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Gender and Race/Ethnicity Affect the Cost-Effectiveness of Colorectal Cancer Screening

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Background and Aims: Colorectal cancer screening beginning at age 50 is recommended for all Americans considered at average risk for the development of colorectal cancer regardless of gender or race/ethnicity. We determined the influence of gender and race/ethnicity on the cost-effectiveness of recommended colorectal cancer screening regimens.

Methods: We determined age-specific colorectal cancer incidence rates; the proportion of left-sided cancers; and the proportion of localized cancers in Asian, black, Latino and white men and women using the California Cancer Registry. We incorporated these data and available data for life expectancy and colorectal cancer survival to model the cost-effectiveness of two 35-year colorectal cancer-screening interventions.

Results: Age-specific colorectal cancer incidence rates were highest in black men and lowest in Latino women. Screening beginning at age 50 was most cost-effective in black men and least cost-effective in Latino women (measured as dollars spent per year of life saved) using annual fecal occult blood testing combined with flexible sigmoidoscopy every five years and using colonoscopy every 10 years. The cost-effectiveness of a 35-year screening program in black men beginning at age 45 was similar to the cost-effectiveness of screening white men and black women beginning at age 50 and more cost-effective than screening nonblack women as well as Asian and Latino men beginning at age 50.

Conclusions: Screening is most cost-effective in black men because of high age-specific colorectal cancer incidence rates. Initiation of colorectal cancer screening in this high-risk group prior to age 50 should be strongly considered.

Key words: colorectal cancer ■ screening ■ race/ethnicity ■ cost-effectiveness

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INTRODUCTION

Colorectal cancer will be diagnosed in approximately 131,000 Americans this year, and about 55,000 will die of the disease,[1] making this cancer the second leading cause of death from cancer in this country. Colorectal cancer screening allows the detection of asymptomatic cancers that are more amenable to curative therapy and also allows the removal of adenomas that could subsequently develop into invasive cancer. Colorectal screening programs are proven to reduce the mortality from colorectal cancer.[2-9] Nearly every case of colon cancer could be prevented if every American were to undergo periodic total colonic evaluation starting at a very young age. Such a program is impractical, however, and working groups of the American Cancer Society and others have published colorectal cancer screening guidelines that balance the medical benefits of screening against its costs.

The American Cancer Society has recommended screening for colorectal cancer since 1980.[10] The 1997 recommendation called for everyone age >50 who is at average risk to be screened with annual fecal occult blood testing (FOBT) and sigmoidoscopy every five years or total colon examination—either by colonoscopy (every 10 years) or by double-contrast barium enema (every 5–10 years).[11] The more recent recommendation broadened recommended tests to include annual FOBT and sigmoidoscopy without FOBT.[12] "Average risk" is defined by exclusion as individuals without a personal or family history of colorectal cancer, adenomatous polyps or inflammatory bowel disease.[11] Between 70–80% of all colorectal cancers occur among patients at average risk.[13]

Most studies of the cost-effectiveness of colorectal screening have considered Americans to be a homogeneous population and have used aggregated data sources (SEER) and data from case series to estimate cost-effectiveness. We recently used specific racial and ethnic colorectal cancer data to model the cost-effectiveness of colorectal screening programs in individual racial and ethnic groups.[14]

Gender also affects colorectal cancer disease patterns. Men and women of the four major racial and ethnic groups in America exhibit different age-specific colorectal cancer incidence rates,[15] proportions of left-sided cancers,[16] stage at diagnosis,[15,16] colorectal cancer survival[17,18] and life expectancies.[19] We investigated the influence of unique patterns of colorectal cancer in men and women of different races and ethnicities on the cost-effectiveness of colorectal cancer screening.

METHODS

The California Cancer Registry collects information on every case of cancer diagnosed or treated in California. Standard data are abstracted from the medical record for each case by trained tumor registrars, according to *Cancer Reporting in California: Volume 1, Abstracting and Coding Procedures for Hospitals*[20] and computerized using C/NET, a software package developed for tumor registries. C/NET meets all reporting requirements of the Surveillance, Epidemiology and End Results (SEER) program, the American College of Surgeons and the California Cancer Reporting System. The quality of data is maintained through periodic training programs for hospital registrars and field abstractors, reabstraction of a 10% sample of case finding, and computer edits for completion and consistency.[21] Additional audits of case finding and data abstraction are conducted by the California Department of Health Services. Completeness of coverage is estimated by comparing the number of cases reported by year to an expected number of cases for that year.

Table 1. Assumptions used in the cost-effectiveness analysis

Variable	Value
Natural History of the Disease	
Prevalence of adenomas at age 50, %	30
Proportion of all clinically detected cancers that begin as polyps, %	70
Years required for a 5-mm adenoma to progress to colorectal cancer	5 or 10
Years required for a new invasive cancer to progress to late-stage cancer	2
Years before late-stage colorectal cancer is detected	2
Prevalence of lifetime-latent cancers at 50 years of age	2/1,000
Annual incidence of lifetime-latent cancer	2/10,000
Accuracy, %	
Fecal occult blood test	
Sensitivity for polyps	10
Sensitivity for colorectal cancer	60
Specificity	90
Sigmoidoscopy and Colonoscopy	
Sensitivity for polyps (within reach of the scope)	90
Specificity for polyps	95
Medical Risks, %	
Rate of colonoscopy-induced perforation of the large bowel	7/10,000
Colonoscopy-induced mortality	5/100,000
Surgery-related mortality in patients with colorectal cancer	1/50
Costs, $	
Fecal occult blood test	4
Screening sigmoidoscopy	401
Screening Colonoscopy	696
Therapeutic colonoscopy	1013
Treatment of patients with cancer	45,228
Treatment of patients with colonoscopy-induced perforations	13,000
Treatment of patients who die as a result of colonoscopy	30,000

Completeness is estimated to be higher than 99% annually from 1988 through 1998.[22]

Recorded data includes demographic information [age, gender, race/ethnicity (white, black, Latino or Asian)], pathology, site of disease, stage of disease, treatment during the first four months and survival status. Tumor site and histology are coded according to criteria specified by the World Health Organization in *International Classification of Diseases for Oncology* (*ICD-O*).[23] All cases included in this paper were primary invasive adenocarcinomas of the colon or rectum, and >99% were confirmed histologically. Tumors from the cecum to the transverse colon were considered ascending and transverse colon tumors (right-sided cancers), while tumors from the splenic flexure to the rectum were considered left-sided cancers. Invasive cancers localized to the colon or rectum (node-negative without metastases) were considered localized. Node-positive or metastatic cancers were considered nonlocalized. Average annual age-specific colorectal cancer incidence rates for each race or ethnicity were calculated by dividing the age-specific number of incident colorectal cancers cases from 1988–1995 in California by the age-specific population over the same period.

SEER data for colorectal cancer survival were obtained from the SEER Cancer Incidence Public-Use Database 1992–1998.[17] Age-specific colorectal cancer survival tables were available for white and black men and women. Age-specific colorectal cancer survival tables of "other than white" were used for Latino and Asian men and women.

Life expectancy tables for Californians from 1989–1991 were obtained from the National Center for Health Statistics at the Centers for Disease Control and Prevention.[19] Life expectancy tables were available for white and black men and women. Life expectancy tables of "other than white" were used for Latino and Asian men and women.

Modeling

Cost-effectiveness modeling of colorectal screening programs was done using a model developed at the Office for Technology Assessment (Washington, DC) and described in detail elsewhere.[24-28] This model estimates the net present value of lifetime costs and years of life gained in a cohort of 100,000 50-year-old persons over a 35-year period from different colorectal cancer screening strategies using specified assumptions about the natural history of colorectal cancer and the adenoma or carcinoma sequence, the sensitivity and specificity of each screening technology for early cancer and polyps, the cost of screening, follow-up and postpolypectomy surveillance procedures, and the incremental costs of treating colorectal cancer. Costs were taken from 2000 Medicare reimbursement rates.[29] Costs were discounted to their present value at 5% per

Table 2. Sampling of age-specific colorectal cancer incidence rates per 100,000 (and 95% CI) in men by race/ethnicity in California, 1988–1995

Age	Asian	Black	Latino	White
45	15.7 (9.9–23.5)	22.3 (13.8–34.1)	9.32 (6.20–13.5)	17.4 (14.9–20.2)
50	38.9 (28.0–52.6)	51.3 (36.3–70.5)	33.5 (26.2–42.2)	37.6 (33.4–42.1)
55	61.6 (46.1–80.5)	103 (79.2–131)	41.1 (31.9–52.3)	74.0 (67.5–81.0)
60	113 (89.1–140)	170 (135–210)	79.7 (65.3–96.3)	137 (128–147)
65	192 (159–230)	263 (216–317)	156 (134–182)	219 (207–231)
70	250 (208–300)	330 (271–398)	164 (136–196)	296 (282–312)
75	297 (241–362)	402 (322–496)	282 (235–337)	406 (386–427)
80	363 (287–455)	537 (418–679)	383 (314–464)	531 (502–561)
85	475 (350–630)	594 (411–830)	269 (193–365)	603 (559–649)

Table 3. Sampling of age-specific colorectal cancer incidence rates per 100,000 (and 95% CI) in women by race/ethnicity in California, 1988–1995

Age	Asian	Black	Latino	White
45	20.8 (14.4–29.1)	23.9 (15.5–35.3)	11.2 (7.70–15.7)	14.6 (12.3–17.2)
50	31.7 (22.3–43.7)	61.4 (45.6–80.9)	19.8 (14.3–26.6)	28.8 (25.2–32.8)
55	53.7 (40.1–70.4)	75.0 (55.9–98.7)	32.8 (24.9–42.5)	56.5 (50.8–62.6)
60	84.9 (66.6–106)	115 (88.7–146)	50.6 (39.9–63.4)	87.5 (80.3–95.2)
65	108 (86.7–134)	144 (113–180)	76.4 (62.0–93.1)	144 (135–154)
70	126 (100–157)	227 (185–276)	124 (102–148)	204 (193–215)
75	191 (151–238)	310 (254–377)	170 (139–205)	275 (260–289)
80	277 (215–352)	423 (343–517)	204 (165–250)	362 (344–382)
85	279 (191–394)	429 (322–562)	273 (214–345)	440 (414–467)

year. The main assumptions of the model are summarized in Table 1. Justification of model assumptions are based on reviews of the published literature.[24-28]

Statistics

Confidence intervals were constructed using the exact method of Poisson, and comparisons of mean age-specific colorectal cancer incidence rates were performed with SAS statistical software.[30,31]

RESULTS

Table 2 and Table 3 list age-specific incidence rates of colorectal cancer in California from 1988–1995 for men and women, respectively, of each of four racial and ethnic groups. Age-specific colorectal cancer incidence rates were highest in black men and lowest in Latino women. For most ages between 45–85, the rank of incidence rates was consistent (black men > white men > Asian men > black women > white women > Latino men > Asian women > Latino women).

The utility and cost-effectiveness of flexible sigmoidoscopy are influenced by the percentage of colorectal cancers that are detectable with this test. Flexible sigmoidoscopy can reach 60 cm into the colon or to the splenic flexure. We analyzed California Cancer Registry data to determine the percentage of colorectal cancers within men and women of each racial or ethnic group that occur at or distal to the splenic flexure and therefore could be detected by flexible sigmoidoscopy (Table 4). Within each race/ethnicity, men had a higher proportion of left-sided cancers. Both gender as well as race/ethnicity, however, affected the proportion of left-sided cancers (Asian men > Latino men > Asian women > white men > Latino women > black men > black women > white women).

The cost-effectiveness of screening is influenced by the proportion of cancers that are detected without screening at an early stage. These cancers are more likely to be cured even without the benefits of early detection offered by screening. We analyzed California Cancer Registry data to determine the percentage of colorectal cancers within each racial and ethnic group that are diagnosed while still localized (node-negative) to the colon or rectum (Table 5). The proportion of localized disease was highest in white men and lowest in Latino women (38% vs. 33%). In general, men of each race/ethnicity had a slightly higher proportion of localized cancers compared to women.

We incorporated racial and ethnic differences in colorectal cancer incidence, the proportion of left-sided cancers and the proportion of early cancers to model the cost-effectiveness of colorectal cancer screening. We used two established strategies: 1) annual FOBT and every-five-years flexible sigmoidoscopy and 2) colonoscopy every 10 years, starting at age 50 and ending at age 85. These models also incorporated published differences in colorectal cancer survival and life expectancy between men and women of the four racial/ethnic groups.[15,18] Assumptions underlying the model are summarized in Table 1.

After adjusting for racial or ethnic differences in colorectal cancer, screening black men by either screening regimen was most cost-effective regardless of assuming a five- or 10-year polyp dwell time (the time it takes for a detectable polyp to become invasive cancer): black men > black women > white men > Asian men > white women > Latino men> Asian women > Latino women (Table 6). Cost-effectiveness ratios for black men were nearly half those of black women and white men and nearly one-fifth those of Latino women. Not surprisingly, sensitivity analyses indicated that cost-effectiveness estimates were largely (inversely) proportional to age-specific colorectal cancer incidence rates (data not shown). The superior life expectancy of women compared to men also had a significant impact by lowering cost-effectiveness ratios: since women live longer, they have more to gain by having colorectal cancer prevented or detected at a curable stage.

Table 4. Proportion of colorectal cancer at or distal to the splenic flexure (percentage) stratified by gender and race/ethnicity in California, 1988–1995

	Men	Women
White	65	56
Black	62	57
Latino	69	62
Asian	76	70

Table 5. Stage of disease of colorectal cancer at diagnosis stratified by gender and race/ethnicity in California, 1988–1995 (percentage)

	Localized	Regional	Distant
Men			
White	38	43	19
Black	34	43	23
Latino	36	42	22
Asian	35	45	20
Women			
White	36	45	19
Black	35	40	25
Latino	33	46	21
Asian	34	48	18

Hence, the cost-effectiveness of black women was superior to that of white and Asian men despite the fact that black women had lower age-specific incidence rates. Although black male cost-effectiveness estimates were lowest of any group, their estimates would have been even lower had not the life expectancy estimates for black men been lower than that of the other groups.[19]

These models assumed a similar polyp incidence among men and women of each racial and ethnic group. Polyp incidence data in racial and ethnic groups have not been reported. It is possible that a group with elevated colorectal cancer incidence may have a higher polyp incidence and that the percentage of polyps that become malignant is similar to that of other groups. Alternatively, the group may have a similar polyp incidence rate to that of other groups but a higher proportion of polyps may become malignant. To take into account the former possibility, we doubled the polyp incidence rate of black men. This adjustment resulted in a small change in cost-effectiveness. For example, using every-10-years colonoscopic screening, the cost-effectiveness estimates for black men increased from $22,392 to $23,312 per year of life saved (10-year polyp dwell time). Cost-effectiveness estimates in men and women in the other racial and ethnic groups were also insensitive to changes in polyp incidence rate using both screening regimens (data not shown).

We assessed the cost-effectiveness of a 35-year screening program in black men beginning at ages <50 to determine at what age cost-effectiveness estimates using colonoscopy exceeded the cost-effectiveness estimate of Latino women (the group in which screening was least cost-effective). We continued to adjust for the proportion of early cancers as well as colorectal cancer survival, life expectancy and colorectal cancer incidence using age-appropriate data. A 35-year screening program in black men beginning at age 40 (five-year polyp dwell time: $114,961 per year of life saved; 10-year polyp dwell time: $63,736 per year of life saved) was similar in cost-effectiveness to a 35-year screening program in white women beginning at age 50 and more cost-effective than 35-year screening programs in Latino men, Asian women and Latino women beginning at age 50. This was true even after doubling the polyp incidence rate in black men (data not shown). Furthermore, a 35-year screening program in black men beginning at age 45 (five-year polyp dwell time: $79,008 per year of life saved; 10-year polyp dwell time: $42,383 per year of life saved) was similar in cost-effectiveness to 35-year screening programs in white men and black women beginning at age 50 and more cost-effective than 35-year screening programs in Latino and Asian men as well as nonblack women. This was true even after doubling the polyp incidence rate in black men (data not shown).

DISCUSSION

Cancer screening in the United States has evolved to include the use of gender and race/ethnicity to stratify patient risk. Mammography is recommended only in women because of the low incidence of male breast cancer. Prostate cancer screening is recommended for most men at age 50 but is recommended for black men at age 45 because of high age-specific incidence rates in this group.[12]

Table 6. Cost-effectiveness estimates (cost per year of life saved) of a 35-year colorectal cancer screening program beginning at age 50 (or as noted) after adjusting for gender and racial/ethnic differences in colorectal cancer incidence, proportion of left-sided cancers, proportion of localized cancers, colorectal cancer survival and life expectancy

	Annual FOBT Plus Sigmoidoscopy Every Five Years		Colonoscopy Every 10 Years	
	Five-Year Polyp Dwell	10-Year Polyp Dwell	Five-Year Polyp Dwell	10-Year Polyp Dwell
Men				
White	$51,780	$47,817	$77,833	$41,530
Black	$39,776	$36,578	$43,532	$22,392
Latino	$82,239	$77,304	$124,903	$71,753
Asian	$61,671	$58,220	$99,305	$53,510
Black (age 45)			$79,008	$42,383
Black (age 40)			$114,961	$63,736
Women				
White	$70,843	$65,620	$106,422	$59,220
Black	$50,445	$46,777	$72,765	$41,183
Latino	$120,941	$113,398	$187,453	$107,756
Asian	$92,897	$87,608	$143,271	$81,657

We have shown that gender-specific racial/ethnic colorectal cancer disease patterns affect the cost-effectiveness of colorectal screening. Colorectal screening was much more cost-effective in black men than in other groups. Screening black men beginning at age 45 was similar in cost-effectiveness to screening white men and black women and more cost-effective than screening Latino and Asian men and nonblack women beginning at age 50. Differences were robust and persisted after doubling the polyp incidence rate for black men. The favorable cost-effectiveness ratio of screening black men largely reflected high age-specific colorectal cancer incidence rates in this group.

Screening for colonic neoplasia is a complex process that only begins with the screening test. Program effectiveness must consider each of the steps required for treating identified lesions and their associated costs. If, however, the cost and effectiveness of identifying and treating colorectal cancer are similar in men and women of all racial and ethnic groups, it is clear that black men serve to benefit most from colorectal cancer screening. This benefit is not subtle. Our analysis indicates that screening black men for colorectal cancer beginning at age 45 would be as good or a better use of resources than screening all other groups.

Use of colorectal screening strategies will impact colorectal incidence rates. Racial and ethnic groups that utilize screening protocols will initially have increased colorectal cancer incidence rates as the result of the detection of asymptomatic cancers; eventually, these groups will have decreased colorectal incidence rates as a result of the excision of polyps before they become malignant. Groups that utilize screening programs also will tend to have cancers detected at earlier stages than if the cancer had been detected when symptomatic. We have commented previously that it is unlikely that age-specific California colorectal incidence rates from 1988–1995 were corrupted by the current use of screening programs.[14] Our data indicate that the incidence of colorectal cancer in black men is higher than any other group by age 50, the currently recommended age for initiation of colorectal cancer screening. Furthermore, we assessed whether there was a trend toward increased colorectal cancer incidence rates that might reflect increased detection from screening within racial or ethnic groups in our database. We compared average annual colorectal cancer incidence rates from 1988–1991 with rates from 1992–1995 within each racial and ethnic group at five-year intervals starting at age 45. We did not observe any significant increase in average annual colorectal cancer rates for any racial and ethnic group at any age tested.

The screening model assumed a screening methodology that is recommended for the 70–80% of patients at average risk for colorectal cancer. Our model did not discriminate between patients of high, moderate or average risk for colorectal cancer and did not address the issue of whether different racial and ethnic groups have different proportions of high- or moderate-risk patients. It is probable that different proportions of each of the four major racial and ethnic groups in this country are at high or moderate risk for colorectal cancer. For instance, polyposis syndromes and ulcerative colitis are rarely reported among Latino and Asian patients. Removing these high-risk groups from consideration will lower overall colorectal cancer incidence rates and thereby reduce cost-effectiveness within a particular racial or ethnic group. If whites and blacks have higher proportions of high-risk individuals, then modeling only those average-risk patients may yield cost-effectiveness estimates nearer to those of Latinos and Asians. The completion of population-based studies of colorectal cancer in this country will allow the segregation of racial and ethnic groups into specific risk categories that can then be individually modeled for colorectal screening cost-effectiveness. However, it is well known that the majority of colorectal cancers in men and women of all races/ethnicities occur in average-risk patients.

While our study is an attempt to define more useful colorectal cancer-screening guidelines, it will not prove to be of great benefit to patients unless more men and women of each racial and ethnic group increase the practice of colorectal cancer screening. Discussion of gender-specific racial and ethnic colorectal-cancer disease patterns may serve as a stimulus to the development of interventions that will prove most useful within each group. Discussion of unique gender-specific racial and ethnic disease patterns may also yield implications for screening guidelines for other diseases and allow for the prioritization of screening interventions in men and women of individual races/ethnicities.[32]

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