Title

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Journal

Digestive Diseases and Sciences, 56(7)

ISSN

0163-2116

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Publication Date

2011-07-01

DOI

10.1007/s10620-010-1528-3

Peer reviewed

Dig Dis Sci (2011) 56:2104–2113
DOI 10.1007/s10620-010-1528-3

ORIGINAL ARTICLE

Screening Prevalence and Incidence of Colorectal Cancer Among American Indian/Alaskan Natives in the Indian Health Service

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Received: 18 August 2010 / Accepted: 9 December 2010 / Published online: 14 January 2011

Abstract
Background Studies on colorectal cancer (CRC) screening and incidence among American Indian/Alaska Natives (AI/AN) are few.
Aims Our aim was to determine CRC screening prevalence and to calculate CRC incidence among AI/AN receiving care within the Indian Health Service (IHS).
Methods A retrospective cohort study of AI/AN who utilized IHS from 1996 to 2004. AI/AN who were average-risk for CRC and received primary care within IHS were identified by searching the IHS Resource Patient Management System for selected ICD-9/CPT codes ($n = 142{,}051$). CRC screening prevalence was calculated and predictors of screening were determined for this group. CRC incidence rates were ascertained for the entire AI/AN population ages 50–80 who received IHS medical care between 1996 and 2004 ($n = 283{,}717$).
Results CRC screening was performed in 4.0% of average-risk AI/AN. CRC screening was more common among women than men (RR = 1.6, 95% CI 1.4–1.7) and among AI/AN living in the Alaska region compared to the Pacific Coast region (RR = 2.5, 95% CI 2.2–2.8) while patients living in the Northern Plains (RR = 0.4, 95% CI 0.3–0.4) were less likely to have been screened. CRC screening was less common among patients with a greater number of primary care visits. The age-adjusted CRC incidence among AI/AN ages 50–80 was 227 cancers per 100,000 person-years.
Conclusions CRC was common among AI/AN receiving medical care within IHS. However, CRC screening prevalence was far lower than has been reported for the U.S. population.

Keywords Screening · Incidence · Colonoscopy · Health disparity

The findings or views expressed in this manuscript are those of the authors and do not necessarily reflect those of the Indian Health Service or the Centers for Disease Control and Prevention.

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Introduction

Colorectal cancer (CRC) is a leading cause of morbidity and mortality among American Indian/Alaskan Natives (AI/AN) [1]. AI/AN have more advanced disease [2] and lower survival rates [3], and there has been no change in CRC mortality rates over the last decade for AI/AN [4].

One important question that warrants further attention is how well CRC screening services are provided to AI/AN. While there are more data assessing CRC screening and development of screening programs for Hispanics [5, 6], Asians [7, 8], and African–Americans [9–11], there are few studies that report the CRC screening experience of AI/AN.

Existing studies on this topic have been hampered by small numbers of AI/AN included, racial misclassification, and methodological problems [4, 12–14].

Such gaps in knowledge may exacerbate existing disparities in cancer control programs and in the reliability of measures of disease burden between AI/AN and other ethnic groups. The development and evaluation of interventions to increase screening and lower CRC-related mortality in the AI/AN community hinge on reliable data on screening and incidence. Our study aims were to determine CRC screening prevalence among average-risk AI/AN ages 50–80 who received primary care within the Indian Health Service (IHS) and to estimate CRC incidence among AI/AN IHS health care users.

Methods

Data Source

IHS is an agency of the U.S. Department of Health and Human Services that provides health care services to members of federally recognized AI/AN tribes. IHS utilizes the Resource and Patient Management System (RPMS) to store patient demographics, create electronic medical records, and record and manage patient billing information. RPMS data for each calendar year from 1996–2004 were merged into a single dataset representing all IHS patients ages 50——80 from 1996 to 2004.

AI/AN Cohort That Used IHS as Their Primary Source of Health Care

AI/AN patients ≥50 years by December 31, 2004 who received their primary care from IHS between January 1, 1999 and December 31, 2004 were identified. Patients were identified who had one visit to a primary care clinic between January 1, 2004 and December 31, 2004 and who had another primary care clinic visit within the preceding 5 years (January 1, 1999 through December 31, 2003). A primary care clinic included Cancer Screening, Chronic Disease, Diabetes, Internal/General Medicine, Elder Care, Family Practice, Gastroenterology/Hepatology, General Preventative, Men's and Women's Health Screening, Obstetrics/Gynecology, Traditional Medicine, or Wellness clinics. These clinics have been previously defined as primary care clinics in other studies [15] or provided equivalent primary care within IHS.

Defining Average-Risk AI/AN for Colorectal Cancer

Patients were excluded from the CRC screening analysis if they were considered at increased risk for colorectal cancer [16]. Patients were excluded if they were <50 years of age at the time they underwent a CRC screening test, had a diagnosis of colorectal cancer/colonic polyps prior to CRC screening, and/or a diagnosis of ulcerative colitis/Crohn's disease defined using International Clinical Diagnosis (ICD)-9 code(s) codes [17] recorded at any point between January 1, 1996 through December 31, 2004. Patients were excluded if they had specific symptoms (Table 1) at any time prior to a CRC screening method that prompted an endoscopic evaluation other than for screening purposes.

AI/AN who Underwent Colorectal Cancer Screening

The screening eligible cohort consisted of patients who received primary care within IHS from 1999 to 2004, and who were considered at average-risk for CRC. Among this cohort of patients, it was then determined which ones had undergone a CRC screening test by searching the dataset for selected ICD-9 and/or Current Procedural Terminology (CPT) codes [18] (Table 1). To qualify as having been screened, a patient had to have undergone (according to the following hierarchy) at least one colonoscopy during 1996–2004, one flexible sigmoidoscopy during 2000–2004, one double contrast barium enema (DCBE) during 2000–2004, or one fecal occult blood test (FOBT) during 2003–2004. If a patient received multiple screening tests, the most recent date and method was selected as the time of screening.

A sensitivity analysis was then performed by (1) varying our timeframe for methods included for CRC screening, and (2) altering the CRC screening cohort eligibility inclusion criteria in order to determine if these changes influenced CRC screening prevalence. First, the CRC screening definition was modified by eliminating any timeframe for receipt of any of the recommended screening tests. Secondly, the CRC screening cohort eligibility criteria was varied while at the same time continuing the original definition of screening.

Detection of New Cases of Colorectal Cancer

The entire population of 283,717 AI/AN patients between ages 50–80 who received medical care within IHS between 1996–2004 were included in the CRC incidence analysis. We searched for ICD-9 codes that represented colon and rectal cancer (Table 1). The first documentation of an ICD-9 code for either cancer represented the year of initial diagnosis. A patient could only be counted once as having CRC.

Data Abstracted

Data collected on patients included age at the time of screening/CRC diagnosis, sex, IHS geographic region where the patient received screening/CRC diagnosis, number of comorbid medical conditions, and number of primary care

Table 1 ICD-9 and CPT codes used to identify CRC screening methods, colorectal cancer/colonic polyps, and several exclusion criteria

	ICD-9 codes	CPT codes
CRC screening method		
Colonoscopy	453.25, 453.55, 453.78, 453.80, 453.81, 453.83, 453.84, 453.85, 443.88, 443.89, 443.92, 443.93, 443.94, G0121, G0105	45.22, 45.23, 45.25, 45.42, 45.43
Flexible sigmoidoscopy/ Rigid proctosigmoidoscopy	453.00, 453.05, 453.08, 453.09, 453.15, 453.20, 453.30, 453.31, 453.33, 453.35, 453.38, 453.39, G0104	45.24, 48.22, 48.23, 48.24, 48.26, 48.36
Double-contrast barium enema	742.80, 742.75, 742.70, G0106, G0120, G0122	87.64
Fecal occult blood testing	822.70, 822.71, 822.72, 822.74, 892.05, G0107, G0328, G0394	N/A
Colorectal cancer/Colonic polyp		
Colon cancer	153.0, 153.1, 153.2, 153.3, 153.4, 153.5, 153.6, 153.7, 153.8, 153.9, 197.5, V10.05, 230.3	N/A
Rectal cancer	154.0, 154.1, V10.06, 230.4	N/A
Colonic polyp	211.3, 211.4	N/A
Excluding symptoms/diseases		
Anemia	280.0, 280.9	N/A
Constipation	564.00	N/A
Diarrhea	787.91, 564.5	N/A
Abdominal pain	555.1, 789.00, 789.01, 789.02, 789.03, 789.04, 789.05, 789.06, 789.07	N/A
Hematochezia/Melena	578.1	N/A
Crohn's disease	555.0, 555.1, 555.2, 555.3, 555.4, 555.5, 555.6, 555.7, 555.8, 555.9	N/A
Ulcerative colitis	556.0, 556.1, 556.2, 556.3, 556.4, 556.5, 556.6, 556.7, 556.8, 556.9	N/A

visits. IHS geographic regions were categorized as follows: Alaska, Pacific Coast (California, Oregon, Washington, Idaho), Southwest (Nevada, Colorado, Arizona, Utah, New Mexico), Northern Plains (North Dakota, South Dakota, Nebraska, Iowa, Minnesota, Wisconsin, Michigan, Montana, Wyoming), and East (Kansas, Oklahoma, Texas, Louisiana, Alabama, Tennessee, South Carolina, Florida, New York, Maine, Pennsylvania, Massachusetts, Rhode Island, Connecticut). These geographic regions have been used in previous publications [19, 20]. To determine co-morbid medical conditions ICD-9 codes were counted according to the Agency for Healthcare Research and Quality codebook [21]. In order to prevent bias due to variation in observation time, in the univariate analysis the average number of co-morbid medical conditions per year (and primary care visits per year) is reported. For the Poisson regression model, co-morbid medical conditions and primary care visits were modeled as the actual number of medical conditions (or visits) per subject per age group per period.

Statistical Analysis

CRC screening prevalence was calculated by dividing the number of patients that underwent CRC screening by the number of eligible, average-risk IHS patients. Unadjusted estimates within demographic subgroups (i.e. sex, age, etc.) and their exact binomial confidence intervals were calculated. A Pearson's chi-square test was used to assess the statistical association between CRC screening and demographic subgroups. In order to ascertain the effect of demographic and clinical variables on CRC screening multivariable Poisson regression models were built. The models assumed all subjects had the same follow up time within each calendar period. A P value of less than 0.05 was considered statistically significant.

CRC incidence rates were calculated by dividing the number of new CRC cases by the number of all patients followed in our combined datasets from 1996 to 2004 (expressed as 100,000 person-years). CRC incidence rates were age-adjusted by 6 age groups (50–54, 55–59, 60–64, 65–70, 71–74, and 75–80 years) by the direct method using the 2000 U.S. standard population [22]. All analyses were performed using SAS® software (version 9.1.3; SAS Institute, Cary, North Carolina).

The study protocol was approved by the University of California, San Francisco Committee on Human Research and the National IHS Institutional Review Board.

Results

Baseline Demographics

The nine yearly datasets (1996–2004) comprised 283,717 unique patients. A total of 141,666 patients were excluded (49.9%) from the analysis of colorectal cancer screening.

The majority of patients were excluded because they did not meet our definition of receiving primary care within IHS (Fig. 1). The primary study population consisted of 142,051 average-risk patients; 54.5% of patients were aged 50–54 years at their first IHS medical visit and were female (59.5%) (Table 2).

Colorectal Cancer Screening Prevalence

Of 142,051 AI/AN patients considered at average-risk for CRC, 5,661 patients underwent recommended CRC screening between 1996 and 2004 for a screening prevalence of 4.0%. Among average-risk patients who underwent CRC screening 1.9% underwent FOBT in 2003–2004, 1.1% had a double-contrast barium enema between 2000 and 2004, 0.7% underwent colonoscopy between 1996 and 2004, and 0.3% had a flexible sigmoidoscopy between 2000 and 2004 (see Fig. 1). Women and patients residing in the Alaska and East regions had the highest CRC screening prevalence (Table 3). The methods utilized for screening varied by geographic region (Fig. 2).

CRC Screening Sensitivity Analysis

If average-risk IHS AI/AN patients underwent any recommended CRC screening method at any time from 1996 to 2004, 5,860 patients were screened for a prevalence of 4.1% (95% confidence interval 4.0–4.2%). If we changed our primary care definition to include patients who had a primary care visit in both 2004 and 2003, our CRC screening prevalence was 4.1% (95% CI 4.0–4.2%). Our CRC screening prevalence was 4.0% if we did not exclude patients with symptoms. Lastly, if no restrictions were placed on inclusion into our screening eligible cohort then CRC screening prevalence was 10.0% (95% CI 9.9–10.1%).

Colorectal Cancer Screening Predictors

Independent predictors of CRC screening were sex (RR = 1.6, 95% CI 1.4–1.5 for women compared to men), and geographic region. In particular, patients residing in the Alaska region were more likely to be screened

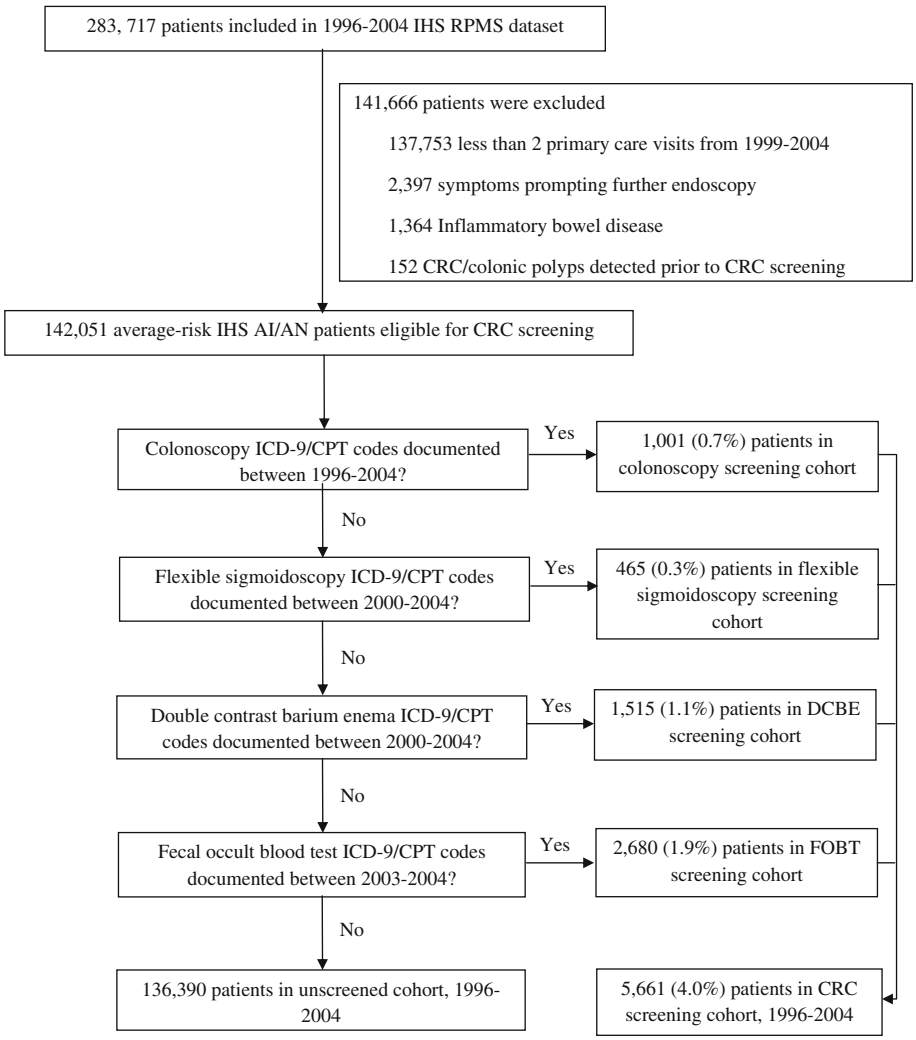

Fig. 1 Flow diagram of determining whether or not eligible, average-risk AI/AN patients, aged 50–80 years, underwent CRC screening in IHS from 1996–2004

Table 2 Demographic information on average-risk AI/AN IHS patients, aged 50–80 years

Demographic Information	Number of eligible patients (%)
Sex[a]	
Female	84,505 (59.5)
Male	57,529 (40.5)
Age at first IHS medical visit (years)	
50–54	77,449 (54.5)
55–59	24,954 (17.6)
60–64	19,607 (13.8)
65–69	13,220 (9.3)
70–74	6,222 (4.4)
75–80	599 (0.4)
IHS geographic region	
Southwest	44,880 (31.6)
East	41,551 (29.3)
Northern Plains	26,949 (19.0)
Pacific Coast	16,690 (11.7)
Alaska	11,981 (8.4)
Average number of comorbid medical conditions per year	
None	3,647 (2.6)
One	7,672 (5.4)
Two	15,492 (10.9)
Three or more	115,240 (81.1)
Average number of medical visits per calendar year[b]	
One	8,404 (5.9)
Two	19,428 (13.7)
Three or more	114,219 (80.4)

[a] 17 patients had an unknown sex

[b] Includes any IHS primary care medical visit

compared to patients in the Pacific Coast (RR = 2.5, 95% CI 2.2–2.8), while patients living in the Northern Plains (RR = 0.4, 95% CI 0.3–0.4) and Southwest (RR = 0.5, 95% CI 0.5–0.6) were less likely to have been screened. There was a trend toward increased screening with a greater number of co-morbid medical conditions, although this did not reach statistical significance. In addition, CRC screening appeared lower in patients who had an increasing number of primary care medical visits (Table 4).

Colorectal Cancer Incidence

There were 3,558 new cases of colorectal cancer (2,684 colon and 874 rectal) documented among the 283,717 AI/AN patients analyzed. The colon cancer incidence rate was 183 cancers per 100,000 person-years while for rectal cancer it was 60 cancers per 100,000 person-years. The age-adjusted CRC incidence rate for AI/AN aged

Table 3 Number of colorectal cancer screening examinations among eligible, average-risk AI/AN IHS patients, aged 50–80 years, from 1996 to 2004

Variable	All CRC screening methods[a] (%, 95% confidence interval)
Sex[b]	
Female	3,840 (4.5, 4.4–4.7)
Male	1,821 (3.2, 3.0–3.3)
Age at CRC screening (years)[b]	
50–54	1,701 (2.2, 2.1–2.3)
55–59	1,271 (2.1, 2.0–2.2)
60–64	1,075 (2.2, 2.1–2.3)
65–69	818 (2.3, 2.1–2.4)
70–74	554 (2.5, 2.3–2.7)
75–80	242 (2.7, 2.4–3.0)
IHS geographic region[b]	
Alaska	1,178 (9.8, 9.3–10.4)
East	2,176 (5.2, 5.0–5.5)
Pacific Coast	789 (4.7, 4.4–5.1)
Southwest	1,043 (2.3, 2.2–2.5)
Northern Plains	475 (1.8, 1.6–1.9)
Average number of comorbid medical conditions per calendar year[b]	
None	19 (0.5, 0.3–0.8)
One	276 (3.6, 3.2–4.0)
Two	692 (4.5, 4.1–4.8)
Three or more	4,674 (4.1, 3.9–4.2)
Average number of primary care visits per calendar year[b,c]	
One	358 (4.3 3.8–4.7)
Two	935 (4.8, 4.5–5.1)
Three or more	4,368 (3.8, 3.7–3.9)
Calendar year	
1996[d]	0
1997[d]	0
1998[d]	0
1999[d]	27 (0.03, 0.02–0.05)
2000[e]	2,044 (2.5, 2.4–2.6)
2001[e]	239 (0.3, 0.3–0.3)
2002[e]	230 (0.3, 0.2–0.3)
2003[f]	1,727 (2.0, 1.9–2.1)
2004[f]	1,394 (1.7, 1.6–1.7)
Overall CRC screening	5,661 (4.0, 3.9–4.1)

[a] Includes average-risk patients who underwent colonoscopy, flexible sigmoidoscopy, double-contrast barium enema, or fecal occult blood test for screening purposes

[b] Differences between variables within subgroup were statistically significant, $P < 0.001$

[c] Primary care visits include patients with medical encounters in the following clinics: Cancer Screening, Chronic Disease, Diabetes, Internal/General Medicine, Elder Care, Family Practice, Gastroenterology/Hepatology, General Preventative, Men's and Women's Health Screening, Obstetrics/Gynecology, Traditional Medicine, or Wellness clinics

[d] Screening method includes only colonoscopy

[e] Screening method includes colonoscopy, DCBE, or flexible sigmoidoscopy

[f] Screening method includes colonoscopy, DCBE, flexible sigmoidoscopy, or FOBT

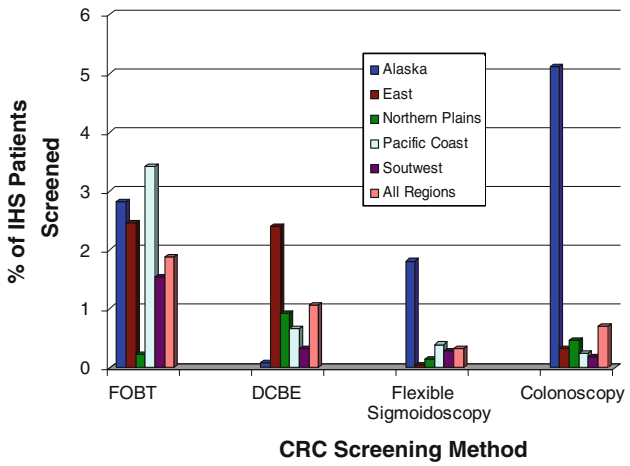

Fig. 2 Proportion of eligible, average-risk AI/AN IHS patients, aged 50–80 years, who underwent CRC screening during 1996–2004 stratified by method and IHS geographical region

Table 4 CRC screening predictors in average-risk AI/AN IHS patients, aged 50–80 years

Predictor	Relative risk (95% confidence interval)[a]
Female sex	1.6 (1.4–1.7)
IHS geographic region	
Pacific Coast	1.0
Alaska	2.5 (2.2–2.8)
East[b]	1.1 (0.9–1.2)
Southwest	0.5 (0.5–0.6)
Northern Plains	0.4 (0.3–0.4)
Calendar year[c]	
1999–2000	1.0
2001–2002	0.2 (0.2–0.3)
2003–2004	1.5 (1.4–1.7)
Number of comorbid medical conditions	
None	1.0
One[b]	12.9 (1.0–176.0)
Two	18.2 (1.3–247.0)
Three or more	34.0 (2.5–463.0)
Number of primary care visits[d]	
One	1.0
Two	0.8 (0.7–0.9)
Three or more	0.5 (0.4–0.5)

[a] P value < 0.001 unless stated otherwise

[b] P value > 0.05

[c] Predictors for years prior to 1999 were not utilized in the Poisson regression model given that there was very little CRC screening documented during this timeframe (27 cases) and only one screening method (colonoscopy) was allowed to be performed during this time

[d] Primary care visits includes patients with medical visits in the following clinics: Cancer Screening, Chronic Disease, Diabetes, Internal/General Medicine, Elder Care, Family Practice, Gastroenterology/Hepatology, General Preventative, Men's and Women's Health Screening, Obstetrics/Gynecology, Traditional Medicine, or Wellness clinics

50–80 years in our IHS RPMS database was 227 colorectal cancers per 100,000 person-years. Colorectal cancer was slightly more common in AI/AN men than women and in those individuals with a greater number of comorbid medical conditions and IHS medical care visits. Age was associated with CRC incidence with older AI/AN individuals more likely to have colorectal cancer than younger patients. Additionally, CRC was less common among patients who had undergone screening. Interestingly CRC incidence was associated with geographic region. For example, AI/AN living in Alaska were three times more likely to have CRC detected when compared to residents of other IHS regions (Table 5).

Discussion

To our knowledge, this is the first study to investigate CRC screening prevalence and predictors in a large, national cohort of AI/AN. Our study determined that only 4.0% of asymptomatic, average-risk AI/AN receiving IHS medical care underwent recommended CRC screening between 1996 and 2004. Women and residents of the Alaska region were more likely to have been screened, but even among women in this region screening was only undertaken 10.8% of the time.

The CRC screening prevalence we detected is below previously published results for AI/AN [4, 12, 14, 23, 24] and below those for the overall U.S. population [25]. While there is marked variation in the reported prevalence of CRC screening among AI/AN, with estimates ranging from 26 to 44% [4, 12, 13], all these estimates exceeded what we discovered. Methodological designs of past studies may in part explain their elevated reported screening compared to ours. CRC screening estimates from previous studies encompassing a similar timeframe as ours are largely based on telephone surveys and patient self-reported questionnaires which introduce recall and selection biases and examine a distinct group of AI/AN who had access to landline telephones, spoke and understood English and were willing to participate [14]. Furthermore, some of these studies focused on a small sample of AI/AN within one specific geographical region and did not examine IHS healthcare users [12, 24].

Our low CRC screening prevalence requires explanation. Attitudes and perceptions play an important role in people who decide to undergo screening. The lack of understanding CRC screening benefits [26–28], concerns or embarrassment [29], and implications from receiving a diagnosis of CRC [26–28] all contribute to lower screening prevalence. Some of these issues have been reported in small studies of AI/AN [12, 13]. Also, refusal and lack of adherence to screening is higher in minority populations

Table 5 New cases of colorectal cancer documented in AI/AN patients, aged 50–80 years, who utilized IHS from 1996 to 2004

Variable	New cases of colorectal cancer (%, 95% CI)
Sex[a,b]	
Male ($n = 127,095$)	1,687 (1.3, 1.3-1.4)
Female ($n = 156,543$)	1,870 (1.2, 1.1-1.3)
Age at cancer diagnosis (years)[b]	
50-54 ($n = 144,689$)	607 (0.4, 0.4-0.5)
55-59 ($n = 113,960$)	557 (0.5, 0.5-0.5)
60-64 ($n = 92,106$)	686 (0.8, 0.7-0.8)
65-69 ($n = 72,085$)	592 (0.8, 0.8-0.9)
70-74 ($n = 53,076$)	584 (1.1, 1.0-1.2)
75-80 ($n = 38,710$)	532 (1.4, 1.3-1.5)
IHS geographic region[b]	
Alaska ($n = 23,385$)	680 (2.9, 2.7-3.1)
East ($n = 81,259$)	1071 (1.3, 1.2-1.4)
Northern Plains ($n = 56,537$)	736 (1.3, 1.2-1.4)
Pacific Coast ($n = 37,346$)	351 (0.9, 0.8-1.0)
Southwest ($n = 85,190$)	720 (0.9, 0.8-0.9)
Number of comorbid medical conditions[b]	
None ($n = 13,019$)	35 (0.3, 0.2-0.4)
One ($n = 22,514$)	196 (0.9, 0.8-1.0)
Two ($n = 23,287$)	320 (1.4, 1.2-1.5)
Three or more ($n = 224,897$)	3,007 (1.3, 1.3-1.4)
Number of medical visits[b,c]	
One ($n = 24,945$)	155 (0.6, 0.5-0.7)
Two ($n = 22,502$)	139 (0.6, 0.5-0.7)
Three or more ($n = 236,270$)	3,264 (1.4, 1.3-1.4)
Patient underwent CRC screening[b]	
Unscreened ($n = 278,056$)	3,517 (1.3, 1.2-1.3)
Screened ($n = 5,661$)	41 (0.7, 0.5-1.0)
Overall ($n = 283,717$)	3,558 (1.3, 1.2-1.3)
Incidence rate (per 100,000 person-years)	242
Age-adjusted incidence rate (per 100,000 person-years)	227

[a] There were 79 patients with unknown gender, 1 of whom had colon cancer

[b] Differences between variables within subgroup were statistically significant, $P < 0.001$

[c] Includes any IHS medical visit

[30–32]. However, this has yet to be directly studied in the AI/AN community and such issues may play a role in the low CRC screening prevalence we observed. Furthermore, IHS healthcare providers may not recommend CRC screening, may be unfamiliar with CRC screening guidelines, or they may be impeded by insufficient funding. Another potential barrier to CRC screening may be a limited capacity to provide endoscopic services for screening. Access to specialty care within IHS can be challenging due to limited resources and geographic location thereby limiting the number of trained physicians able to perform endoscopy for screening purposes.

CRC screening predictors may shed light on the cause of the low prevalence of screening we found. We confirmed that geographic region and sex were important predictors, both of which have been reported previously [12, 13, 24]. One of the strongest predictors for screening pertained to geography. Regional differences in CRC screening are key in that they not only reflect the diversity of the AI/AN community, but exemplify potential differences in access to CRC screening, financial resources, and cultural beliefs about screening. Additionally, regional disparities draw attention to programs aimed at increasing screening within particular communities as well as individual screening preferences by local IHS leadership. Our finding that residing in Alaska was one of the strongest screening predictors reflects a concerted effort by the tribal leadership, IHS, and the Centers for Disease Control and Prevention to increase CRC screening in this community using endoscopy [33, 34]. A similar result was reflected in the Pacific Coast where there has been an increased effort to use FOBT for CRC screening [35].

There was a trend toward increased screening with a greater number of co-morbid medical conditions compared to lower CRC screening in patients with multiple primary care visits. Such a finding appears contradictory to what is reported in the literature [36]. One possible explanation is that patients in our study with multiple primary care visits may represent a distinct group with other social issues or complex medical problems that are not reflected in the number of co-morbid medical conditions. AI/AN have higher rates of substance abuse, tobacco usage, and obesity resulting in more complex medical and social problems compared with other groups [14]; all conditions not easily captured in the number of co-morbid medical conditions. Also, healthcare providers may be less inclined to recommend CRC screening to patients with more primary care visits as this may represent a subset of patients who are less compliant with their medications, have a poorer understanding of their disease process, or have diseases that may preclude them from invasive CRC screening.

Another finding of our study was the high CRC incidence estimated among AI/AN IHS users. The age-adjusted CRC incidence rate of 227 cancers per 100,000 person-years is higher than previously reported [2]. In comparison, using 2006 SEER data, age-adjusted CRC incidence for the U.S. population for individuals older than 50 years was 150 cancers per 100,000; for African-Americans it was 184 cancers; and for Caucasians it was 148 cancers [37]. Our rate should be interpreted with caution. Our study only examined IHS patients and was limited to a specific age range. We relied on ICD-9 codes

to document CRC rather than on a histological diagnosis as has been performed in previous analyses [2]. Also, miscoding of CRC using ICD-9 codes may occur using RPMS data. To our knowledge, there are no studies available that directly assess the reliability of ICD-9 coding and the diagnosis of CRC in IHS patients using RPMS data. A separate study that examines ICD-9 coding in RPMS and CRC diagnosis with confirmation using IHS medical records would be helpful but has yet to be conducted. Finally, persons eligible for IHS services but less likely to seek them, such as those not experiencing symptoms, are less likely to be included in the analysis.

While our overall CRC incidence for AI/AN was high, more strikingly, significant geographical variation existed in CRC detected among IHS AI/AN. This variation was most notable among Alaskan Natives who had three times the CRC incidence rate of other regions. Our findings that geography was linked with higher rates of CRC have been illustrated in previous studies [2, 38]. One potential reason for this discrepancy in CRC incidence may relate to differential prevalence of CRC screening. CRC screening is a vital tool in the early detection of CRC and the removal of precancerous lesions (polyps) and has led to important reductions in CRC incidence and mortality [1, 4]. However, AN had nearly ten times the rate of screening compared with other regions indicating that other factors aside from screening may profoundly influence CRC incidence among this group. A number of alternate theories have been postulated to account for these differences in CRC incidence. One possible reason is that geography itself has shaped the risk for CRC in AN: Alaska is separated from the transcontinental U.S. by significant distances and this can affect CRC incidence in many arenas in comparison with other regions of the U.S. Lifestyle factors may contribute to the development of CRC. For example, tobacco usage [39, 40], higher alcohol consumption and binge drinking [39, 40], sedentary lifestyle [39], and obesity [39, 41] increase one's risk for CRC; all of which have been consistently shown to be significantly higher in AN compared with other AI in IHS regions [14]. Also, geography encompasses cultural differences that may include diet and use of alternative medications which may impact CRC incidence. Again, AN have diets low in fruits and vegetables [14] which may increase their risk for CRC compared to other AI [42]. Lastly, varying CRC incidence among regions may also reflect a genetic component in the development of CRC among AI/AN. All these factors, either separately or acting in concert with one another, can play a role in the higher CRC incidence noted in AN.

Several limitations may influence the interpretation of our study. First, methodological considerations may have underestimated CRC screening prevalence. In particular, distinguishing between screening and diagnostic/surveillance examinations using RPMS data is challenging. We systematically excluded patients with symptoms/diseases that would have resulted in further endoscopic evaluation for non-CRC screening purposes thus resulting in a more representative patient population of average-risk individuals. Second, IHS provides healthcare to approximately 57% of U.S. AI/AN that are mostly a rural population thereby limiting the generalizability of our results. Third, a subset of IHS patients may have received CRC screening from another health care facility outside of IHS for which we could not account. This data are exceedingly difficult to capture and has not been extensively studied. To date, the only study to examine this issue was a small pilot study that examined the medical records of IHS patients identified as having undergone CRC screening in five IHS facilities. This data demonstrated that only a small fraction of patients underwent screening at a facility outside of IHS (0.6%) [43]. The number of IHS users who may select to have CRC screening at outside facilities may be higher than this estimate but currently such information is unavailable. Thus, while patients do have the option to obtain CRC screening at facilities outside of IHS limited data suggest that this number is small and unlikely to affect our results. Currently, a survey of IHS sites is being conducted which is assessing CRC capacity and will provide a much better estimate of what is performed within IHS healthcare facilities versus referral. A fourth limitation is that data beyond 2004 may reflect a more accurate representation of CRC screening prevalence for AI/AN. However, our study period overlaps with other studies, few studies exist examining screening in AI/AN after 2004, and the available studies do so only from a regional perspective [12, 13]. Also, we used coding data to represent CRC screening and this raises issues of systematic and random coding errors occurring in our dataset. Only one small (618 patients), unpublished study has addressed this issue. In this study, the authors discovered a 25% misclassification rate between screening and diagnostic colonoscopy for IHS patients. Further examination of their data revealed a miscoding rate of only 7.6% and was based overwhelming on the use of one specific ICD-9 code that we did not utilize to capture screening methods for our study. Also, this study did not exclude patients who had previously documented symptoms that may have led to a diagnostic endoscopy, a method that we employed in our analysis [43]. Lastly, a vast majority of IHS AI/AN individuals had multiple comorbid medical conditions which may introduce some ascertainment bias into our results. However, this finding is not surprising given that AI/AN are disproportionally affected by more chronic diseases such as diabetes, hypertension, heart disease, and several forms of cancer when compared with other racial groups [4, 14]. Moreover, as previously discussed, AI/AN have elevated

rates of long-term tobacco usage and alcohol consumption compared with other groups thus predisposing them to the multiple medical consequences/diseases of such usage which is likely reflected in our data. Also, patients with chronic diseases are more likely to seek health care and thus be a part of the IHS medical system as compared with healthy, asymptomatic patients who are less likely to seek care. Despite these limitations, we believe our study adds an important perspective in portraying CRC screening prevalence among average-risk AI/AN.

In conclusion, CRC screening among asymptomatic, average-risk AI/AN who used IHS for medical care was extraordinarily low from 1996 to 2004. Unexplained discrepancies exist in CRC screening prevalence based on sex, geographic location, and health-care utilization. The low prevalence of recommended screening for AI/AN served by IHS is disturbing and highlights potential areas where efforts for awareness and access to CRC screening should be directed.

Conflict of interest None of the authors have any conflicts of interest associated with the work presented in this manuscript. The manuscript is original and all authors meet the criteria for authorship, including acceptance of responsibility for the scientific content of the manuscript.

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