIV-1 (diagnosed/not diagnosed); 9) gastroenterologist (teaching versus consultant); and 10) insurance status (Commercial, Medicare, Medicaid, Self-pay). Patients who had both Commercial and Medicare insurance were classified in the Commercial category. Patients who had both Medicare and Medicaid insurance were classified in the Medicare category. Family history of colon cancer or a polyp in a first degree relative, was not included in the analysis since that data was unevenly collected.

2225 patients with colonoscopy screening were used in this analysis: DMC (N = 444, 20%), Kings County (N = 1134, 51%), SBUMC (N = 647, 29%). The outcomes of interest were: adenomas, advanced adenomas, and right colon adenomas.

Statistical analysis

Descriptive statistics and multivariable logistic regression models were used to examine the relationship between potential risk factors and the detection of three different types of adenomas (all adenomas, advanced adenomas, and right colon adenomas). Due to the high correlation between “race” and “institution”, three sets of multivariable logistic regression models were fitted for each clinical outcome: 1) both “race” and “institution” were used in the model; 2) only “race” was used in the model; and 3) only “institution” was used in the model. Since, in general, significant risk factors from 3 multivariable regression models were consistent, and based on c-index values, results from the models that contained both “race” and “institution” were reported here.

In each multivariable regression analysis, an OR > 1 indicates that one category has more risk of having adenoma detection than the reference category, and OR < 1 indicates that one category has less risk of having adenoma detection than the reference category. Generalized linear mixed models considering patients from the same institution as clusters were also considered. However, since there is no strong evidence that patients with same institution were highly correlated, results from logistic regression models were only reported here. Statistical analysis was performed using SAS 9.4 and significance level was set at 0.05 (SAS Institute, Inc., Cary, NC).

3. Results

Table 1 displays the descriptive table for clinical outcomes and patients' demographics stratified by institution. Based on this table, marginally, all variables were significantly associated with the institutions. For example, 29.73% of patients from DMC had adenoma, while 17.11% of patients from Kings County had adenoma, and 25.97% of patients from SBUMC had adenoma (P-value¹ < 0.0001).

Table 2 describes patients' demographics by the clinical outcomes of interest: adenoma, advanced adenoma, and right colonic adenoma. Based on this table, marginally, age, gender, insurance, institution, race, type of attending, tobacco use, diabetes, and HIV-negative status were significantly associated with having an adenoma. For example, 28.54% of patients having adenoma had diabetes, while 23.74% of patients who do not have adenoma had diabetes (P-value = 0.0294). For advanced adenoma, institution, type of attending, fellow, and tobacco use were marginally associated with having this outcome. For right colon adenoma, age, gender, insurance, institution, and type of attending were marginally associated with having this outcome.

Table 3 shows the results of estimated Odds Ratios (ORs) and 95% confidence intervals of potential risk factors for adenomas based on multivariable logistic regression model. After adjusting for other factors, age, gender, tobacco use, and HIV-negative status remain significantly associated with having an adenoma (P-values < 0.05). For example, female patients were significantly less likely to have adenoma than male patients (OR = 0.626, 95% CI: 0.5 - 0.78, P-value < 0.0001).

Table 4 shows the results of estimated ORs and 95% confidence intervals of explanatory variables for having advanced adenoma based on multivariable logistic regression model. Due to the limited event size (N = 98), forward selection was further performed in the multivariable regression model. After adjusting for other factors, insurance, fellow (fellows accompanied academic gastroenterologists and not consultants), and tobacco use were significantly associated with having an advanced adenoma. For example, patients who currently smoke were significantly more likely to have advanced adenoma than patients who do not smoke (OR = 2.362, 95% CI: 1.37 - 4.06, P-value² = 0.0019).

Table 1. Descriptive table for clinical outcomes and patients' demographics by 3 institutions.

Variable	Missing	level	total	DMC (N = 444)	Kings county (N = 1134)	SBUMC (N = 647)	P-value ¹
Adenoma	0	Yes	494 (22.20%)	132 (29.73%)	194 (17.11%)	168 (25.97%)	<0.0001
		No	1731 (77.80%)	312 (70.27%)	940 (82.89%)	479 (74.03%)	
Advanced adenoma	0	Yes	98 (4.40%)	15 (3.38%)	42 (3.70%)	41 (6.34%)	0.0168
		No	2127 (95.60%)	429 (96.62%)	1092 (96.30%)	606 (93.66%)	
Right colon adenoma	0	Yes	316 (14.20%)	77 (17.34%)	142 (12.52%)	97 (14.99%)	0.0378
		No	1909 (85.80%)	367 (82.66%)	992 (87.48%)	550 (85.01%)	
Age (continuous)	0	444 vs 1134 vs 647	57.00 ± 10.73	58.00 ± 12.00	57.63 ± 10.73	55.00 ± 10.00	<0.0001
		45 - 54	879 (39.51%)	144 (32.43%)	438 (38.62%)	297 (45.90%)	
Age (categorical)	0	55 - 64	919 (41.30%)	187 (42.12%)	490 (43.21%)	242 (37.40%)	<0.0001
		≥ 65	427 (19.19%)	113 (25.45%)	206 (18.17%)	108 (16.69%)	
BMI (continuous)	34	413 vs 1131 vs 647	28.27 ± 7.29	28.30 ± 7.80	28.60 ± 7.30	27.48 ± 6.44	0.0002
		Obese (BMI ≥ 30)	829 (37.82%)	166 (40.10%)	460 (40.67%)	203 (31.38%)	
BMI (categorical)	33	Overweight (BMI ≥ 25, <30)	844 (38.50%)	147 (35.51%)	430 (38.02%)	267 (41.27%)	0.0015
		Underweight + Healthy (BMI < 25)	519 (23.68%)	101 (24.40%)	241 (21.31%)	177 (27.36%)	
Gender	0	Female	1437 (64.58%)	276 (62.16%)	772 (68.08%)	389 (60.12%)	0.0016
		Male	788 (35.42%)	168 (37.84%)	362 (31.92%)	258 (39.88%)	
Insurance	0	Private	759 (34.11%)	129 (29.05%)	195 (17.20%)	435 (67.23%)	<0.0001
		Medicare	236 (10.61%)	95 (21.40%)	57 (5.03%)	84 (12.98%)	
		Medicaid	695 (31.24%)	187 (42.12%)	404 (35.63%)	104 (16.07%)	
Race	0	Self-Pay	535 (24.04%)	33 (7.43%)	478 (42.15%)	24 (3.71%)	<0.0001
		African-American	1117 (50.20%)	175 (39.41%)	900 (79.37%)	42 (6.49%)	
		Afro-Caribbean	378 (16.99%)	216 (48.65%)	160 (14.11%)	2 (0.31%)	
		American Indian or Alaskan Native	2 (0.09%)	0 (0.00%)	1 (0.09%)	1 (0.15%)	
		Asian	43 (1.93%)	6 (1.35%)	9 (0.79%)	28 (4.33%)	
Race combined	0	Other	119 (5.35%)	13 (2.93%)	59 (5.20%)	47 (7.26%)	<0.0001
		White	566 (25.44%)	34 (7.66%)	5 (0.44%)	527 (81.45%)	
		White	566 (25.44%)	34 (7.66%)	5 (0.44%)	527 (81.45%)	
		Black	1495 (67.19%)	391 (88.06%)	1060 (93.47%)	44 (6.80%)	
Ethnicity	0	Other	164 (7.37%)	19 (4.28%)	69 (6.08%)	76 (11.75%)	0.0003
		Hispanic	134 (6.02%)	33 (7.43%)	46 (4.06%)	55 (8.50%)	
Type of Attending	0	Non-Hispanic	2091 (93.98%)	411 (92.57%)	1088 (95.94%)	592 (91.50%)	<0.0001
		Consultant	1058 (47.55%)	25 (5.63%)	976 (86.07%)	57 (8.81%)	
		Teaching	1167 (52.45%)	419 (94.37%)	158 (13.93%)	590 (91.19%)	

Continued

Fellow	0	Yes	247 (11.10%)	6 (1.35%)	132 (11.64%)	109 (16.85%)	<0.0001
		No	1978 (88.90%)	438 (98.65%)	1002 (88.36%)	538 (83.15%)	
Tobacco use	68	Current	202 (9.36%)	53 (14.10%)	66 (5.82%)	83 (12.83%)	<0.0001
		Not current	1955 (90.64%)	323 (85.90%)	1068 (94.18%)	564 (87.17%)	
Diabetes	0	Yes	552 (24.81%)	135 (30.41%)	339 (29.89%)	78 (12.06%)	<0.0001
		No	1673 (75.19%)	309 (69.59%)	795 (70.11%)	569 (87.94%)	
HIV Status	1	Yes	85 (3.82%)	38 (8.56%)	42 (3.70%)	5 (0.77%)	<0.0001
		No	2139 (96.18%)	406 (91.44%)	1092 (96.30%)	641 (99.23%)	
Insulin Use	7	Yes	165 (7.44%)	37 (8.45%)	114 (10.05%)	14 (2.17%)	<0.0001
		No	380 (17.13%)	92 (21.00%)	225 (19.84%)	63 (9.75%)	
Metformin Use	8	No diabetes	1673 (75.43%)	309 (70.55%)	795 (70.11%)	569 (88.08%)	<0.0001
		Yes	365 (16.46%)	60 (13.70%)	253 (22.33%)	52 (8.05%)	
		No	179 (8.07%)	69 (15.75%)	85 (7.50%)	25 (3.87%)	
		No diabetes	1673 (75.46%)	309 (70.55%)	795 (70.17%)	569 (88.08%)	

¹For categorical variables, P-value was based on Chi-squared test with exact P-value from Monte Carlo simulation. For continuous variables, P-value was based on Wilcoxon rank sum test and median with IQR were reported. *Since 1 patient from DMC institution had BMI as “>30”, this patient was treated as having missing value when using BMI as continuous values.

Table 2. Descriptive table for patients’ demographics by 3 clinical outcomes.

Variable	Missing	Level	Adenoma			P-value ¹
			Total	Yes (N = 494, 22.2%)	No (N = 1731, 77.8%)	
Age (continuous)	0	494 vs 1731	57.00 ± 10.73	58.76 ± 11.39	56.85 ± 10.84	<0.0001
Age (categorical)	0	45 - 54	879 (39.51%)	159 (32.19%)	720 (41.59%)	0.0002
		≥65	427 (19.19%)	119 (24.09%)	308 (17.79%)	
BMI (continuous)	34	481 vs 1710	28.27 ± 7.29	28.00 ± 6.50	28.30 ± 7.35	0.1718
BMI (categorical)	33	Obese (BMI ≥ 30)	829 (37.82%)	168 (34.85%)	661 (38.65%)	0.2609
		Overweight (BMI ≥ 25, <30)	844 (38.50%)	199 (41.29%)	645 (37.72%)	
		Underweight + Healthy (BMI < 25)	519 (23.68%)	115 (23.86%)	404 (23.63%)	
Gender	0	Female	1437 (64.58%)	275 (55.67%)	1162 (67.13%)	<0.0001
		Male	788 (35.42%)	219 (44.33%)	569 (32.87%)	
Insurance	0	Private	759 (34.11%)	179 (36.23%)	580 (33.51%)	<0.0001
		Medicare	236 (10.61%)	79 (15.99%)	157 (9.07%)	
		Medicaid	695 (31.24%)	142 (28.74%)	553 (31.95%)	
		Self-Pay	535 (24.04%)	94 (19.03%)	441 (25.48%)	

Continued

		DMC	444 (19.96%)	132 (26.72%)	312 (18.02%)	
Institution	0	Kings county	1134 (50.97%)	194 (39.27%)	940 (54.30%)	<0.0001
		SBUMC	647 (29.08%)	168 (34.01%)	479 (27.67%)	
		African-American	1117 (50.20%)	207 (41.90%)	910 (52.57%)	
		Afro-Caribbean	378 (16.99%)	90 (18.22%)	288 (16.64%)	
Race	0	American Indian or Alaskan Native	2 (0.09%)	0 (0.00%)	2 (0.12%)	0.0005
		Asian	43 (1.93%)	10 (2.02%)	33 (1.91%)	
		Other	119 (5.35%)	37 (7.49%)	82 (4.74%)	
		White	566 (25.44%)	150 (30.36%)	416 (24.03%)	
		White	566 (25.44%)	150 (30.36%)	416 (24.03%)	
Race combined	0	Black	1495 (67.19%)	297 (60.12%)	1198 (69.21%)	0.0006
		Other	164 (7.37%)	47 (9.51%)	117 (6.76%)	
		Hispanic	134 (6.02%)	35 (7.09%)	99 (5.72%)	
Ethnicity	0	Non-Hispanic	2091 (93.98%)	459 (92.91%)	1632 (94.28%)	0.2604
		Consultant	1058 (47.55%)	181 (36.64%)	877 (50.66%)	
Type of Attending	0	Teaching	1167 (52.45%)	313 (63.36%)	854 (49.34%)	<0.0001
		Yes	247 (11.10%)	60 (12.15%)	187 (10.80%)	
Fellow	0	No	1978 (88.90%)	434 (87.85%)	1544 (89.20%)	0.4021
		Current	202 (9.36%)	61 (12.79%)	141 (8.39%)	
Tobacco use	68	Not current	1955 (90.64%)	416 (87.21%)	1539 (91.61%)	0.0036
		Yes	552 (24.81%)	141 (28.54%)	411 (23.74%)	
Diabetes	0	No	1673 (75.19%)	353 (71.46%)	1320 (76.26%)	0.0294
		Yes	85 (3.82%)	11 (2.23%)	74 (4.27%)	
HIV Status	1	No	2139 (96.18%)	482 (97.77%)	1657 (95.73%)	0.041

Advanced adenoma

Variable	Missing	Level	Total	Yes (N=98, 4.4%)	No (N=2127, 95.6%)	P-value ¹
Age (continuous)	0	98 vs 2127	57.00 ± 10.73	57.46 ± 10.26	57.00 ± 10.78	0.4729
		45 - 54	879 (39.51%)	33 (33.67%)	846 (39.77%)	
Age (categorical)	0	55 - 64	919 (41.30%)	45 (45.92%)	874 (41.09%)	0.4746
		≥65	427 (19.19%)	20 (20.41%)	407 (19.13%)	
BMI (continuous)	34	98 vs 2093	28.27 ± 7.29	28.45 ± 7.30	28.20 ± 7.20	0.7217
		Obese (BMI ≥ 30)	829 (37.82%)	34 (34.69%)	795 (37.97%)	
BMI (categorical)	33	Overweight (BMI ≥ 25, <30)	844 (38.50%)	43 (43.88%)	801 (38.25%)	0.5332
		Underweight + Healthy (BMI < 25)	519 (23.68%)	21 (21.43%)	498 (23.78%)	

Continued

Gender	0	Female	1437 (64.58%)	55 (56.12%)	1382 (64.97%)	0.0732
		Male	788 (35.42%)	43 (43.88%)	745 (35.03%)	
Insurance	0	Private	759 (34.11%)	31 (31.63%)	728 (34.23%)	0.0691
		Medicare	236 (10.61%)	18 (18.37%)	218 (10.25%)	
		Medicaid	695 (31.24%)	25 (25.51%)	670 (31.50%)	
		Self-Pay	535 (24.04%)	24 (24.49%)	511 (24.02%)	
Institution	0	DMC	444 (19.96%)	15 (15.31%)	429 (20.17%)	0.0168
		Kings county	1134 (50.97%)	42 (42.86%)	1092 (51.34%)	
		SBUMC	647 (29.08%)	41 (41.84%)	606 (28.49%)	
		African-American	1117 (50.20%)	41 (41.84%)	1076 (50.59%)	
Race	0	Afro-Caribbean	378 (16.99%)	17 (17.35%)	361 (16.97%)	0.35
		American Indian or Alaskan Native	2 (0.09%)	0 (0.00%)	2 (0.09%)	
		Asian	43 (1.93%)	1 (1.02%)	42 (1.97%)	
		Other	119 (5.35%)	8 (8.16%)	111 (5.22%)	
		White	566 (25.44%)	31 (31.63%)	535 (25.15%)	
		White	566 (25.44%)	31 (31.63%)	535 (25.15%)	
Race combined	0	Black	1495 (67.19%)	58 (59.18%)	1437 (67.56%)	0.2252
		Other	164 (7.37%)	9 (9.18%)	155 (7.29%)	
Ethnicity	0	Hispanic	134 (6.02%)	5 (5.10%)	129 (6.06%)	0.6953
		Non-Hispanic	2091 (93.98%)	93 (94.90%)	1998 (93.94%)	
Type of Attending	0	Consultant	1058 (47.55%)	37 (37.76%)	1021 (48.00%)	0.047
		Teaching	1167 (52.45%)	61 (62.24%)	1106 (52.00%)	
Fellow	0	Yes	247 (11.10%)	19 (19.39%)	228 (10.72%)	0.0076
		No	1978 (88.90%)	79 (80.61%)	1899 (89.28%)	
Tobacco use	68	Current	202 (9.36%)	18 (18.37%)	184 (8.94%)	0.0034
		Not current	1955 (90.64%)	80 (81.63%)	1875 (91.06%)	
Diabetes	0	Yes	552 (24.81%)	29 (29.59%)	523 (24.59%)	0.2622
		No	1673 (75.19%)	69 (70.41%)	1604 (75.41%)	
HIV Status	1	Yes	85 (3.82%)	1 (1.02%)	84 (3.95%)	0.1801
		No	2139 (96.18%)	97 (98.98%)	2042 (96.05%)	

Right colon adenoma

Variable	Missing	Level	Total	Yes (N = 316, 14.2%)	No (N = 1909, 85.8%)	P-value ¹
Age (continuous)	0	316 vs 1909	57.00 ± 10.73	58.96 ± 10.49	57.00 ± 10.98	<0.0001
		45 - 54	879 (39.51%)	98 (31.01%)	781 (40.91%)	
Age (categorical)	0	55 - 64	919 (41.30%)	142 (44.94%)	777 (40.70%)	0.002
		≥65	427 (19.19%)	76 (24.05%)	351 (18.39%)	

Continued

BMI (continuous)	34	305 vs 1886	28.27 ± 7.29	28.00 ± 6.70	28.30 ± 7.20	0.2358
		Obese (BMI ≥ 30)	829 (37.82%)	106 (34.64%)	723 (38.34%)	
BMI (categorical)	33	Overweight (BMI ≥ 25, <30)	844 (38.50%)	123 (40.20%)	721 (38.23%)	0.4615
		Underweight + Healthy (BMI < 25)	519 (23.68%)	77 (25.16%)	442 (23.44%)	
Gender	0	Female	1437 (64.58%)	181 (57.28%)	1256 (65.79%)	0.0034
		Male	788 (35.42%)	135 (42.72%)	653 (34.21%)	
Insurance	0	Private	759 (34.11%)	110 (34.81%)	649 (34.00%)	0.0004
		Medicare	236 (10.61%)	54 (17.09%)	182 (9.53%)	
		Medicaid	695 (31.24%)	89 (28.16%)	606 (31.74%)	
		Self-Pay	535 (24.04%)	63 (19.94%)	472 (24.72%)	
		DMC	444 (19.96%)	77 (24.37%)	367 (19.22%)	
Institution	0	Kings county	1134 (50.97%)	142 (44.94%)	992 (51.96%)	0.0378
		SBUMC	647 (29.08%)	97 (30.70%)	550 (28.81%)	
		African-American	1117 (50.20%)	146 (46.20%)	971 (50.86%)	
		Afro-Caribbean	378 (16.99%)	52 (16.46%)	326 (17.08%)	
Race	0	American Indian or Alaskan Native	2 (0.09%)	0 (0.00%)	2 (0.10%)	0.2208
		Asian	43 (1.93%)	7 (2.22%)	36 (1.89%)	
		Other	119 (5.35%)	25 (7.91%)	94 (4.92%)	
		White	566 (25.44%)	86 (27.22%)	480 (25.14%)	
		White	566 (25.44%)	86 (27.22%)	480 (25.14%)	
Race combined	0	Black	1495 (67.19%)	198 (62.66%)	1297 (67.94%)	0.0679
		Other	164 (7.37%)	32 (10.13%)	132 (6.91%)	
Ethnicity	0	Hispanic	134 (6.02%)	23 (7.28%)	111 (5.81%)	0.311
		Non-Hispanic	2091 (93.98%)	293 (92.72%)	1798 (94.19%)	
Type of Attending	0	Consultant	1058 (47.55%)	126 (39.87%)	932 (48.82%)	0.0032
		Teaching	1167 (52.45%)	190 (60.13%)	977 (51.18%)	
Fellow	0	Yes	247 (11.10%)	36 (11.39%)	211 (11.05%)	0.8588
		No	1978 (88.90%)	280 (88.61%)	1698 (88.95%)	
Tobacco use	68	Current	202 (9.36%)	35 (11.40%)	167 (9.03%)	0.1862
		Not current	1955 (90.64%)	272 (88.60%)	1683 (90.97%)	
Diabetes	0	Yes	552 (24.81%)	91 (28.80%)	461 (24.15%)	0.0764
		No	1673 (75.19%)	225 (71.20%)	1448 (75.85%)	
HIV Status	1	Yes	85 (3.82%)	6 (1.90%)	79 (4.14%)	0.056
		No	2139 (96.18%)	309 (98.10%)	1830 (95.86%)	

¹For categorical variables, P-value was based on Chi-squared test with exact P-value from Monte Carlo simulation. For continuous variables, P-value was based on Wilcoxon rank sum test and median with IQR were reported. *Since 1 patient from DMC institution had BMI as “>30”, this patient was treated as having missing value when using BMI as continuous values.

Table 3. Estimated odds ratio and their 95% confidence intervals of all potential risk factors for Adenoma based on multivariable logistic regression model (c-index: 0.647).

Variable	Levels	Odds Ratio (95% CI)	P-value ²
Age	Every 1 year increase in Age	1.027 (1.01 - 1.04)	0.0009
BMI	Every 1 unit increase in BMI	0.987 (0.97 - 1.01)	0.1658
Gender	Female vs Male	0.626 (0.5 - 0.78)	<0.0001
	Private vs Medicare	0.767 (0.53 - 1.1)	
	Private vs Medicaid	1.053 (0.79 - 1.4)	
Insurance	Private vs Self-Pay	1.003 (0.71 - 1.41)	0.404
	Medicare vs Medicaid	1.373 (0.94 - 1.99)	
	Medicare vs Self-Pay	1.308 (0.86 - 2)	
	Medicaid vs Self-Pay	0.953 (0.69 - 1.31)	
Institution	DMC vs Kings county	1.515 (0.94 - 2.43)	0.0694
	DMC vs SBUMC	1.605 (0.99 - 2.59)	
	Kings county vs SBUMC	1.059 (0.59 - 1.89)	
Race combined	White vs Black	1.426 (0.89 - 2.29)	0.1116
	White vs Other	0.849 (0.53 - 1.37)	
Ethnicity	Black vs Other	0.596 (0.36 - 0.98)	0.957
	Hispanic vs Non-Hispanic	0.986 (0.6 - 1.62)	
Type of attending	Consultant vs Teaching	0.741 (0.49 - 1.12)	0.1543
	Fellow	Yes vs No	
Tobacco use	Current vs Not current	1.499 (1.07 - 2.11)	0.0195
Diabetes	Yes vs No	1.265 (0.98 - 1.63)	0.066
HIV status	Yes vs No	0.473 (0.24 - 0.95)	0.0348

²P-value was based on type3 analysis from multivariable logistic regression model.

Table 4. Estimated odds ratio and their 95% confidence intervals of all potential risk factors for advanced adenoma based on multivariable logistic regression model (c-index: 0.612).

Variable	Levels	Odds Ratio (95% CI)	P-value ²
Insurance	Private vs Medicare	0.448 (0.24 - 0.82)	0.0245
	Private vs Medicaid	1.137 (0.66 - 1.95)	
	Private vs Self-Pay	0.875 (0.51 - 1.51)	
	Medicare vs Medicaid	2.54 (1.35 - 4.78)	
	Medicare vs Self-Pay	1.953 (1.03 - 3.7)	
	Medicaid vs Self-Pay	0.769 (0.43 - 1.37)	
Fellow	Yes vs No	1.912 (1.13 - 3.24)	0.0158
Tobacco use	Current vs Not current	2.362 (1.37 - 4.06)	0.0019

²P-value was based on type3 analysis from multivariable logistic regression model.

Table 5 shows the results of estimated ORs and 95% confidence intervals of explanatory variables for having right colon adenoma based on multivariable logistic regression model. After adjusting for other factors, age, gender, type of attending, and HIV-negative status were significantly associated with having a right colon adenoma. Older patients were significantly more likely to have right colon adenomas than younger patients (OR = 1.026, 95% CI: 1.01 - 1.05, P-value² = 0.0067).

Table 6 demonstrates the extent to which the ADR of gastroenterologists confounded the other risk factors. It describes the estimated odds ratio and their 95% confidence intervals of all potential risk factors for each clinical outcome based on three sets of multivariable logistic regression model (1st model: Both “race” and “institution” were used in the model; 2nd model: only “race” was used in the model; 3rd model: only “institution” was used in the model). The significant risk factors from all three multivariable regression models were consistent. For example, based on three sets of multivariable regression models, older people were more likely to have adenoma after controlling other factors (ORs > 1, P-values < 0.05). Negative HIV status was significantly associated with having an adenoma after controlling for other factors in 1st and 3rd model (P-values = 0.0348, 0.031, respectively). In contrast, HIV was not significantly associated with having an adenoma but the statistical significance was on the border-line (P-value = 0.0523) based on the 2nd model.

Table 5. Estimated odds ratio and their 95% confidence intervals of all potential risk factors for right colon adenoma based on multivariable logistic regression model (c-index: 0.623).

Variable	Levels	Odds Ratio (95% CI)	P-value ²
Age	Every 1 year increase in Age	1.026 (1.01 - 1.05)	0.0067
BMI	Every 1 unit increase in BMI	0.986 (0.96 - 1.01)	0.2226
Gender	Female vs Male	0.694 (0.54 - 0.9)	0.0049
Insurance	Private vs Medicare	0.689 (0.46 - 1.04)	0.0911
	Private vs Medicaid	1.182 (0.84 - 1.66)	
	Private vs Self-Pay	1.154 (0.78 - 1.72)	
	Medicare vs Medicaid	1.714 (1.12 - 2.63)	
	Medicare vs Self-Pay	1.674 (1.03 - 2.71)	
Institution	Medicaid vs Self-Pay	0.977 (0.68 - 1.41)	0.1979
	DMC vs Kings county	0.794 (0.45 - 1.41)	
	DMC vs SBUMC	1.482 (0.84 - 2.62)	
Race combined	Kings county vs SBUMC	1.867 (0.93 - 3.74)	0.1355
	White vs Black	1.337 (0.76 - 2.35)	
Ethnicity	White vs Other	0.751 (0.43 - 1.32)	0.9402
	Black vs Other	0.561 (0.32 - 0.99)	
Type of attending	Hispanic vs Non-Hispanic	0.978 (0.55 - 1.75)	0.0322
Fellow	Consultant vs Teaching	0.577 (0.35 - 0.95)	0.6373
	Yes vs No	0.89 (0.55 - 1.44)	
Tobacco use	Current vs Not current	1.302 (0.86 - 1.96)	0.2075
Diabetes	Yes vs No	1.143 (0.85 - 1.53)	0.3706
HIV status	Yes vs No	0.392 (0.15 - 0.99)	0.0486

²P-value was based on type3 analysis from multivariable logistic regression model.

Table 6. Estimated odds ratio and their 95% confidence intervals of all potential risk factors for each clinical outcome based on multivariable logistic regression model.

Outcome	variable	Levels	Both race and institution		Only race		Only institution		
			Odds Ratio (95% CI)	P-value ²	Odds Ratio (95% CI)	P-value ²	Odds Ratio (95% CI)	P-value ²	
Adenoma	Age	Every 1 year increase in Age	1.027 (1.01 - 1.04)	0.0009	1.028 (1.01 - 1.04)	0.0006	1.027 (1.01 - 1.04)	0.001	
	BMI	Every 1 unit increase in BMI	0.987 (0.97 - 1.01)	0.1658	0.986 (0.97 - 1)	0.1483	0.985 (0.97 - 1)	0.1247	
	Insurance	Private vs Medicare		0.767 (0.53 - 1.1)	0.404	0.754 (0.53 - 1.08)	0.3508	0.778 (0.54 - 1.12)	0.4401
		Private vs Medicaid		1.053 (0.79 - 1.4)		1.04 (0.79 - 1.38)		1.055 (0.79 - 1.41)	
		Private vs Self-Pay		1.003 (0.71 - 1.41)		1.047 (0.75 - 1.46)		1.026 (0.73 - 1.44)	
		Medicare vs Medicaid		1.373 (0.94 - 1.99)		1.379 (0.95 - 2)		1.355 (0.93 - 1.97)	
		Medicare vs Self-Pay		1.308 (0.86 - 2)		1.389 (0.92 - 2.1)		1.318 (0.86 - 2.01)	
		Medicaid vs Self-Pay		0.953 (0.69 - 1.31)		1.007 (0.74 - 1.37)		0.972 (0.71 - 1.33)	
	Institution	DMC vs Kings county		1.515 (0.94 - 2.43)	0.0694			1.521 (0.95 - 2.43)	0.2029
		DMC vs SBUMC		1.605 (0.99 - 2.59)				1.2 (0.87 - 1.65)	
			Kings county vs SBUMC	1.059 (0.59 - 1.89)				0.789 (0.51 - 1.21)	
	Race combined	Gender	Female vs Male	0.626 (0.5 - 0.78)	<0.0001	0.615 (0.5 - 0.76)	<0.0001	0.615 (0.5 - 0.76)	<0.0001
			White vs Black	1.426 (0.89 - 2.29)		1.094 (0.82 - 1.47)			
		Race combined	White vs Other	0.849 (0.53 - 1.37)	0.1116	0.781 (0.49 - 1.24)	0.3334		
			Black vs Other	0.596 (0.36 - 0.98)		0.714 (0.46 - 1.12)			
	Ethnicity	Hispanic vs Non-Hispanic	0.986 (0.6 - 1.62)	0.957	1.062 (0.65 - 1.74)	0.812	1.276 (0.84 - 1.94)	0.256	
	Type of attending	Consultant vs Teaching	0.741 (0.49 - 1.12)	0.1543	0.59 (0.45 - 0.77)	<0.0001	0.746 (0.49 - 1.13)	0.1631	
Fellow	Yes vs No	1.176 (0.8 - 1.74)	0.4155	1.001 (0.71 - 1.41)	0.9973	1.184 (0.8 - 1.75)	0.3954		
Tobacco use	Current vs Not current	1.499 (1.07 - 2.11)	0.0195	1.522 (1.09 - 2.13)	0.0147	1.485 (1.06 - 2.08)	0.0225		
Diabetes	Yes vs No	1.265 (0.98 - 1.63)	0.066	1.267 (0.99 - 1.63)	0.0644	1.254 (0.98 - 1.61)	0.0761		
HIV status	Yes vs No	0.473 (0.24 - 0.95)	0.0348	0.505 (0.25 - 1.01)	0.0523	0.466 (0.23 - 0.93)	0.031		

Continued

Advanced adenoma *Forward selection was further considered due to the limited event size	Insurance	Private vs Medicare	0.448 (0.24 - 0.82)		0.448 (0.24 - 0.82)		0.448 (0.24 - 0.82)	
		Private vs Medicaid	1.137 (0.66 - 1.95)		1.137 (0.66 - 1.95)		1.137 (0.66 - 1.95)	
		Private vs Self-Pay	0.875 (0.51 - 1.51)	0.0245	0.875 (0.51 - 1.51)	0.0245	0.875 (0.51 - 1.51)	0.0245
		Medicare vs Medicaid	2.54 (1.35 - 4.78)		2.54 (1.35 - 4.78)		2.54 (1.35 - 4.78)	
		Medicare vs Self-Pay	1.953 (1.03 - 3.7)		1.953 (1.03 - 3.7)		1.953 (1.03 - 3.7)	
		Medicaid vs Self-Pay	0.769 (0.43 - 1.37)		0.769 (0.43 - 1.37)		0.769 (0.43 - 1.37)	
Fellow	Yes vs No	1.912 (1.13 - 3.24)	0.0158	1.912 (1.13 - 3.24)	0.0158	1.912 (1.13 - 3.24)	0.0158	
Tobacco use	Current vs Not current	2.362 (1.37 - 4.06)	0.0019	2.362 (1.37 - 4.06)	0.0019	2.362 (1.37 - 4.06)	0.0019	
Age	Every 1 year increase in Age	1.026 (1.01 - 1.05)	0.0067	1.027 (1.01 - 1.05)	0.005	1.026 (1.01 - 1.04)	0.0077	
BMI	Every 1 unit increase in BMI	0.986 (0.96 - 1.01)	0.2226	0.986 (0.96 - 1.01)	0.2192	0.985 (0.96 - 1.01)	0.1789	
Right colon adenoma	Insurance	Private vs Medicare	0.689 (0.46 - 1.04)		0.676 (0.45 - 1.02)		0.698 (0.46 - 1.05)	
		Private vs Medicaid	1.182 (0.84 - 1.66)		1.105 (0.79 - 1.54)		1.179 (0.84 - 1.66)	
		Private vs Self-Pay	1.154 (0.78 - 1.72)	0.0911	1.074 (0.73 - 1.58)	0.1334	1.174 (0.79 - 1.74)	0.0994
		Medicare vs Medicaid	1.714 (1.12 - 2.63)		1.635 (1.07 - 2.49)		1.689 (1.1 - 2.58)	
		Medicare vs Self-Pay	1.674 (1.03 - 2.71)		1.588 (0.99 - 2.54)		1.68 (1.04 - 2.71)	
		Medicaid vs Self-Pay	0.977 (0.68 - 1.41)		0.971 (0.68 - 1.4)		0.995 (0.69 - 1.44)	
Institution	DMC vs Kings county	0.794 (0.45 - 1.41)				0.791 (0.45 - 1.4)		
	DMC vs SBUMC	1.482 (0.84 - 2.62)	0.1979			1.156 (0.79 - 1.69)	0.3305	
	Kings county vs SBUMC	1.867 (0.93 - 3.74)				1.461 (0.87 - 2.46)		
Gender	Female vs Male	0.694 (0.54 - 0.9)	0.0049	0.69 (0.54 - 0.89)	0.0043	0.681 (0.53 - 0.88)	0.003	
Race combined	White vs Black	1.337 (0.76 - 2.35)		0.917 (0.65 - 1.3)				
	White vs Other	0.751 (0.43 - 1.32)	0.1355	0.636 (0.37 - 1.08)	0.2423			
	Black vs Other	0.561 (0.32 - 0.99)		0.694 (0.42 - 1.16)				

Continued

Ethnicity	Hispanic vs Non-Hispanic	0.978 (0.55 - 1.75)	0.9402	1.043 (0.59 - 1.85)	0.8865	1.328 (0.82 - 2.16)	0.2545
Type of attending	Consultant vs Teaching	0.577 (0.35 - 0.95)	0.0322	0.718 (0.53 - 0.98)	0.0354	0.58 (0.35 - 0.96)	0.0331
Fellow	Yes vs No	0.89 (0.55 - 1.44)	0.6373	0.996 (0.66 - 1.5)	0.9851	0.895 (0.55 - 1.45)	0.6509
Tobacco use	Current vs Not current	1.302 (0.86 - 1.96)	0.2075	1.266 (0.84 - 1.9)	0.2578	1.292 (0.86 - 1.95)	0.2206
Diabetes	Yes vs No	1.143 (0.85 - 1.53)	0.3706	1.155 (0.86 - 1.55)	0.3326	1.138 (0.85 - 1.52)	0.3861
HIV status	Yes vs No	0.392 (0.15 - 0.99)	0.0486	0.402 (0.16 - 1.02)	0.0544	0.384 (0.15 - 0.97)	0.0437

²P-value was based on type3 analysis from multivariable logistic regression model.

4. Discussion

In this study our hypothesis that older age, male sex and current smoking were associated with a higher risk of detecting adenoma was confirmed. These findings concur with those observed in a large study conducted by Kaiser Permanente and a meta-analysis of 18 studies examining risk factors for colon polyps [19] [20].

Given that Black/African-Americans have a higher incidence of colon cancer, our pretest hypothesis was that Black/African-American race would be associated with a higher risk of detecting adenomas. However, in the univariate analysis, Caucasian race was associated with a higher risk and in the multivariable analysis race was not significantly associated with the risk of detecting adenoma. A similar finding was noted in a smaller study among uninsured patients in New York [21] but is contrary to other larger studies which demonstrated an increased adenoma risk among Black/African-Americans [22] [23] [24] [25]. There are several possible explanations for this finding including differences in sex, smoking status, genetic background and adenoma detection rates of the gastroenterologist.

Blacks/African-Americans receive screening at an older age which would confer a higher risk of adenomas but they had lower rates of the other risk factors such as male sex and current smoking. Additionally, this Black/African-American population may consist of subgroups that inherently have a lower risk for adenomas. Approximately half of the Black/African American patients seen at DMC and 40% of those at Kings County were documented as Afro Caribbean [26]. The risk of colon malignancy and polyps in Afro-Caribbean subjects may be different from Black/African-Americans born in the US and may be similar to Non-Hispanic Caucasians as reported in a Florida based study [27]. We were unable to perform subgroup analysis on the Black/African American population in our study as country of origin was not consistently documented at all of the sites.

Another factor that likely contributed to the lack of association between race and adenomas is that the analysis may have been confounded by significant differences in the ADR of the gastroenterologists performing the procedures. A significantly higher proportion of colonoscopies among Black/African-American patients was performed by non-teaching or consultant gastroenterologists who had a significantly lower ADR at one of the three institutions. A recent study on interval colon cancer in Medicare enrollees noted that a higher proportion of black persons (52.8%) than white persons (46.2%) received colonoscopies from physicians with a lower Polyp Detection Rate [28]. This rate was significantly associated with interval CRC risk.

A recent joint task force of the American College of Gastroenterology and the American Society of Gastrointestinal Endoscopy recommended ADR benchmarks of 25% for all patients and sex-specific rates of 30% for men and 20% for women [29]. Our study included colonoscopies performed during 2012, when the benchmark adenoma detection rate was 20% overall (15% female and 25% male). Our finding of a significant difference in ADR between teaching and contracted consultant gastroenterologists reinforces the concept that detection of colon polyps is operator dependent [30] [31] as we controlled for the patient factors that contribute to lower ADR such as bowel prep quality and cecal intubation rate. Unfortunately cecal withdrawal time was not recorded consistently so we were unable to control for this.

Various colonoscopy screening programs have been implemented to improve access of uninsured and minority patients to screening colonoscopies [32] [33]. While rates of colonoscopy completion have been used as measures of success of these programs, this finding in our study indicates the importance of continued surveillance of the quality of these colonoscopies to ensure that the optimal benefit is being achieved. Implementation of quality metric monitoring and direct feedback to gastroenterologists has been shown to improve ADR [34] [35] and this has been implemented at all the institutions in this study.

The lack of any association with Black/African-American race and proximal adenoma is contrary to the observed distribution of right sided colon cancers in this population [20] [36] [37] [38] [39] [40] and concurs with the findings of a similar study conducted by Freidburg *et al.* [41]. Either sample size or operator dependence could also have affected our results regarding the detection of proximal adenomas.

There have been conflicting observations of the prevalence of advanced adenomas in Black/African-American patients [39] [40] [41] and no association was observed in our study. The effect of operator dependence may have had less of an effect for this metric since most of the advanced adenomas were larger in size. One study has suggested that advanced adenoma detection is independent of ADR [42].

The American Cancer Society updated their CRC screening recommendations in May 2018 to initiate screening for all patients at age 45 years [43]. However this recommendation has been in place for African-Americans since 2009 by

multiple societies [44]. However in our study the median age of initial screening among Black/African American patients was significantly higher than Caucasian patients. One reason for this is that acceptance of screening colonoscopies may be lower than the alternative of annual fecal immunochemical testing (FIT) in the Black/African/American population [45]. Furthermore it should be noted that current programs supporting free colorectal screening (largely FIT based), do not support initiating screening for individuals under the age of 50 [46].

Although it is hypothesized that HIV infection increases the risk of Non-AIDS defining malignancies [47], a meta-analysis of previous studies shows no association between HIV infection and colorectal cancer [48]. Conflicting results have been reported regarding the relationship between HIV infection and the detection of adenoma [49] [50] [51]. In our study, no association between adenomas was observed in HIV-infected individuals. Discrepant findings may be as a result of the small number of HIV-infected patients in these studies, and may also be as a result of lower CRC screening rates among HIV-infected patients [52].

One of the major strengths of this study is the sample size and the representation of Black/African-Americans in the sample which allowed for comparisons of multiple variables with the Caucasian population. Additionally, the exclusion criteria ensured that only patients with average risk screening colonoscopies were included. The exclusion criteria also removed other determinants of ADR as incomplete studies and those with inadequate prep.

A major limitation of our study is the variation in ADR due to the type of gastroenterologist during 2012 which would have impacted the effect of other variables on detection of adenomas. Additionally, there are recent observations that some proximal serrated adenomas may have been misclassified as hyperplastic polyps and this is variable amongst pathologists [53] [54] [55]. Due to the retrospective design of the study we were unable to control for this variability in pathologists. In our analysis we excluded all hyperplastic polyps regardless of site which may have resulted in an underestimation of adenoma.

5. Conclusion

In this study male sex, older age, current smoking and diabetes were associated with increased prevalence of adenoma. This finding may have been influenced by disparities in the ADR of gastroenterologists performing screening in the Black/African American populations. However, initiatives to improve quality have been implemented across all the institutions. Now that the effect of operator dependence has been greatly reduced, we plan to resume collection of data for this study beginning with 2019 to better define the populations at higher risk of adenoma. Further studies delineating the biologic factors including the microbiome affecting adenomas should also be conducted. The hope is that early preventive interventions to reduce the prevalence of these risk factors and treatment options targeting them may further reduce colon cancer incidence and mortality in this population.

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Conflicts of Interest

The authors declare no conflict of interest.

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