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Racial and Ethnic Colorectal Cancer Patterns Affect the Cost-effectiveness of Colorectal Cancer Screening in the United States

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Background & Aims: Colorectal cancer screening beginning at age 50 is recommended for all Americans considered at “average” risk for the development of colorectal cancer. **Methods:** We used 1988–1995 California Cancer Registry data to compare the cost-effectiveness of two 35-year colorectal cancer screening interventions among Asians, blacks, Latinos, and Whites. **Results:** Average annual age-specific colorectal cancer incidence rates were highest in blacks and lowest in Latinos. Screening beginning at age 50 was most cost-effective in blacks and least cost-effective in Latinos (measured as dollars spent per year of life saved), using annual fecal occult blood testing (FOBT) combined with flexible sigmoidoscopy every 5 years and using colonoscopy every 10 years. A 35-year screening program beginning in blacks at age 42, whites at age 44, or Asians at age 46 was more cost-effective than screening Latinos beginning at age 50. **Conclusions:** Colorectal cancer screening programs beginning at age 50, using either FOBT and flexible sigmoidoscopy or colonoscopy in each racial or ethnic group, are within the \$40,000–\$60,000 per year of life saved upper cost limit considered acceptable for preventive strategies. Screening is most cost-effective in blacks because of high age-specific colorectal cancer incidence rates.

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 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 not practical, 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 current recommendation (1997) calls for everyone older than 50 years who is at “average risk” to be screened with annual fecal occult blood testing (FOBT) and sigmoidoscopy every 5 years or total colon examination, either by colonoscopy (every 10 years) or by double-contrast barium enema (every 5–10 years).¹¹ 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% and 80% of all colorectal cancers occur among patients at average risk.¹²

Studies of the cost-effectiveness of colorectal screening have considered Americans to be a homogeneous population and have used aggregated data sources, such as the Surveillance, Epidemiology and End Results (SEER) Program, and data from case series to estimate cost-effectiveness. The availability of data reflecting racial and ethnic colorectal cancer disease patterns, however, allows

Abbreviations used in this paper: CI, confidence interval; FOBT, fecal occult blood test; SEER, Surveillance, Epidemiology and End Results (Program).

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for accurate modeling of the cost-effectiveness of colorectal screening programs in individual racial and ethnic groups.

In the case of colorectal cancer, the 4 major racial and ethnic groups in America exhibit different age-specific colorectal cancer incidence rates,¹³ proportions of left-sided cancers,¹⁴ stage at diagnosis,¹⁵ and life expectancies.¹⁶ They may also have different polyp incidence rates, percentage of cancers originating as polyps, and polyp dwell times, although these issues have not been studied. We investigated whether the unique age and site distribution of colorectal cancer in patients of different races and ethnicities would affect the cost-effectiveness of colorectal cancer screening.

Materials and 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*¹⁷ and computerized using C/NET (C/NET Solutions, Berkeley, CA), a software package developed for tumor registries. C/NET meets all reporting requirements of the 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 cases from each reporting facility, reviews for completeness of case finding, and computer edits for completion and consistency.¹⁸ 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. Completeness is estimated to be higher than 99% annually for 1988 through 1998.¹⁹

Recorded data include demographic information (age, sex, race/ethnicity [white, black, Latino, or Asian), pathology, site of disease, stage of disease, treatment during the first 4 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; World Health Organization²⁰). All cases included in this article were primary invasive adenocarcinomas of the colon or rectum, and more than 99% were confirmed histologically. Tumors from the cecum to the splenic flexure were considered right-sided cancers, and tumors at 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 to 1995 in California by the age-specific population over the same period.

SEER data were obtained from the SEER Cancer Incidence Public-Use Database 1973–1996, U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health, National Cancer Institute, Cancer Statistics Branch (Bethesda, MD).

Life expectancy tables for Californians from 1989 to 1991 were obtained from the National Center for Health Statistics at the Centers for Disease Control and Prevention.¹⁶ Life expectancy tables were available for whites and blacks. Life expectancy tables for "other than white" were used for Latinos and Asians.

Modeling

Cost-effectiveness modeling of colorectal screening programs was done using a model developed at the Office for Technology Assessment (Washington, D.C.) and described in detail previously.^{21–25} 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 technology for early cancer and polyps; the cost of screening, follow-up, and postpolypectomy surveillance procedures; and the incremental costs of treating early- and late-stage colorectal cancer. Costs and years of life saved are discounted to their present value at 5% per year. The main assumptions of the model are summarized in Table 1. Justification of model assumptions are based on reviews of the published literature.^{21–25}

Statistics

Categorical variables were compared with χ^2 and logistic regression using SAS statistical software.^{26,27} Statistical significance was assumed for a *P* value of <0.05 (2-tailed).

Results

The proportion of colorectal cancers diagnosed before age 50 is nearly twice as high in Asians, blacks, and Latinos as in whites using both California Cancer Registry and SEER data (Table 2). Hence, even if patients were entirely compliant with a completely sensitive colorectal screening program that began at age 50, nearly 10% of colorectal cancers in Asians, blacks, and Latinos would not be detected until symptomatic.

The higher proportion of colorectal cancers found in young non-white races or ethnicities may be the result of increased colorectal cancer incidence rates or may reflect a higher proportion of individuals younger than 50 years in non-white groups. Figure 1 illustrates and Table 3 lists the annual age-specific incidence rates of colorectal

Table 1. Assumptions Used in the Cost-effectiveness Analysis

Variable	Value
Natural history of 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
Proportion of cancers detected in the early stage (%)	33-36
Prevalence of lifetime-latent cancers at 50 yr of age	2/1000
Annual incidence of lifetime-latent cancer	2/10,000
Accuracy (%)	
FOBT	
Sensitivity for polyps	10
Sensitivity for colorectal cancer	60
Specificity	90
Sigmoidoscopy and colonoscopy (%)	
Sensitivity for polyps	90
Specificity for polyps	98
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 (\$)	
FOBT	10
Screening sigmoidoscopy	80
Diagnostic colonoscopy	310
Therapeutic colonoscopy	523
Treatment of patients with early cancer	35,000
Treatment of patients with late cancer	45,000
Treatment of patients with colonoscopy-induced perforations	35,000
Treatment of patients who die as a result of colonoscopy	30,000

cancer in California from 1988 to 1995 for each of 4 racial and ethnic groups. Average annual age-specific colorectal cancer incidence rates (with 95% confidence interval [CI]) were highest in blacks and lowest in Latinos at age 50: blacks (56.6 [95% CI, 44.8–68.4]/100,000) > Asians (35.2 [95% CI, 27.4–42.9]/100,000) > whites (33.2 [95% CI, 30.3–36.0]/100,000) > Latinos (26.6 [95% CI, 21.7–31.4]/100,000). The average annual age-specific incidence rate for blacks at age 47 exceeded the age-specific incidence rate of each of the other racial and ethnic groups at age 50. This was true for both men and women (data not shown). For most ages between 50 and 85, the rank of average annual incidence rates was consistent (blacks > whites > Asians > Latinos; Table 4).

The cost-effectiveness of flexible sigmoidoscopy is 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 each racial or ethnic group that occur at or distal to the splenic flexure and therefore could be detected by flexible sigmoidoscopy. Table 5 indicates that 73% of Asian, 66% of Latino, 60% of white, and 59% of black colorectal cancers occur in the distal colon and rectum ($P < 0.05$). Table 6 indicates that, after adjusting for sex and age, blacks are more likely to have right-sided cancers than whites (odds ratio [OR], 1.072; 95% CI, 1.054–1.092), whereas Asians and Latinos are much less likely to have right-sided cancers than whites (OR, 0.579; 95% CI, 0.567–0.590; and OR, 0.813, 95% CI, 0.800–0.826, respectively).

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 curable 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 to the colon or rectum (i.e., are node negative). Table 5 indicates that 36% of white, 34% of Latino, 33% of Asian, and 33% of black colorectal cancers are localized at the time of diagnosis. The proportion of localized cancers in each non-white race or ethnic group was significantly lower than those of whites ($P < 0.001$).

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 2 established strategies: (1) annual FOBT and every-5-year flexible sigmoidoscopy and (2) every-10-year colonoscopy, starting at age 50 and ending at age 85. These models also incorporated published differences in life expectancy between the 4 racial/ethnic groups. The assumptions underlying these estimates are summarized in Table 1.

After adjusting for racial or ethnic differences in colorectal cancer, screening blacks by either screening regimen was most cost-effective regardless of assuming a 5-

Table 2. Proportion of Colorectal Cancers Occurring Before Age 50 in Patients of Different Races and Ethnicities in California, 1988–1995, and in the United States (SEER Data), 1970–1994

Ethnicity	California	SEER
Asian	13.0	8.6
Black	10.7	10.6
Latino	13.7	11.1
White	5.4	5.5

Figure 1. Average annual colorectal cancer incidence rates (per 100,000 persons) by age for Asians (brown), blacks (green), Latinos (blue), and whites (red) in California, 1988–1995.

or 10-year polyp dwell time (black > white > Asian > Latino; Table 7). Cost-effectiveness estimates largely reflected the different average annual age-specific colorectal cancer incidence rates among groups. Cost-effectiveness estimates for blacks would have been even lower had not the life expectancy estimates for this group been lower than for the others.

Although flexible sigmoidoscopy is capable of reaching the splenic flexure, screening in routine clinical practice may reliably survey only the sigmoid colon and rectum. We therefore adjusted the model of screening with FOBT and sigmoidoscopy to assume that sigmoidoscopy detected only those cancers located in the sigmoid colon and rectum. In every case (for each racial and ethnic group at either polyp dwell time), the cost-effectiveness estimates were within \$1000 per year of life saved of the estimates shown in Table 6 made assuming sigmoidoscopy reached the splenic flexure (data not shown).

Cost-effectiveness estimates were similar for each racial or ethnic group using FOBT and sigmoidoscopy at either polyp dwell time. In the case of colonoscopic surveillance every 10 years, however, costs were much higher assuming a 5-year polyp dwell time. The increased

cost-per-year-of-life-saved estimates using colonoscopy rather than FOBT and sigmoidoscopy, assuming a 5-year polyp dwell time, were highest in Latinos and lowest in blacks (Latinos \$16,713 > Asians \$14,446 > whites \$10,773 > blacks \$8,257).

These models assumed a similar polyp incidence among all racial and ethnic groups. Polyp incidence data in racial and ethnic groups have not been reported, although the overall prevalence of adenomas in asymptomatic average-risk African Americans is comparable to that of whites.²⁸ 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 increased the polyp incidence rate of the group at highest risk of colorectal cancer (blacks) by a factor of 2 in comparison to that of the group with the lowest risk of colorectal cancer (Latinos). This adjustment resulted in a small change in cost-effectiveness in blacks. For example, using every-10-years colonoscopic

Table 3. Average Annual Age-Specific Colorectal Cancer Incidence Rates by Race and Ethnicity in California in 1988–1995

Age (yr)	Asian	Black	Latino	White
35	3.8	5.2	2.4	3.8
36	5.3	5.8	4.4	5.0
37	5.8	7.6	4.8	5.5
38	7.3	9.4	5.3	6.9
39	9.9	7.4	5.4	8.0
40	9.2	17.1	5.9	8.7
41	10.4	15.5	8.6	11.7
42	15.5	21.9	7.7	10.6
43	14.4	22.6	9.0	13.2
44	15.9	24.0	11.7	15.2
45	18.4	23.2	10.2	16.0
46	21.3	31.8	15.0	20.1
47	27.2	33.4	20.2	21.2
48	26.7	38.0	18.7	23.9
49	32.4	46.1	23.3	28.3
50	35.2	56.6	26.6	33.2
51	36.6	53.5	23.2	41.0
52	40.3	66.9	31.0	42.6
53	47.1	78.7	38.0	51.7
54	47.5	99.2	40.9	54.1
55	57.4	88.3	36.9	65.2
56	63.6	104.8	47.7	76.1
57	51.7	115.0	53.8	80.0
58	75.4	128.6	64.0	86.7
59	97.8	125.4	71.4	101.2
60	97.2	140.1	64.3	111.6
61	97.9	174.3	78.9	128.7
62	102.2	143.1	97.5	128.4
63	108.1	156.2	97.1	142.8
64	125.6	191.8	99.3	150.3
65	144.7	196.3	113.0	178.7
66	147.2	249.9	143.9	181.8
67	157.4	241.2	138.2	199.0
68	185.2	226.4	160.6	213.3
69	186.8	264.3	144.2	225.7
70	181.0	270.8	141.6	245.1
71	202.2	271.2	160.7	255.6
72	201.8	307.2	171.0	264.4
73	209.1	341.2	183.7	294.4
74	252.6	311.1	207.8	319.1
75	238.0	346.8	215.4	330.5
76	250.2	402.2	222.0	354.5
77	255.6	398.7	208.6	375.8
78	278.2	399.3	252.9	372.8
79	300.5	393.7	229.8	404.6
80	317.2	464.4	272.4	426.7
81	402.0	427.8	268.7	448.2
82	369.6	489.8	265.0	454.3
83	374.0	534.9	245.6	470.0
84	383.2	506.1	274.2	495.0
85	371.2	481.5	271.9	492.7

screening, the cost-effectiveness estimates for blacks increased from \$9777 to \$10,574 per year of life saved (10-year polyp dwell time) and from \$21,595 to \$22,830 per year of life saved (5-year polyp dwell time). Cost-effectiveness estimates in the other racial and ethnic groups were also minimally sensitive to changes in polyp incidence rate (data not shown).

We assessed the cost-effectiveness of a 35-year screening program in blacks, whites, and Asians starting at ages younger than 50 years to determine at what age cost-effectiveness estimates using flexible sigmoidoscopy with FOBT would exceed the cost-effectiveness estimate of Latinos (the group in whom screening was least cost-effective). We continued to adjust for the proportion of left-sided cancers and the proportion of early cancers, as well as life expectancy and colorectal cancer incidence, using age-appropriate data. We also incorporated age-appropriate 5-year all-cause survival from colorectal cancer. Thirty-five-year screening programs beginning in blacks at age 42 (5-year polyp dwell time, \$23,686 per year of life saved; 10-year polyp dwell time, \$21,599 per year of life saved), whites at age 44 (5-year polyp dwell time, \$24,565 per year of life saved; 10-year polyp dwell time, \$22,285 per year of life saved), and Asians at age 46 (5-year polyp dwell time, \$24,444 per year of life saved; 10-year polyp dwell time, \$22,753 per year of life saved) were more cost-effective than a 35-year screening program beginning in Latinos at age 50. This was true even after doubling the polyp incidence rate in non-Latino racial and ethnic groups (data not shown).

Discussion

We have shown that racial and ethnic colorectal cancer disease patterns affect the cost-effectiveness of colorectal screening. In all cases, estimates of cost-effectiveness of screening each racial or ethnic group with sigmoidoscopy and FOBT or colonoscopy starting at age 50 were within the \$40,000–\$60,000 per year-of-life-saved upper cost limit considered acceptable for preventive strategies.^{24,29–31} When an established colorectal cancer screening model included age-specific incidence rates, proportion of localized cancers, proportion of left-sided cancers, and life expectancy estimates specific for each race and ethnicity, however, the cost-effectiveness of colorectal screening varied dramatically. Screening was most cost-effective in blacks (blacks > whites > Asians > Latinos). The cost-effectiveness of screening largely reflected average annual age-specific colorectal cancer incidence rates (blacks > whites > Asians > Latinos). Differences were robust and persisted after increasing the polyp incidence rate for groups with higher average annual age-specific colorectal cancer rates.

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. However, if the cost and effectiveness of identifying and treating colorectal cancer are similar in all racial and

Table 4. Average Annual Age-Specific Colorectal Cancer Incidence Rates per 100,000 Persons (and 95% CI) by Racial and Ethnic Group in California in 1988–1995

Age (yr)	Asian	Black	Latino	White
45	18.4 (13.6–23.2)	23.2 (16.5–29.9)	10.2 (7.68–12.8)	16.0 (14.2–17.8)
50	35.2 (27.4–42.9)	56.6 (44.8–68.4)	26.6 (21.7–31.4)	33.2 (30.3–36)
55	57.4 (46.4–68.4)	88.3 (72.2–104)	36.9 (30.4–43.4)	65.2 (60.8–70)
60	97.2 (81.8–112)	140 (118–162)	64.3 (55.0–73.7)	112 (106–118)
65	145 (124–164)	196 (168–225)	113 (99.4–126)	179 (171–186)
70	181 (156–206)	271 (234–308)	142 (124–160)	245 (236–254)
75	238 (203–273)	347 (298–396)	215 (188–243)	330 (318–342)
80	317 (265–369)	464 (394–535)	272 (234–310)	427 (410–443)
85	371 (290–452)	482 (380–583)	272 (222–322)	493 (470–516)

ethnic groups, it is clear that for colorectal cancer screening to be equally cost-effective for all groups, non-Latino groups need to begin colorectal screening at earlier ages. This is particularly true in the case of blacks, in whom a 35-year colorectal screening program starting at age 42 was predicted to be more cost-effective than a comparable program starting in Latinos at age 50.

Use of colorectal screening strategies will impact colorectal incidence rates. For instance, racial and ethnic groups who 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 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 cannot discount with certainty that the 1988–1995 age-specific California colorectal incidence rates were corrupted by the current use of screening strategies. Public health surveys indicate that blacks are less likely than whites to utilize colorectal screening tests.^{32,33} While it is possible that disproportionate screening utilization accounts for differences between average annual incidence rates in these groups, the majority of both groups have never utilized either FOBT or endoscopy.^{32,33} It has also been known for some time that blacks are diagnosed with colorectal cancer at a younger age than whites.¹³ Furthermore, our data indicate that black colorectal cancer

incidence rates are significantly higher than those of other racial and ethnic groups before the age (50 years) when screening programs should begin. Asians and Latinos are much less likely to be screened than whites and blacks,^{32,34} and the low age-specific colorectal incidence rates in these groups are unlikely to reflect the utilization of screening tests. Finally, 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 to 1991 with rates from 1992 to 1995 within each racial and ethnic group at 5-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 4 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

Table 5. Proportion of Colorectal Cancers Occurring at or Distal to the Splenic Flexure and Proportion of Localized Cancers (Node Negative) by Race and Ethnicity in California in 1988–1995

Race/ethnicity	Proportion left-sided (%)	Proportion localized (%)
Asian	73	33
Black	59	33
Latino	66	34
White	60	36

Table 6. Logistic Regression of the Propensity for Having Colorectal Cancer Proximal to the Splenic Flexure by Race and Ethnicity With Adjustment for Sex and Age in California in 1988–1995

Race/ethnicity	OR (95% CI)
White	Referent
Asian	0.579 (0.567–0.590)
Black	1.072 (1.054–1.092)
Latino	0.813 (0.800–0.826)

Table 7. Cost-effectiveness Estimates (Cost Per Year of Life Saved) of Colorectal Cancer Screening Starting at Age 50 After Adjusting for Racial and Ethnic Differences in Colorectal Cancer Incidence, Proportion of Left-Sided Cancers, Proportion of Localized Cancers, and Life Expectancy

Racial/ethnic group	Annual FOBT plus sigmoidoscopy every 5 yr		Colonoscopy every 10 yr	
	5-yr polyp dwell	10-yr polyp dwell	5-yr polyp dwell	10-yr polyp dwell
Asian	\$18,888	\$17,415	\$33,334	\$16,198
Black	\$13,338	\$11,844	\$21,595	\$ 9777
Latino	\$25,598	\$23,578	\$42,311	\$22,301
White	\$15,524	\$13,756	\$26,297	\$11,842

lower overall colorectal cancer incidence rates and 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.

Considerable controversy exists over whether screening with flexible sigmoidoscopy should be abandoned in favor of a total colonic evaluation with either colonoscopy or double-contrast barium enema. Advocates of total colonic evaluation point out that most patients with right-sided cancers do not have left-sided polyps.^{35–41} These patients must rely on FOBT, which has limited sensitivity for detecting neoplasia,⁴² to serve as an indicator of proximal polyps or curable cancers. Advocates of sigmoidoscopy point out its improved cost-effectiveness assuming a short polyp dwell time and the fact that it can be performed without sedation in the primary care setting or by paramedical personnel in the community setting. Our data indicate that racial and ethnic colorectal cancer patterns influence the relative cost-effectiveness of screening with flexible sigmoidoscopy and FOBT or with colonoscopy.

Assuming a 5-year polyp dwell time, our analysis indicated that the increase in cost per year of life saved using colonoscopy performed every 10 years instead of annual FOBT combined with sigmoidoscopy was more pronounced in racial and ethnic groups with a higher proportion of left-sided cancers. Hence, assuming a 5-year polyp dwell time, the use of flexible sigmoidoscopy and FOBT was nearly \$15,000 less per year of life

saved in Asians and Latinos than colonoscopy. Latinos and Asians are much less likely to utilize colorectal screening than whites or blacks.^{32,34} The use of sigmoidoscopy, which can be performed by paramedical personnel outside of medical facilities and which may be more cost-effective in these ethnic groups should be strongly advocated. Additional cost-effectiveness modeling incorporating recent recommendations to screen with flexible sigmoidoscopy before age 65 and colonoscopy after age 65 should be studied in these groups.⁴³

Our study used colorectal cancer incidence data from the state of California and not from the entire United States. The ethnic and racial make-up of California is diverse, as evidenced by the fact that 2 of the California cancer registries are also SEER registries and the California Cancer Registry contained sufficient numbers of each of the 4 largest racial and ethnic groups in the United States to allow statistical comparisons of age-specific colorectal cancer incidence rates. It is possible that the make-up of blacks, whites, Asians, and Latinos in California is not representative of the country as a whole. However, we observed that the proportion of colorectal cancers occurring before age 50 analyzed using SEER or California Cancer Registry data was nearly identical in blacks and whites. In the case of Asian and Latino patients, a higher proportion of cases in the California Cancer Registry occurred before age 50. This likely reflects the high proportion of young Latino and Asian immigrants in California, because the age-specific colorectal cancer incidence rates of these 2 groups were lower than those of whites and blacks. California Latinos and Asians may be dissimilar from those in other parts of the country. However, it is well known that Latinos and Asians living in all regions of the United States are much more likely to be immigrants than blacks or whites and that colorectal cancer rates are low in nearly every Asian and Latino country in comparison to rates among American whites and blacks.⁴⁴ Given lower age-specific colorectal cancer incidence rates, it is unlikely that the cost-effectiveness of colorectal screening any U.S. Asian or Latino group will approach the cost-effectiveness estimates of screening blacks or whites. Continued study of these groups is warranted, however, because the incidence of colorectal cancer in these largely immigrant groups may change as they westernize their diets and lifestyles.

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 Americans of each racial and ethnic group increase the practice of colorectal screening. Discussion of racial and ethnic colorectal disease patterns may serve as a stimulus to the

development of interventions that will prove most useful within each group. Discussion of unique racial and ethnic disease patterns may also yield implications for screening guidelines for other diseases.

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