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Rural/Nonrural Differences in Colorectal Cancer Incidence in the United States, 1998–2001

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Descriptive Epidemiology of Colorectal Cancer in the United States, 1998–2001, Utilizing Data from the NPCR and SEER Programs

Supplement to ***Cancer***

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BACKGROUND. Few studies of colorectal cancer incidence by rural, suburban, and metropolitan residence have been published.

METHODS. The authors examined colorectal cancer incidence among men and women in U.S. counties classified as rural, suburban, and metropolitan for the period 1998–2001. They examined rural/suburban/metropolitan differences in incidence by age, race, Hispanic ethnicity, stage at diagnosis, histology, and percentage of the total county population below the poverty level, using data from the CDC's National Program of Cancer Registries, the NCI's Surveillance, Epidemiology, and End Results Program, and the 2000 U.S. Census.

RESULTS. A total of 495,770 newly diagnosed or incident cases of colorectal cancer were included in this analysis (249,919 among men and 245,851 among women). Over the period 1998–2001, the colorectal cancer incidence rates among men tended to be lower among those who resided in rural areas, for each of the subgroups examined, with the exception of Asians and Pacific Islanders and those living in more affluent counties. Among women aged 75 years and older, the colorectal cancer incidence rates tended to be lower among rural than metropolitan or suburban residents, though the differences were slight. In multivariate analysis, the incidence of colorectal cancer was higher in metropolitan, suburban, and rural areas for blacks than that for whites (incidence rate ratios [RR] = 1.12, 1.07, and 1.06, respectively, all $P < 0.015$).

CONCLUSIONS. This study suggests that black men who reside in metropolitan areas have a higher risk of colorectal cancer than black men who reside in rural areas. This finding suggests the need for diverse approaches for reducing colorectal cancer when targeting rural compared with metropolitan areas. ***Cancer* 2006;107(5 Suppl):1181–8.** *© 2006 American Cancer Society.*

KEYWORDS: Asians and Pacific Islanders, blacks, colorectal cancer, Hispanics, incidence, poverty.

Previous studies have suggested that there may be important rural/nonrural differences in colorectal cancer incidence and mortality among men and women in the United States.[1–4] Such geographic variation may be partly due to differences in colorectal cancer screening because routine screening can reduce both mortality from the disease and morbidity over time.[5] Residents of poor or medically underserved areas, such as some rural areas of the United States, may face important barriers to screening.[6–8] Likewise, residents of some inner city areas may experience barriers. Atlases of cancer mortality and incidence indicate that colorectal cancer rates are highest in the Northeast and Midwest regions of the United

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States. These regions cover large geographic areas and include major metropolitan, suburban, and rural areas,[1,2,4] thus making it difficult to identify rural/nonrural differences using these data. An analysis of colorectal cancer mortality in the Appalachian region of the United States from 1969 to 1999 showed that death rates had declined in the more recent years, but in 1999 the rates for white males and white females were still significantly higher in Appalachia than in the rest of the country.[9] The higher death rates in Appalachia, which is disproportionately rural, may be due to the cancers being diagnosed at a later stage when survival is relatively poor, to poorer treatment, or to other factors. Lower screening rates may partly account for the higher than expected rates of late-stage colorectal cancer in some areas. Death certificate data do not include information about the decedents' stage of colorectal cancer at diagnosis or the histology, but incidence studies can provide such information and attempt to clarify rural/nonrural differences in the disease. However, a detailed examination of colorectal cancer incidence in metropolitan, suburban, and rural areas of the United States, with broad coverage by geographic location, race, and ethnicity, has not been published.

To help clarify these relationships, we examined colorectal cancer incidence among men and women in U.S. counties classified as rural, suburban, and metropolitan. We assessed incidence among rural, suburban, and metropolitan residents by age, race, Hispanic ethnicity, stage at diagnosis, histology, and poverty indication.

MATERIALS AND METHODS

For this analysis, we used data from the National Program of Cancer Registries (NPCR) reported to the Centers for Disease Control and Prevention (CDC) as of January 31, 2004, for registries that met the U.S. Cancer Statistics Publication Standard for data quality for all cancer sites combined.[10] We also used data from the November 2003 submission to the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) Program.[11] Data from Alaska, Hawaii, Illinois, and Minnesota were excluded because county-level data on rural/nonrural residence are not available for these states. SEER data from the Atlanta Metropolitan area were excluded because they included no rural residents. In California, stage data were not submitted to NPCR. Therefore, we excluded data from California from analyses involving stage of cancer diagnosis because stage data were available only from SEER registries in the state, and those SEER areas included no rural residents. The final analytic dataset included incidence data for 35 states and the District of Columbia, representing about 80% of the U.S. population. We combined data for invasive cancer diagnoses between 1998 and 2001, inclusive, among adults aged 20 years or older at the time of diagnosis.

We computed incidence rates and 95% confidence intervals (CIs) for the period 1998–2001. We compared the incidence of colorectal cancer in metropolitan, suburban, and rural counties of the United States, using the U.S. Department of Agriculture's urban/rural continuum codes that are based on information from the 2000 U.S. Census.[12] Codes 0–3 correspond to metropolitan counties (including metropolitan areas with populations of about 250,000 to greater than 1 million); codes 4–5 correspond to predominately suburban populations of 20,000 or greater, but less than 250,000; and codes 6–9 correspond to rural populations and small towns of up to 19,999. According to their county of residence, persons were assigned a county-level rural–urban continuum code and categorized as residents of a) metropolitan areas (codes 0–3), b) suburban areas (codes 4–5), or c) rural areas (codes 6–9).

We examined colorectal cancer incidence rates in metropolitan, suburban, and rural areas by age categories, gender, race, ethnicity, stage at cancer diagnosis, histology, and an area-based indicator of poverty. We categorized patient age at diagnosis in 5-year intervals for ages 20–84 years, with a final category of >85 years. Among rural, suburban, and metropolitan residents, incidence rates by residence were examined for black, white, and Asian/Pacific Islander men and women. We also examined differences in incidence by residence and Hispanic ethnicity. Data were not available for Asian/Pacific Islander or Hispanic subgroups. Incidence rates were not calculated separately for American Indians and Alaska Natives, but these persons were included in overall analyses.

Stage at diagnosis was categorized according to SEER summary stage (localized, regional, distant, or unstaged). Analyses by histologic type included the following ICD-O-3 groupings[13]: adenocarcinoma (histologic codes 8140–8147, 8160–8162, 8180–8221, 8250–8506, 8520–8550, 8560, 8570–8573, 8940–8941) including papillary carcinoma not otherwise specified (8050); nonadenocarcinoma (all other types except 'unspecified'); and unspecified (not otherwise specified).

Poverty was defined as the percentage of the total county population below the federal poverty level as reported in the 2000 U.S. Census.[14] We categorized counties as <10%, 10% to <20%, or ≥20% of the total county population below poverty level.

TABLE 1
Age-Specific Colorectal Cancer Incidence Rates* by Metropolitan, Suburban, Rural Resident Status among Men, United States, 1998–2001†

	Total			Metropolitan			Suburban			Rural		
Age (yr)	Cases	Rate	95% CI	Cases	Rate	95% CI	Cases	Rate	95% CI	Cases	Rate	95% CI
20–24	238	0.8	(0.7–0.9)	192	0.7	(0.6–0.9)	19	0.8	(0.5–1.3)	26	1.0	(0.7–1.5)
25–29	626	2.0	(1.8–2.2)	518	1.9	(1.8–2.1)	53	2.6	(2.0–3.5)	55	2.3	(1.7–3.0)
30–34	1314	4.0	(3.7–4.2)	1134	4.0	(3.8–4.2)	87	4.1	(3.3–5.1)	93	3.7	(3.0–4.5)
35–39	2872	8.0	(7.7–8.3)	2407	7.9	(7.6–8.2)	200	8.4	(7.3–9.6)	262	8.8	(7.7–9.9)
40–44	5392	15.3	(14.8–15.7)	4500	15.2	(14.7–15.6)	395	16.2	(14.6–17.9)	492	15.7	(14.3–17.1)
45–49	9631	30.7	(30.1–31.4)	7948	30.5	(29.9–31.2)	737	32.7	(30.4–35.2)	938	31.9	(29.9–34.0)
50–54	15,862	58.7	(57.8–59.7)	13,054	58.5	(57.5–59.5)	1255	63.5	(60.1–67.2)	1542	59.3	(56.4–62.4)
55–59	20,758	101.0	(99.6–102.3)	16,948	100.9	(99.4–102.4)	1600	102.7	(97.7–107.9)	2194	102.6	(98.3–107.0)
60–64	26,883	164.1	(162.2–166.1)	21,638	164.6	(162.4–166.8)	2220	168.4	(161.4–175.5)	3005	161.1	(155.4–167.0)
65–69	35,119	246.4	(243.8–249.0)	28,285	248.0	(245.1–250.9)	2873	245.7	(236.8–254.9)	3944	240.0	(232.6–247.7)
70–74	41,428	326.8	(323.7–330.0)	33,328	328.1	(324.6–331.7)	3451	329.1	(318.2–340.3)	4633	321.2	(312.1–330.6)
75–79	39,972	404.1	(400.2–408.1)	32,499	407.0	(402.6–411.4)	3311	413.0	(399.1–427.3)	4142	382.2	(370.6–394.0)
80–84	28,401	471.5	(466.0–477.0)	23,020	474.5	(468.4–480.7)	2349	482.0	(462.7–501.8)	3024	449.1	(433.2–465.4)
≥85	21,423	531.6	(524.5–538.8)	17,348	538.5	(530.5–546.6)	1639	515.0	(490.3–540.5)	2430	504.0	(484.1–524.4)

* Rates are per 100,000 persons.

† Data are from selected population-based cancer registries that participate in the National Program of Cancer Registries and/or the Surveillance Epidemiology and End Results Program and meet high-quality data criteria: Alabama, Arizona, California, Colorado, Connecticut, District of Columbia, Florida, Idaho, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Massachusetts, Michigan, Missouri, Montana, Nebraska, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Texas, Utah, Vermont, Washington, West Virginia, Wisconsin, Wyoming. These registries cover ~80% of the U.S. population. Alaska, Atlanta (Georgia), Hawaii, Illinois, and Minnesota were excluded (see Methods).

Area-based measures of socioeconomic position have been widely used by other investigators to characterize important aspects of the social environment.[15–17]

All rates, except age-specific rates, were adjusted by the direct method to the 2000 U.S. standard population by 5-year age groups. Rates were compared only if there were at least 16 cases in each cell. Ninety-five percent CIs were estimated following a gamma distribution.[18] The rate ratio test was used to compare incidence rates in rural areas to the other 2 groups. $P < .05$ indicated statistical significance. No adjustment was made for multiple comparisons.

We used negative binomial modeling techniques to examine the effects of age, gender, race (or Hispanic ethnicity), year of diagnosis, and percentage below the poverty level, and to adjust for these factors while examining metropolitan, suburban, and rural differences in the colorectal cancer incidence rates.[19] Negative binomial models[19] were used rather than Poisson models because of large amounts of overdispersion in the Poisson models. Two-way interactions between area (metropolitan, suburban, or rural) and each of the other covariates were examined to determine if the area effect was similar across levels of these variables. A statistically significant effect modification was observed between area (metropolitan, suburban, or rural) and both poverty level and gender. However, this effect was primarily due to the large sample size and power to detect small differences; there was not meaningful variation in the incidence rate ratios among groups. Therefore, these interactions were omitted from the model. Race and ethnicity could not be included in the same model because population data are not available for some race/ethnicity combinations, as race and Hispanic ethnicity were recorded separately. As a result, separate models were fit for these variables. Statistical testing in all models was performed using the likelihood ratio test.

The CDC Institutional Review Board approved this study.

RESULTS

A total of 495,770 newly diagnosed cases of colorectal cancer were included in this analysis (249,919 among men and 245,851 among women). Age-specific colorectal cancer incidence rates by metropolitan, suburban, and rural residence among men and among women, for the period 1998–2001, are shown in Tables 1 and 2, respectively. Among rural, suburban, and metropolitan residents, the rates increased with advancing age and were highest among men in the oldest age categories. Among men aged 75–84 years, the colorectal cancer incidence rates were lower among those who resided in rural areas than among those who resided in other areas. Among women aged 75 and older, the colorectal cancer incidence

TABLE 2
Age-Specific Colorectal Cancer Incidence Rates* by Metropolitan, Suburban, Rural Resident Status among Women, United States, 1998–2001[†]

	Total			Metropolitan			Suburban			Rural		
Age (yr)	Cases	Rate	95% CI	Cases	Rate	95% CI	Cases	Rate	95% CI	Cases	Rate	95% CI
20–24	229	0.8	(0.7–0.9)	183	0.7	(0.6–0.8)	17	0.8	(0.5–1.3)	29	1.3	(0.9–1.9)
25–29	529	1.7	(1.6–1.9)	438	1.7	(1.5–1.8)	38	2.0	(1.4–2.8)	51	2.3	(1.7–3.0)
30–34	1,204	3.7	(3.5–3.9)	1022	3.6	(3.4–3.8)	78	3.9	(3.1–4.9)	104	4.3	(3.5–5.2)
35–39	2590	7.2	(6.9–7.4)	2213	7.2	(6.9–7.5)	151	6.4	(5.5–7.6)	225	7.7	(6.7–8.7)
40–44	5058	14.1	(13.7–14.5)	4239	14.0	(13.6–14.4)	373	15.3	(13.8–17.0)	445	14.4	(13.1–15.8)
45–49	8385	25.9	(25.4–26.5)	7028	26.0	(25.4–26.6)	592	26.3	(24.2–28.5)	763	26.4	(24.6–28.3)
50–54	12,750	45.2	(44.4–46.0)	10,620	45.1	(44.3–46.0)	917	45.9	(43.0–49.0)	1207	46.5	(43.9–49.2)
55–59	15,282	69.3	(68.2–70.4)	12,561	69.3	(68.1–70.5)	1160	70.8	(66.8–75.0)	1554	70.1	(66.7–73.7)
60–64	19,881	109.6	(108.0–111.1)	16,161	109.8	(108.1–111.5)	1548	109.3	(103.9–114.9)	2162	110.3	(105.7–115.0)
65–69	27,319	164.1	(162.2–166.1)	22,051	163.7	(161.5–165.9)	2181	165.0	(158.1–172.1)	3069	169.3	(163.4–175.4)
70–74	35,693	221.5	(219.2–223.8)	29,030	221.6	(219.0–224.1)	2898	227.0	(218.8–235.4)	3753	220.7	(213.7–227.9)
75–79	40,678	288.0	(285.2–290.8)	33,467	290.5	(287.4–293.6)	3147	283.6	(273.8–293.7)	4042	275.2	(266.8–283.9)
80–84	36,267	358.2	(354.5–361.9)	29,613	361.4	(357.3–365.6)	2797	348.4	(335.6–361.5)	3845	346.9	(336.0–358.0)
≥85	39,986	410.0	(406.0–414.1)	32,444	414.5	(410.0–419.0)	3089	400.5	(386.5–414.8)	4430	390.8	(379.3–402.4)

* Rates are per 100,000 persons.

† Data are from selected population-based cancer registries that participate in the National Program of Cancer Registries and/or the Surveillance Epidemiology and End Results Program and meet high-quality data criteria (see Table 1 footnote for list of registries). These registries cover ~80% of the U.S. population.

TABLE 3
Age-Adjusted Colorectal Cancer Incidence Rates* by Race, Ethnicity, Stage, Poverty Status, and Metropolitan, Suburban, Rural Resident Status among Men Aged 20 Years and Older, United States, 1998–2001[†]

	Total			Metropolitan			Suburban			Rural		
Characteristic	Cases	Rate	95% CI	Cases	Rate	95% CI	Cases	Rate	95% CI	Cases	Rate	95% CI
Overall[‡§]	249,919	92.4	(92.1–92.8)	202,819	92.8	(92.4–93.2)	20,189	93.9	(92.6–95.3)	26,780	90.1	(89.1–91.2)
Race												
White[‡§]	221,581	91.9	(91.5–92.3)	177,341	92.3	(91.9–92.8)	18,960	93.7	(92.4–95.1)	25,183	89.8	(88.7–90.9)
Black[‡]	20,338	97.4	(96.0–98.8)	18,221	98.3	(96.8–99.8)	943	95.3	(89.2–101.9)	1159	87.8	(82.7–93.1)
Asian/Pacific Islander[‡]	4673	63.7	(61.7–65.7)	4573	63.3	(61.3–65.3)	61	93.1	(67.7–127.6)	37	99.2	(67.9–142.3)
Ethnicity												
Hispanic	13,811	76.1	(74.7–77.5)	12,656	76.3	(74.9–77.8)	532	79.2	(72.1–87.0)	619	74.8	(68.7–81.4)
Non-Hispanic[‡§]	236,094	93.6	(93.2–94.0)	190,152	94.2	(93.7–94.6)	19,654	94.4	(93.1–95.8)	26,161	90.6	(89.5–91.7)
Stage												
Localized[‡§]	77,652	33.0	(32.8–33.3)	61,382	33.3	(33.1–33.6)	6981	33.6	(32.8–34.4)	9249	31.5	(30.9–32.2)
Regional[‡]	84,323	35.8	(35.5–36.0)	66,947	36.3	(36.0–36.5)	7314	35.1	(34.3–35.9)	10,025	34.2	(33.6–34.9)
Distant[‡]	36,383	15.3	(15.1–15.4)	28,819	15.4	(15.2–15.6)	3227	15.3	(14.8–15.9)	4321	14.7	(14.2–15.1)
Unstaged	22,291	10.0	(9.8–10.1)	17,397	9.9	(9.8–10.1)	2022	10.2	(9.7–10.6)	2834	10.1	(9.7–10.5)
Percentage below poverty level												
<10	78,592	94.7	(94.0–95.4)	68,912	94.7	(94.0–95.4)	4522	95.5	(92.7–98.3)	5158	94.4	(91.8- 97.0)
10 to <20[‡§]	149,005	91.7	(91.2–92.2)	118,978	91.7	(91.2–92.3)	13,530	94.0	(92.4–95.6)	16,497	89.9	(88.5–91.3)
≥20[‡]	22,191	91.7	(90.5–92.9)	14,929	93.8	(92.3–95.3)	2137	90.3	(86.4–94.3)	5125	86.8	(84.4–89.2)

No adjustments were made for multiple comparisons to control the Type I error-rate. Statistically significant differences should be interpreted with caution.

* Rates are per 100,000 persons and are age-adjusted to the 2000 U.S. standard population.

† Data are from selected population-based cancer registries that participate in the National Program of Cancer Registries and/or the Surveillance Epidemiology and End Results Program and meet high-quality data criteria (see Table 1 footnote for list of registries). These registries cover ~80% of the U.S. population. California was excluded from analysis by stage because of missing stage data. Hispanic origin is not mutually exclusive from race categories.

‡ $P < 0.05$ for testing for differences between metropolitan vs. rural areas.

§ $P < 0.05$ for testing for differences between suburban vs. rural areas.

TABLE 4
Age-Adjusted Colorectal Cancer Incidence Rates* by Race, Ethnicity, Poverty Status, and Metropolitan, Suburban, and Rural Resident Status among Women Aged 20 Years and Older, United States, 1998–2001†

	Total			Metropolitan			Suburban			Rural		
Characteristic	Cases	Rate	95% CI	Cases	Rate	95% CI	Cases	Rate	95% CI	Cases	Rate	95% CI
Overall	245,851	66.8	(66.6–67.1)	201,070	67.1	(66.8–67.4)	18,986	66.8	(65.8–67.8)	25,679	66.4	(65.5–67.2)
Race												
White	215,336	65.9	(65.6–66.2)	173,631	66.0	(65.7–66.4)	17,767	66.6	(65.6–67.6)	23,846	65.6	(64.7–66.4)
Black	22,953	74.8	(73.8–75.8)	20,573	75.1	(74.1–76.2)	971	71.3	(66.9–76.0)	1399	74.1	(70.2–78.1)
Asian/Pacific Islander‡§	4516	48.2	(46.7–49.7)	4396	47.9	(46.4–49.4)	57	53.7	(37.7–76.3)	61	103.8	(76.8–139.0)
Ethnicity												
Hispanic	12,076	51.4	(50.4–52.3)	11,234	51.7	(50.7–52.7)	368	46.8	(42.0–52.0)	474	51.5	(46.9–56.4)
Non-Hispanic‡	233,760	67.9	(67.6–68.1)	189,824	68.2	(67.9–68.5)	18,616	67.3	(66.4–68.3)	25,204	66.7	(65.9–67.6)
Stage												
Localized§	73,641	23.0	(22.8–23.2)	58,543	23.1	(22.9–23.3)	6469	23.6	(23.0–24.1)	8600	22.6	(22.1–23.1)
Regional‡	85,548	26.8	(26.6–26.9)	68,409	27.0	(26.8–27.2)	7117	25.9	(25.3–26.5)	9991	26.4	(25.9–26.9)
Distant‡	34,704	11.0	(10.9–11.1)	27,862	11.1	(11.0–11.3)	2913	10.8	(10.5–11.3)	3911	10.6	(10.3–10.9)
Unstaged	23,852	7.1	(7.0–7.2)	18,999	7.2	(7.1–7.3)	1938	6.6	(6.4–7.0)	2877	7.0	(6.8–7.3)
Percentage below poverty level												
<10‡	77,231	68.5	(68.0–69.0)	67,710	68.2	(67.7–68.7)	4379	69.5	(67.4–71.6)	5142	71.0	(69.1–73.1)
10 to <20§	145,933	66.3	(65.9–66.6)	117,583	66.2	(65.9–66.6)	12,774	67.4	(66.2–68.6)	15,576	65.6	(64.5–66.6)
≥20‡§	22,571	66.5	(65.7–67.4)	15,777	68.6	(67.5–69.6)	1833	57.9	(55.3–60.7)	4961	64.3	(62.5–66.1)

No adjustments were made for multiple comparisons to control the Type I error-rate. Statistically significant differences should be interpreted with caution.

* Rates are per 100,000 persons and are age-adjusted to the 2000 U.S. standard population.

† Data are from selected population-based cancer registries that participate in the National Program of Cancer Registries and/or the Surveillance Epidemiology and End Results Program and meet high quality data criteria (see Table 1 footnote for list of registries). These registries cover ~80% of the U.S. population. California was excluded from analysis by stage because of missing stage data. Hispanic origin is not mutually exclusive from race categories.

‡ $P < 0.05$ for testing for differences between metropolitan vs. rural areas.

§ $P < 0.05$ for testing for differences between suburban vs. rural areas.

rates tended to be lower in rural than metropolitan areas; the differences were slight, but statistically significant.

Table 3 shows age-adjusted colorectal cancer incidence rates among men, for the period 1998–2001, by residence, race, ethnicity, stage, and percentage below poverty level. The colorectal cancer incidence rates among all men, white men, and black men were lower among those who resided in rural areas than those in metropolitan areas (Table 3). The opposite was true for Asian and Pacific Islander men; rates were higher in rural than in metropolitan areas, although the number of cases was relatively small (Table 3).

Among Asian and Pacific Islander women, rates were higher in rural than in metropolitan areas (Table 4). Among non-Hispanic women, rates were lower in rural than in metropolitan areas (Table 4).

Further analyses were carried out to examine age-adjusted colorectal cancer incidence rates by rural/suburban/metropolitan residence, race, ethnicity, stage, and percentage below poverty level by histologic type (adenocarcinoma, nonadenocarcinoma, unspecified) and gender (results not shown). The majority of cases are adenocarcinomas, and the results mirrored those observed for all histologies combined. The small number of nonadenocarcinoma cases precluded the identification of meaningful differences among subgroups.

In multivariate analysis, the incidence of colorectal cancer was higher in all areas for blacks than for whites (Table 5). In contrast, the incidence of colorectal cancer was lower among Asians and Pacific Islanders than among whites in metropolitan and suburban areas, although the number of cases was relatively small. Hispanic ethnicity was associated with lower incidence (RR = 0.81, 95% CI = 0.79–0.82, $P < .001$). There was no interaction between Hispanic ethnicity and area (metropolitan, suburban, or rural).

DISCUSSION

The results of this study suggest that, after adjustment for age, black men who reside in metropolitan areas of the United States are at greater risk of colorectal cancer than black men who reside in rural areas. In contrast, Asians and Pacific Islanders who

TABLE 5
Negative Binomial Model Predicting Colorectal Cancer Incidence among Men and Women Aged 20 Years and Older, United States, 1998–2001*

Characteristic	Likelihood ratio γ^2	DF	*P*	Incidence rate ratio	95% CI
Age					
35–44 vs. <35	4946.85	6	<0.0001	5.13	4.89–5.40
45–54 vs. <35				18.47	17.63–19.36
55–64 vs. <35				48.82	46.64–51.12
65–74 vs. <35				102.82	98.25–107.60
75–84 vs. <35				159.69	152.57–167.14
>85 vs. <35				199.17	190.04–208.70
Gender					
Female vs. Male	625.21	1	<0.0001	0.75	0.74–0.76
Race†					
Metropolitan	609.44	6	<0.0001		
Black vs. White				1.12	1.09–1.14
API vs. White				0.64	0.62–0.67
Suburban					
Black vs. White				1.07	1.02–1.13
API vs. White				0.81	0.67–0.97
Rural					
Black vs. White				1.06	1.01–1.11
API vs. White				1.20	0.98–1.46
Area†					
White	42.25	6	<0.0001		
Metropolitan vs. Rural				1.01	0.99–1.03
Suburban vs. Rural				1.01	0.99–1.04
Black					
Metropolitan vs. Rural				1.06	1.01–1.11
Suburban vs. Rural				1.02	0.96–1.09
API					
Metropolitan vs. Rural				0.54	0.44–0.67
Suburban vs. Rural				0.68	0.52–0.90
Year					
1999 vs. 1998	36.16	3	<0.0001	0.97	0.95–0.99
2000 vs. 1998				0.96	0.94–0.98
2001 vs. 1998				0.93	0.91–0.95
Percent below poverty level					
10-<20 vs. <10	4.71	2	0.0947	0.98	0.97–1.00
>20 vs. <10				0.98	0.96–1.00

* Data are from selected population-based cancer registries that participate in the National Program of Cancer Registries and/or the Surveillance Epidemiology and End Results Program and meet high-quality data criteria (see Table 1 footnote for list of registries). These registries cover ~80% of the U.S. population.
† Race by area interaction included in model ($P < 0.0001$).

live in rural areas of the United States have a higher risk than Asians and Pacific Islanders in metropolitan areas; the number of cases, however, was relatively small. The reasons for the different patterns in rural versus metropolitan incidence rates for blacks and for Asians and Pacific Islanders are not known. These disparities in colorectal cancer incidence by race and residence may be partly due to an interaction of race and geographic variation in preventive practices such as physical activity, diet, and colorectal cancer screening, although large geographic differences in stage at diagnosis were not observed. Nevertheless, prior studies have shown that colorectal cancer screening rates are lower among rural men and women than those residing in large metropolitan areas, and that colorectal cancer screening rates are low relative to those of other screening tests such as mammography.[7,8] Colorectal cancer screening may increase or decrease colorectal cancer incidence. Rural residence has been inversely associated with both preventive behaviors and socioeconomic position.[7,8] Many metropolitan areas of the United States, however, are socioeconomically diverse and include both affluent areas and inner city areas where many households have incomes below the poverty level.

Rural/nonrural differences in colorectal cancer incidence and mortality may reflect geographic differences in access to health care.[17] Access to professional advice about risk factor modification (e.g., counseling by a primary care physician to exercise more) and access to screening and appropriate follow-up care for colorectal cancer are complex issues. For example, one factor might be the distance a patient has to travel from a sparsely populated rural area to a facility providing preventive health care services or follow-up care. Access may also involve other considerations that are important in both rural and nonrural areas, e.g., health insurance, hours that clinics are open, language barriers, and availability of culturally appropriate and sensitive health care.

The current analysis is limited by the approach that was taken to define rural, suburban, or metropolitan residence. Although the urban/rural continuum codes are commonly used in epidemiologic analysis, rural/nonrural residence based on county-level information may be less satisfactory than sub-county units of analysis. The geographic size of counties varies widely. Rural populations may exist within the boundaries of metropolitan areas, and metropolitan areas may overlap geopolitical boundaries and extend into areas classified as rural or nonmetropolitan. Consequently, some misclassifications likely occurred in the current analysis. The observed differences in rural versus metropolitan colorectal cancer incidence would likely have been greater if the analyses had been based on units of analysis smaller than counties. We were unable to define metropolitan, suburban, and rural status at a smaller geographic level because the county was the smallest geographic unit of analysis in our dataset. Other limitations include small numbers within some subgroups of interest and wide confidence intervals. Nevertheless, the current study had several strengths including the fact that the data covered 80% of the U.S. population.

The proportion of colorectal cancer cases that are histologically confirmed might introduce bias into this analysis. Misclassification may occur through the inclusion of cases that are not histologically confirmed. However, more than 96% of the cases included in this analysis were histologically confirmed, and so, any biases should be small. We included all colorectal cancer cases in the descriptive analyses and then stratified some analyses by histological type (adenocarcinoma versus nonadenocarcinoma).

Analyses by Hispanic ethnicity may have been biased because of variation across states (including states that are predominately rural or predominately nonrural) in the accuracy and completeness of coding for Hispanic ethnicity.[20] Many Asian and Pacific Islander men and women in the continental U.S. reside in urban areas of California and New York, and there may be regional heterogeneity in ethnicity-specific incidence that the current study did not address.

In the current study, we did not observe large geographic differences in stage at diagnosis. Spatial analyses of geographic differences in late-stage colorectal cancer, such as the study by Rushton et al.[21] in Iowa, are also likely to be useful for identifying geographic patterns in colorectal cancer, which may be due to differential access to screening, nutritional factors, physician practice patterns, or other factors.

In conclusion, the results from this study add to the literature on disparities in colorectal cancer incidence by rural/nonrural residence including effect modification by race. An interesting and potentially important finding was that the incidence rate of colorectal cancer was higher among black men who reside in metropolitan areas of the United States than among black men who reside in rural areas. There may also be a higher rate of colorectal cancer incidence among Asians and Pacific Islanders living in rural areas of the United States than among those living in metropolitan areas.

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