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Socioeconomic Factors Impact Colon Cancer Outcomes in Diverse Patient Populations

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Abstract
Purpose Cancer disparities among racial and ethnic groups are major public health concerns. Our objective was to examine the impact of socioeconomic status (SES) on survival of colon cancer patients within major racial and ethnic groups.
Methods Patients with colon adenocarcinoma from Los Angeles County (LAC) were assessed. SES was utilized as an indicator of healthcare access and categorized by tertiles (high, middle, and low). Patient characteristics were compared and survival analyses were performed.
Results In our heterogeneous LAC cohort, we confirmed survival disparities. Asians had the best survival followed by Hispanics, whites, and blacks. For each stage of disease, Asians and Hispanics had better outcomes than whites and blacks. Then, we evaluated the impact of SES on survival within each racial and ethnic group. We observed significantly longer survival for high SES patients compared to middle and low SES patients for all racial/ethnic groups.
Conclusions While disparities across racial/ethnic groups are well-documented, our study is the first to identify socioeconomic disparities in survival for patients within the same group. These novel findings demonstrate the complex role of SES on race and ethnicity and identify the need to improve healthcare access even within select populations.

Keywords Colon cancer · Disparities · Race · Ethnicity · Socioeconomic status

Introduction

Despite a recent decrease in colorectal cancer (CRC)-related mortality, it remains the third most common cause of cancer-related deaths in the USA.[1] It has been well established that the rates of cancer incidence and CRC-related death are variable among patients from different racial and ethnic groups.[2–4] These racial and ethnic disparities in outcomes have been attributed to a wide range of potential factors, with socioeconomic status (SES) typically at the forefront of potential etiologies. However, few studies have examined the extent to which SES may directly affect colon cancer outcomes within diverse patient populations. We hypothesized that the evaluation of differential SES as surrogates of income, education, and access to care, determines prognosis within major racial and ethnic groups.

SES has been recognized as a proxy for household income and education.[5,6] Furthermore, it has been identified as a significant prognostic indicator and health risk factor in a variety of diseases. In fact, lower SES has been established as a poor prognostic indicator for several cancers, including

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breast and prostate.[7,8] SES is not only a useful surrogate of health risk factors and behavior, but also access to and usage of healthcare services. Recent studies have shown that patients from a lower SES underutilize crucial preventive screening measures.[2,9] As a result of poor SES, patients may be diagnosed at later-stage disease and have limited treatment options. Thus, SES may impact disease diagnosis and also determine access to further effective care.

In order to provide optimal patient care through preventative measures and appropriate, timely cancer treatment, there is a critical need to better understand how socioeconomic factors shape outcomes for colon cancer. With varying SES and racial and ethnic diversity in the USA, it is increasingly important to identify the key obstacles to receipt of and benefit from treatment, such that the appropriate clinical and policy initiatives to eliminate cancer health disparities can be implemented. Here, our objective was to examine colon cancer outcomes in a large, heterogeneous population to identify how SES may impact colon cancer survival within racial and ethnic groups.

Methods

Los Angeles County Cancer Surveillance Program

We utilized the Los Angeles County (LAC) Cancer Surveillance Program (CSP), which is the population-based cancer registry for LAC. Data from the registry included patient demographics, tumor record, treatment (surgery and chemotherapy), follow-up, etc., as previously described.[10] CSP presents data on SES in quintiles. In brief, the highest SES quintile in the CSP database was designated as the highest SES group in our study. For a more straightforward analysis, we grouped the second, third, and fourth SES quintiles in CSP and defined them as the middle SES group in our study. We also designated the lowest SES quintile in CSP as the lowest SES group in our study. Institutional Review Board approval was obtained from City of Hope and the State of California for this investigation.

Cancer Surveillance Program Coding

Colon cancer location, histology, staging, and differentiation were coded and reported according to the International Classification of Diseases for Oncology, Second Edition (ICD-O-2) for cases diagnosed between 1988 and 2000, and the Third Edition (ICD-O-3) for cases diagnosed from 2001 to 2006. Colon cancer topography codes which were used include ascending colon (C18.0–18.3), transverse colon (C18.4), and descending and sigmoid colon (C18.5–18.7). Overlapping tumors (C18.8), colon tumors not otherwise specified (NOS) (C18.9), and rectosigmoid tumors (C19.9) were excluded from analysis. The ICD-O-2/3 colon adenocarcinoma histology codes used in our study included

Table 1 Characteristics of patient cohort

Factors	Entire cohort *N*=32,322
Age (mean±SD)	67.5±11.9
Sex	
Male	16,189 (50)
Female	16,133 (50)
Race/ethnicity	
White	18,949 (59)
Black	4,497 (14)
Hispanic	5,082 (16)
Asian	3,794 (12)
SES	
Highest	7,558 (23)
Middle	20,523 (63)
Lowest	4,241 (13)
Extent of disease	
Local	10,278 (32)
Regional	12,768 (40)
Distant	5,308 (16)
Unknown	3,968 (12)
Tumor grade	
Well	3,090 (10)
Moderate	20,214 (63)
Poor	6,146 (19)
Undifferentiated	203 (1)
Unknown	2,669 (8)
Tumor location	
Ascending	14,258 (44)
Transverse	2,852 (9)
Descending/sigmoid	15,212 (47)
Tumor size	
≤5 cm	16,501 (51)
>5 cm	9,347 (29)
Unknown	6,474 (20)
LN examined	
None	4,938 (15)
1–11	14,118 (44)
≥12	10,811 (33)
Unknown	2,455 (8)
LN status	
Negative	15,595 (48)
Positive	9,581 (30)
Unknown	7,146 (22)
Surgery	
No	1,955 (6)
Yes	28,382 (94)
Chemotherapy	
No	22,629 (70)
Yes	8,377 (26)
Unknown	1,316 (4)

SD standard deviation, *SES* socioeconomic status, *LN* lymph nodes

8140 to 8147, 8210 to 8211, 8220 to 8221, 8260 to 8263, 8480 to 8481, and 8570 to 8576.

Coding variables for chemotherapy and surgery were utilized for this investigation. For colon cancer cases prior to 2003, surgical resection codes included partial colectomy with segmental resection (30) and resection of contiguous organ (32), subtotal colectomy or hemicolectomy (40) with resection of contiguous organ (41), total colectomy (50) with resection of contiguous organ (51), and colectomy NOS (80). For colon cancer cases from 2003 onwards, surgical codes included partial colectomy less than hemicolectomy (30) with permanent colostomy (31), subtotal hemicolectomy with right or left colectomy (40), total colectomy (50), and colectomy NOS (80). For analysis of the entire patient cohort, patients who received any of the aforementioned surgical procedures were defined as having had surgery. Tumor grade was categorized as well, moderate, poor, or undifferentiated. The extent of disease was

Table 2 Comparison of patient characteristics by race and ethnicity

Factors	Race/ethnicity				*P* value
	White *N*=18,949	Black *N*=4,497	Hispanic *N*=5,082	Asian *N*=3,794	
Age (mean±SD)	69.3±11.2	65.4±11.7	63.7±13.2	66.3±12.2	<0.001
Sex					<0.001
Male	9,581 (51)	2,054 (46)	2,582 (51)	1,972 (52)	
Female	9,368 (49)	2,443 (54)	2,500 (49)	1,822 (48)	
SES					<0.001
Highest	6,107 (32)	336 (8)	360 (7)	755 (20)	
Middle	11,909 (63)	2,753 (61)	3,388 (67)	2,473 (65)	
Lowest	933 (5)	1,408 (31)	1,334 (26)	566 (15)	
Extent of disease					<0.001
Local	6,290 (37)	1,340 (34)	1,476 (35)	1,172 (36)	
Regional	7,634 (45)	1,691 (43)	1,954 (46)	1,489 (46)	
Distant	3,007 (18)	882 (23)	826 (19)	593 (18)	
Tumor grade					<0.001
Well	1,854 (11)	428 (11)	514 (11)	294 (8)	
Moderate	11,751 (67)	2,843 (70)	3,220 (69)	2,400 (69)	
Poor	3,719 (21)	766 (19)	881 (19)	780 (22)	
Undifferentiated	127 (1)	27 (1)	29 (1)	20 (1)	
Tumor location					<0.001
Ascending	8,476 (45)	2,196 (49)	2,269 (45)	1,317 (35)	
Transverse	1,737 (9)	375 (8)	388 (8)	352 (9)	
Descending/sigmoid	8,736 (46)	1,926 (43)	2,425 (48)	2,125 (56)	
Tumor size					<0.001
≤5 cm	9,851 (65)	2,142 (62)	2,444 (60)	2,064 (68)	
>5 cm	5,418 (35)	1,325 (38)	1,620 (40)	984 (32)	
LN examined					<0.001
None	2,723 (16)	805 (20)	833 (18)	577 (16)	
1–11	8,235 (47)	1,940 (47)	2,251 (47)	1,692 (47)	
≥12	6,486 (37)	1,369 (33)	1,661 (35)	1,295 (36)	
LN status					<0.001
Negative	9,146 (64)	2,020 (59)	2,532 (61)	1,897 (59)	
Positive	5,208 (36)	1,426 (41)	1,632 (39)	1,315 (41)	
Surgery					<0.001
None	1,022 (5)	396 (9)	332 (7)	205 (5)	
Curative intent	16,751 (88)	3,823 (85)	4,441 (87)	3,367 (89)	
Non-curative surgery	1,176 (6)	278 (6)	309 (6)	222 (6)	
Chemotherapy					<0.001
No	13,712 (75)	3,144 (72)	3,295 (68)	2,478 (69)	
Yes	4,498 (25)	1,199 (28)	1,569 (32)	1,111 (31)	

SD standard deviation, *SES* socioeconomic status, *LN* lymph nodes

categorized as local, regional, or distant; and lymph node (LN) status was categorized as positive or negative.

Statistical Analysis

The primary objective was to evaluate the effects of SES within racial and ethnic groups for patients diagnosed with and treated for colon adenocarcinoma in LAC. Patients were categorized by race and ethnicity as white, black, Hispanic, and Asian. Patient and pathologic characteristics were compared using one-way analysis of variance and the chi-square test for continuous and categorical variables, respectively. Factors that were analyzed included age, sex, SES, race and ethnicity, tumor location, tumor grade, LN status, LNs examined, stage of disease, and type of treatment received.

Overall survival was compared among racial and ethnic groups for the entire cohort. Next, we stratified patients according to extent of disease as local, regional, and distant; and compared stage-specific survival across the racial and ethnic groups. Then, overall survival was compared for patients of high, middle, and low SES within each racial and ethnic group. Kaplan–Meier analysis was performed to calculate survival times, which were then compared using the log-rank test. The Cox proportional hazard model was used to calculate hazard ratios (HR) to assess the correlation between race and ethnicity and survival when controlling for other factors. *P* values were two sided and values <0.05 were considered statistically significant.

Results

Characteristics of the Patient Cohort

From the Los Angeles County CSP, there were 32,322 patients identified with colon adenocarcinoma from 1988 to 2006. Clinical and pathologic characteristics of the patient cohort are presented in Table 1. Whites comprised the largest racial and ethnic group, followed by Hispanics, blacks, and Asians (59%, 16%, 14%, and 12%, respectively). Most patients were in the middle SES group for both entire and surgical cohorts. Colon cancers were most commonly located in the descending colon (47%); and patients were diagnosed most commonly with local (32%) or regional (40%) disease. In this group, 94% of patients underwent surgery.

Examination of Factors for Racial and Ethnic Groups

In order to first verify disparities in our study population, we assessed patient characteristics and overall survival for the major racial and ethnic groups. The entire patient cohort was grouped according to race and ethnicity and the clinical and pathologic characteristics were compared (Table 2). Whites had the greatest proportion of patients (32%) with the highest SES and lowest proportion (5%) of low SES patients. After whites, Asians were more likely than blacks and Hispanics to have the highest SES. In contrast, blacks had the greatest proportion of patients (31%) with the lowest SES. Similar to

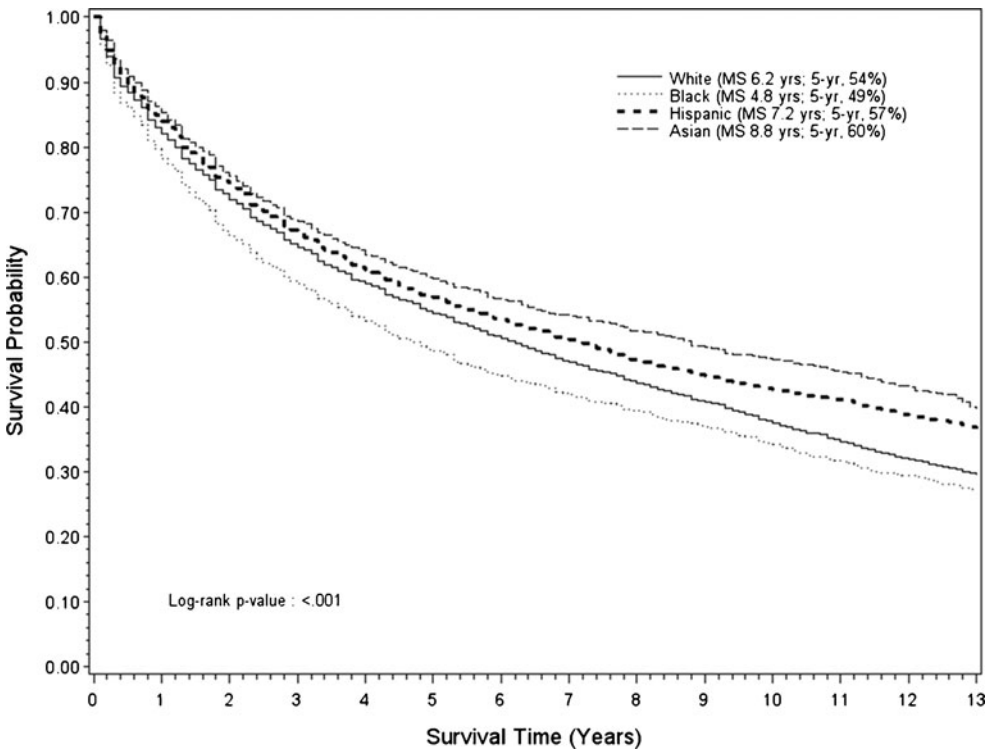


Fig. 1 Kaplan–Meier survival curves by race and ethnicity for all patients

the observations with SES, whites and Asians had higher rates of local disease than black and Hispanics. Although blacks were most likely to present with metastatic disease, Asians and Hispanics were interestingly more likely to receive chemotherapy. Whites had the lowest proportion of patients receiving chemotherapy, which may have been secondary to their greater proportion of local disease. The majority (94%) of the entire cohort underwent surgical resection.

Table 3 Univariate and multivariate analysis for the entire cohort

	Univariate analysis		Multivariate analysis	
	H.R. (95% CI)	*P* value	H.R. (95% CI)	*P* value
Age	1.03 (1.03–1.03)	<0.0001	1.04 (1.03–1.04)	<0.0001
Sex		0.0611		<0.0001
Male	1.0	–	1.0	–
Female	0.97 (0.94–1.00)	0.0611	0.87 (0.84–0.89)	<0.0001
Race/ethnicity		<0.0001		<0.0001
White	1.0	–	1.0	–
Black	1.13 (1.09–1.18)	<0.0001	1.13 (1.08–1.18)	<0.0001
Hispanic	0.88 (0.84–0.92)	<0.0001	0.93 (0.89–0.97)	0.0017
Asian	0.80 (0.76–0.84)	<0.0001	0.81 (0.77–0.86)	<0.0001
SES		<0.0001		<0.0001
Highest	1.0	–	1.0	–
Middle	1.25 (1.20–1.29)	<0.0001	1.18 (1.13–1.22)	<0.0001
Lowest	1.47 (1.40–1.55)	<0.0001	1.34 (1.26–1.41)	<0.0001
Extent of disease		<0.0001		<0.0001
Local	1.0	–	1.0	–
Regional	1.54 (1.49–1.60)	<0.0001	1.40 (1.34–1.46)	<0.0001
Distant	7.33 (7.02–7.64)	<0.0001	6.18 (5.87–6.52)	<0.0001
Tumor grade		<0.0001		<0.0001
Well	1.0	–	1.0	–
Moderate	1.23 (1.17–1.30)	<0.0001	1.10 (1.04–1.16)	0.0010
Poor	1.84 (1.73–1.95)	<0.0001	1.41 (1.33–1.50)	<0.0001
Undifferentiated	1.90 (1.60–2.27)	<0.0001	1.42 (1.18–1.69)	0.0001
Tumor location		<0.0001		<0.0001
Ascending	1.0	–	1.0	–
Transverse	0.97 (0.92–1.02)	0.2769	1.04 (0.99–1.10)	0.1446
Descending/sigmoid	0.83 (0.81–0.86)	<0.0001	0.89 (0.86–0.92)	<0.0001
Tumor size		<0.0001		0.2675
≤5 cm	1.0	–	1.0	–
>5 cm	1.18 (1.14–1.22)	<0.0001	1.02 (0.99–1.06)	0.2501
LN examined		<0.0001		<0.0001
None	1.0	–	1.0	–
1–11	0.74 (0.71–0.77)	<0.0001	0.81 (0.77–0.86)	<0.0001
≥12	0.64 (0.61–0.67)	<0.0001	0.67 (0.63–0.72)	<0.0001
LN status		<0.0001		<0.0001
Negative	1.0	–	1.0	–
Positive	2.17 (2.09–2.25)	<0.0001	1.64 (1.57–1.71)	<0.0001
Surgery		<0.0001		<0.0001
No	1.0	–	1.0	–
Yes	0.21 (0.20–0.22)	<0.0001	0.44 (0.41–0.47)	<0.0001
Chemotherapy		<0.0001		<0.0001
No	1.0	–	1.0	–
Yes	1.29 (1.24–1.33)	<0.0001	0.89 (0.86–0.93)	<0.0001

HR hazard ratio, *CI* confidence interval, *SES* socioeconomic status, *LN* lymph nodes

Survival Analysis of the Patient Cohort According to Race and Ethnicity

After grouping patients according to race and ethnicity, Kaplan–Meier curves were constructed and compared. Asians had the longest survival times followed by Hispanics, whites, and blacks (MS 8.8 vs. 7.2, 6.2, and 4.8 years, respectively; log-rank $p<0.001$) (Fig. 1). Univariate analysis was then performed to identify the factors associated with improved survival (Table 3). Multiple factors were significant predictors of survival, consistent with an extremely large cohort size. By multivariate Cox regression analysis, race and ethnicity and SES were independent predictors of survival ($p<0.001$). In addition, extent of disease, receipt of chemotherapy, and surgery were independent predictors of improved survival.

When all clinical and pathologic characteristics were included in the multivariate model, race/ethnicity and SES did not interact to influence survival. However, when stage of disease was excluded from the statistical model, race/ethnicity and SES were interactive (i.e., race/ethnicity × SES). This interesting finding may be attributed to stage of disease potentially acting as a surrogate for access to care, i.e., patients who had better access to healthcare and routine screening could have been diagnosed at earlier stages of disease stage.[11]

Survival Analysis of Racial and Ethnic Groups According to Stage of Disease

In order to further elucidate the role of race and ethnicity on survival, we grouped patients by disease stage as local, regional, or distant (Tables 4, 5, and 6); and compared stage-specific survival among the major racial and ethnic groups. For patients with local disease, Asians had the longest survival followed by Hispanics, whites, and blacks (MS 14.8 vs. 13.8, 10.8, and 10.6 years, respectively; $p<0.001$; Fig. 2a). For patients with regional disease, Asians also had the longest

Table 4 Comparison of characteristics by race and ethnicity for patients with local disease

Factors	Race/ethnicity				*P* value
	White *N*=6,290	Black *N*=1,350	Hispanic *N*=1,476	Asian *N*=1,172	
Age (mean±SD)	69.3±11.2	65.4±11.7	63.7±13.2	66.3±12.2	<0.001
Sex					0.002
Male	3,273 (52)	638 (48)	768 (52)	648 (55)	
Female	3,017 (48)	702 (52)	708 (48)	524 (45)	
Tumor grade					<0.001
Well	1,070 (20)	229 (21)	271 (21)	143 (14)	
Moderate	3,829 (70)	794 (71)	878 (69)	718 (72)	
Poor	544 (10)	91 (8)	116 (9)	138 (14)	
Undifferentiated	27 (1)	2 (0)	2 (0)	1 (0)	
Tumor location					<0.001
Ascending	2,521 (40)	565 (42)	586 (40)	370 (32)	
Transverse	477 (8)	101 (8)	85 (6)	102 (9)	
Descending/sigmoid	3,292 (52)	674 (50)	805 (55)	700 (60)	
Tumor size					0.001
≤5 cm	3,504 (78)	666 (75)	736 (73)	622 (77)	
>5 cm	970 (22)	218 (25)	279 (27)	182 (23)	
LN examined					0.0014
None	1,382 (24)	337 (27)	375 (27)	273 (24)	
1–11	2,868 (49)	673 (49)	673 (49)	581 (52)	
≥12	1,603 (27)	332 (24)	332 (24)	253 (24)	
LN status					0.024
Negative	4,890 (100)	1,077 (99)	1,237 (99)	1,021 (100)	
Positive	22 (0)	11 (1)	7 (1)	1 (0)	
Surgery					0.056
No	83 (1)	28 (2)	30 (2)	22 (2)	
Yes	6,207 (99)	1,312 (98)	1,446 (98)	1,150 (98)	
Chemotherapy					<0.001
No	5,918 (95)	1,265 (95)	1,321 (91)	1,057 (92)	
Yes	318 (5)	63 (5)	128 (9)	90 (8)	

SD standard deviation, *LN* lymph nodes

Table 5 Comparison of characteristics by race and ethnicity for patients with regional disease

Factors	Race/ethnicity				*P* value
	White *N*=7,634	Black *N*=1,691	Hispanic *N*=1,954	Asian *N*=1,489	
Age (mean±SD)	69.3±11.2	65.4±11.7	63.7±13.2	66.3±12.2	<0.001
Sex					0.008
Male	2,795 (50)	774 (46)	997 (51)	750 (50)	
Female	3,839 (50)	917 (54)	957 (49)	739 (50)	
Tumor grade					0.001
Well	445 (6)	98 (6)	118 (6)	71 (5)	
Moderate	5,051 (68)	1,191 (73)	1,335 (71)	1,017 (70)	
Poor	1,903 (26)	338 (21)	422 (22)	365 (25)	
Undifferentiated	52 (1)	14 (1)	18 (1)	6 (0)	
Tumor location					<0.001
Ascending	3,669 (48)	860 (51)	933 (48)	544 (37)	
Transverse	822 (11)	165 (10)	164 (8)	152 (10)	
Descending/sigmoid	3,143 (41)	666 (39)	857 (44)	793 (53)	
Tumor size					<0.001
≤5 cm	4,076 (59)	874 (58)	988 (56)	895 (65)	
>5 cm	2,872 (41)	629 (42)	784 (44)	479 (35)	
LN examined					0.003
None	168 (2)	58 (4)	57 (3)	31 (2)	
1–11	3,591 (51)	831 (54)	974 (53)	710 (51)	
≥12	3,243 (46)	658 (43)	794 (44)	651 (47)	
LN status					<0.001
Negative	2,675 (46)	548 (41)	700 (43)	516 (40)	
Positive	3,085 (54)	802 (59)	941 (57)	776 (60)	
Surgery					0.008
No	37 (1)	20 (1)	12 (1)	7 (1)	
Yes	7,597 (99)	1,671 (99)	1,942 (99)	1,482 (99)	
Chemotherapy					<0.001
No	4,870 (68)	1,012 (63)	1,046 (57)	781 (57)	
Yes	2,303 (32)	589 (37)	783 (43)	595 (43)	

SD standard deviation, *LN* lymph nodes

survival followed by Hispanics, whites, and blacks (MS 11.4 vs. 8.0, 6.6, and 5.8 years, respectively; $p<0.001$; Fig. 2b). For patients with distant disease, however, Hispanics had the best outcomes followed closely by Asians, whites, and blacks (MS 1.2 vs. 1.0, 1.0, and 0.8 years, respectively; $p<0.001$; Fig. 2c). For all stages of disease, black patients had the worst survival. These results demonstrate the presence of racial and ethnic disparities in outcomes for our study cohort.

Analysis of Socioeconomic Status Within Each Racial and Ethnic Group

Above, we verified that disparities in survival exist according to race and ethnicity in our study population for each stage of disease. Other studies, including our previous investigation, have demonstrated disparities in cancer survival by SES as well.[12,13] However, it is unclear whether socioeconomic disparities exist *within* the major racial and ethnic groups. Next, we grouped patients into high, middle, and low SES, and compared survival across SES levels within each racial and ethnic group. Among whites, patients of high SES had the best survival, whereas patients of low SES had the worst survival (MS 8.2 and 4.2 years, respectively; log-rank $p<0.001$; Fig. 3a). Patients with high SES also had significantly longer survival than those with low SES within the black group (MS 8.2 and 3.6 years, respectively; log-rank $p<0.001$), Hispanic group (MS 11.6 and 6.4 years, respectively; log-rank $p=0.006$), and Asian group (MS 12.6 and 5.0 years, respectively; log-rank $p<0.001$) (Fig. 3b–d, respectively).

Discussion

Although the incidence of colon cancer has been on the decline, selected racial and ethnic groups remain predisposed to having poor outcomes.[14] Our study confirms that

Table 6 Comparison of characteristics by race and ethnicity for patients with distant disease

Factors	Race/ethnicity				*P* value
	White *N*=3,007	Black *N*=882	Hispanic *N*=826	Asian *N*=593	
Age (mean±SD)	69.3±11.2	65.4±11.7	63.7±13.2	66.3±12.2	<0.001
Sex					0.002
Male	1,500 (50)	377 (43)	408 (49)	299 (50)	
Female	1,507 (50)	505 (57)	418 (51)	294 (50)	
Tumor grade					0.013
Well	140 (5)	49 (6)	52 (7)	30 (5)	
Moderate	1,643 (60)	511 (64)	468 (63)	318 (58)	
Poor	926 (34)	228 (29)	218 (29)	192 (35)	
Undifferentiated	37 (1)	8 (1)	6 (1)	12 (2)	
Tumor location					<0.001
Ascending	1,380 (46)	444 (50)	361 (44)	219 (37)	
Transverse	261 (9)	68 (8)	54 (7)	56 (9)	
Descending/sigmoid	1,366 (45)	370 (4)	411 (50)	318 (54)	
Tumor size					0.114
≤5 cm	1,252 (53)	353 (53)	313 (50)	270 (57)	
>5 cm	1,097 (47)	310 (47)	319 (50)	205 (43)	
LN examined					0.351
None	676 (26)	230 (30)	212 (29)	139 (26)	
1–11	1,200 (46)	337 (43)	324 (44)	237 (44)	
≥12	764 (29)	210 (27)	205 (28)	158 (30)	
LN status					0.980
Negative	503 (5)	141 (25)	148 (26)	113 (25)	
Positive	1,509 (75)	425 (75)	425 (74)	335 (75)	
Surgery					0.007
No	557 (19)	206 (23)	170 (21)	104 (18)	
Yes	2,450 (81)	676 (77)	656 (79)	489 (82)	
Chemotherapy					0.003
No	1,358 (48)	430 (51)	328 (42)	256 (47)	
Yes	1,471 (52)	410 (49)	451 (58)	291 (53)	

SD standard deviation, *LN* lymph nodes

prominent disparities in survival exist among colon cancer patients in a diverse population. Such racial and ethnic disparities have long been attributed to differences in SES, with low SES being consistently linked to poor outcomes.[13,15] While SES may be a determinant of survival, there may be a complex interaction between SES and race and ethnicity. This condition is highlighted by our discovery of differences in survival that exist within each major racial and ethnic population when patients were further stratified by SES. These results indicate that SES effects are not only responsible for disparities in outcome between different racial and ethnic groups but are also manifest within racial and ethnic stratifications in colon cancer patients.

Much of the current literature on disparities in colon cancer outcomes focuses primarily on blacks and whites; and the literature does not examine SES within major racial and ethnic groups.[11,14,16,17] In an analysis of national data from the Surveillance, Epidemiology, and End Results Program that examined racial disparities in CRC, Rim et al. showed that Asians and Hispanics had lower incidence of CRC than whites and blacks.[18] In another study, Le et al. examined the effects of SES and treatment disparities in determining outcomes for CRC.[13] Our investigations are consistent with their data demonstrating survival disparities between the major racial and ethnic groups. However, in contrast to these previous studies, we were primarily interested in examining the role of SES disparities within each racial and ethnic group. Although select racial and ethnic groups may survive longer than others, we observed that patients of the lowest SES consistently had the worst prognosis even within groups with favorable overall survival. To our knowledge, this is the first report to identify this condition in patients with colon cancer.

Previous research on colon cancer disparities has identified SES as a key factor responsible for inequities in outcome, with patients of higher SES demonstrating better survival than other groups. Higher SES is associated with increased utilization of health care services, better neighborhood resources and

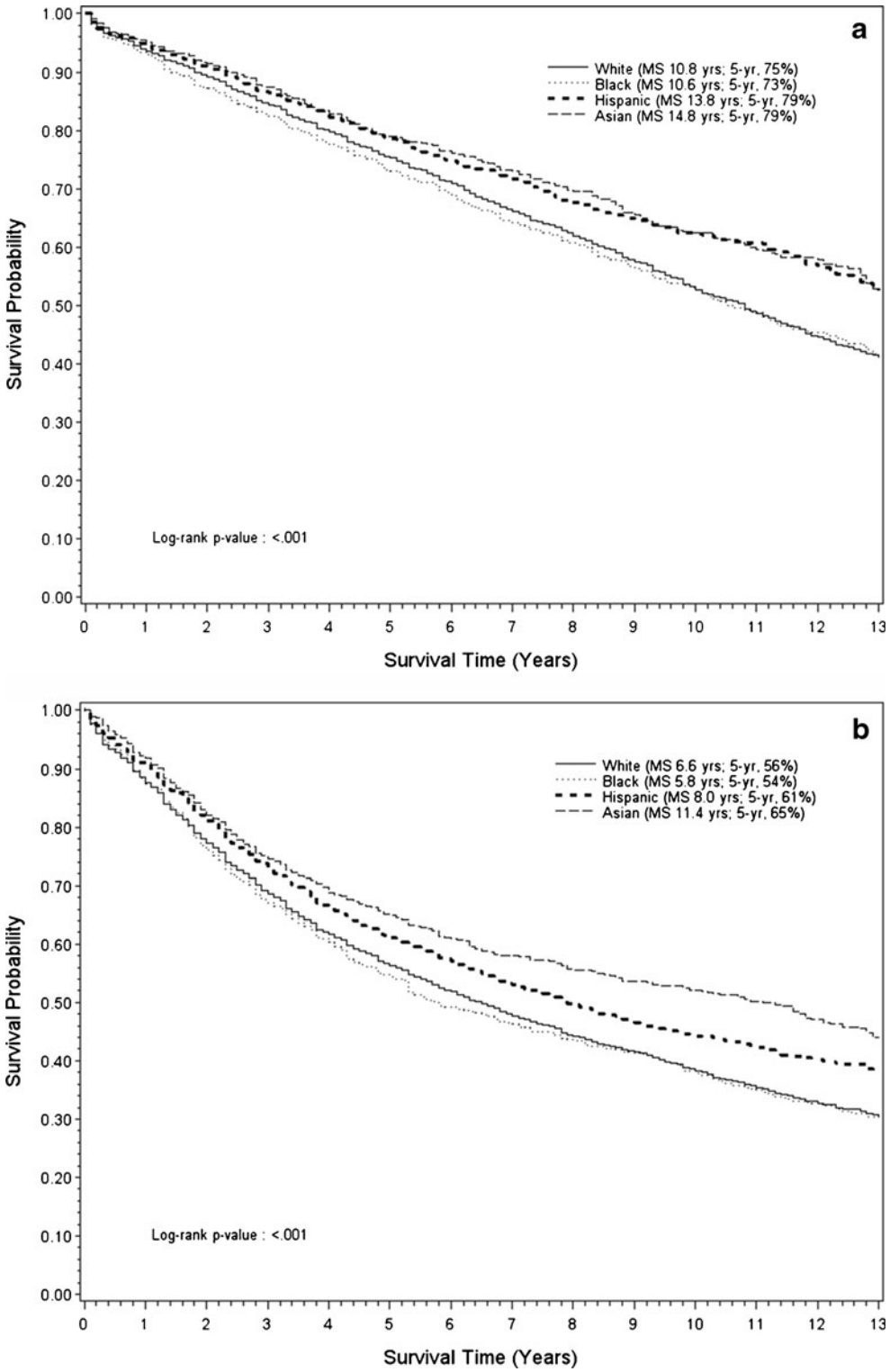
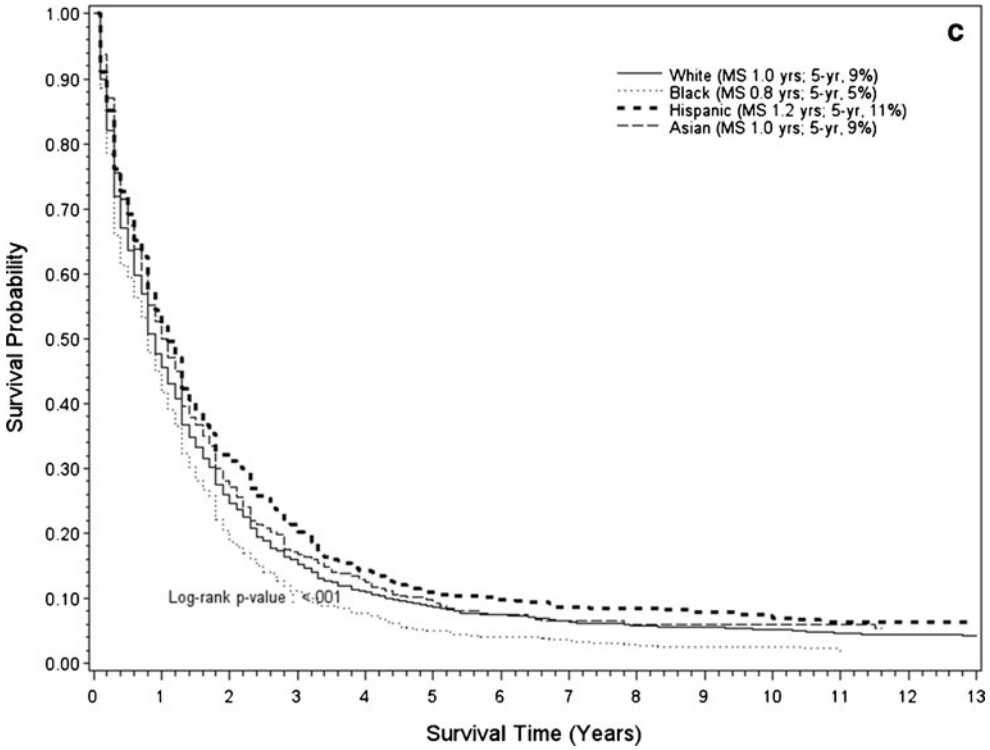


Fig. 2 Kaplan–Meier survival curves by race and ethnicity for patients with **a** local, **b** regional, and **c** distant disease

lifestyle factors, greater health education and awareness, thereby improving overall health status and prognosis.[19] In addition to income, SES is a measure for education, poverty status, occupation, access to healthcare, and preventative care, all of which correspond to access to treatment and the quality of treatment.[19,20] Conversely, lower SES has been traditionally associated with reduced access to sufficient healthcare and treatment, resulting in poorer outcome.[16,21] These factors may

Fig. 2 (continued)



help explain the observation of socioeconomic disparities within each of the major racial and ethnic groups in our study. For example, among Asians who may have improved overall prognosis for colon cancer,[22] our study demonstrated survival rifts between high and low SES groups. These findings highlight the extensive effects of SES within each racial and ethnic group, such that variable SES level contributes to survival disparities even within select groups with favorable composite

Fig. 3 Kaplan–Meier survival curves by socioeconomic status within racial and ethnic groups: **a** white, **b** black, **c** Hispanic, and **d** Asian patients

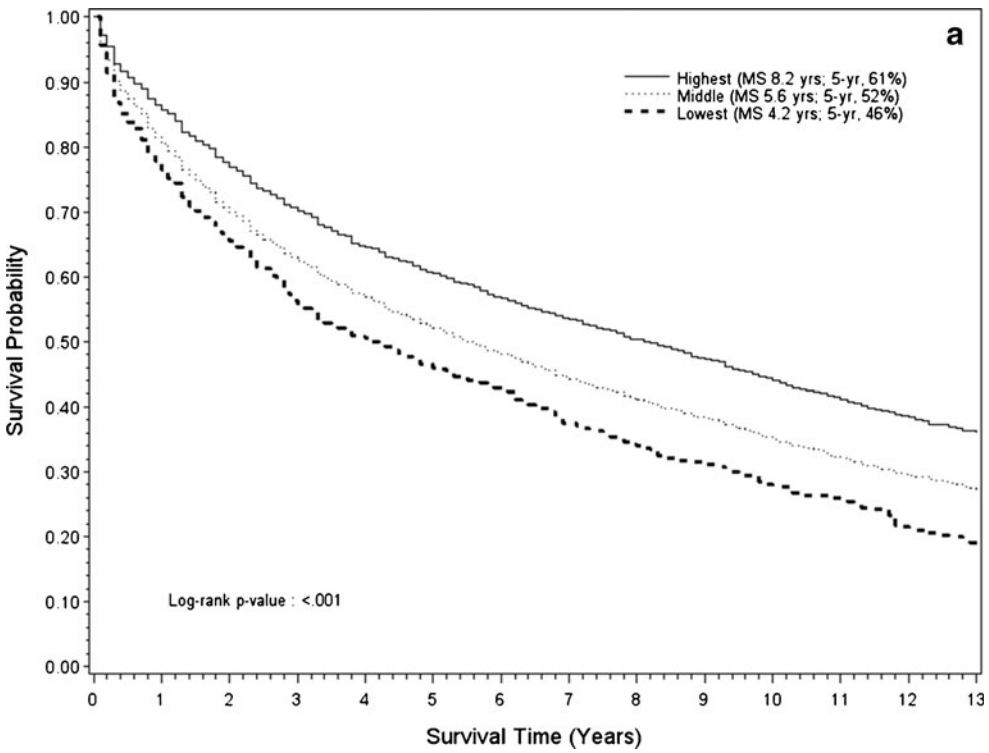
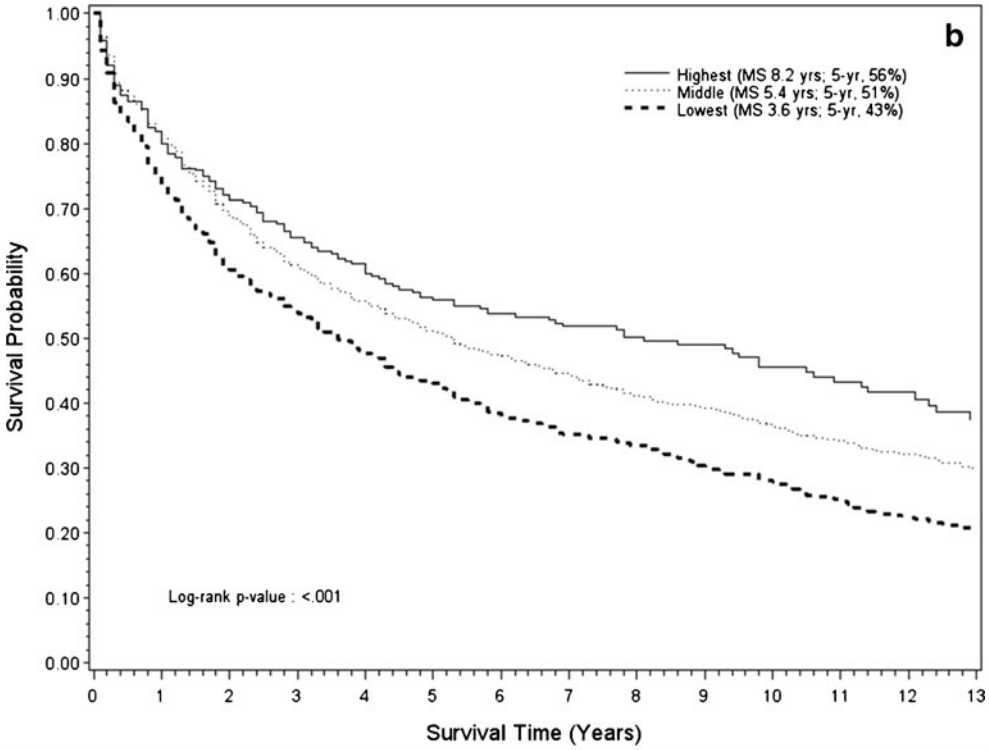
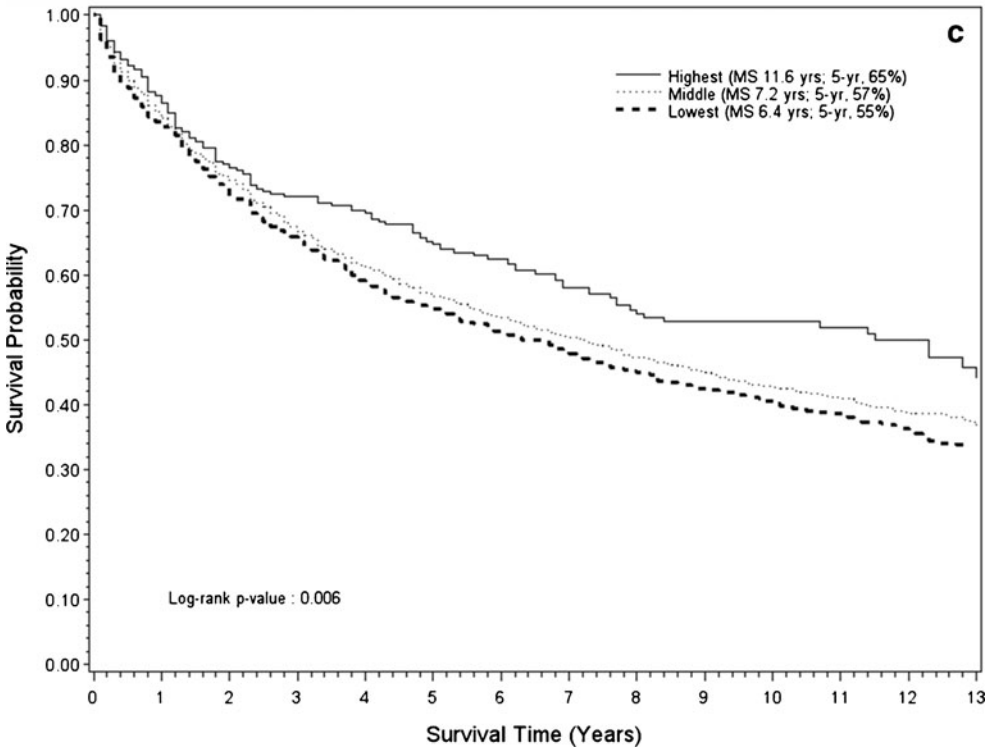


Fig. 3 (continued)

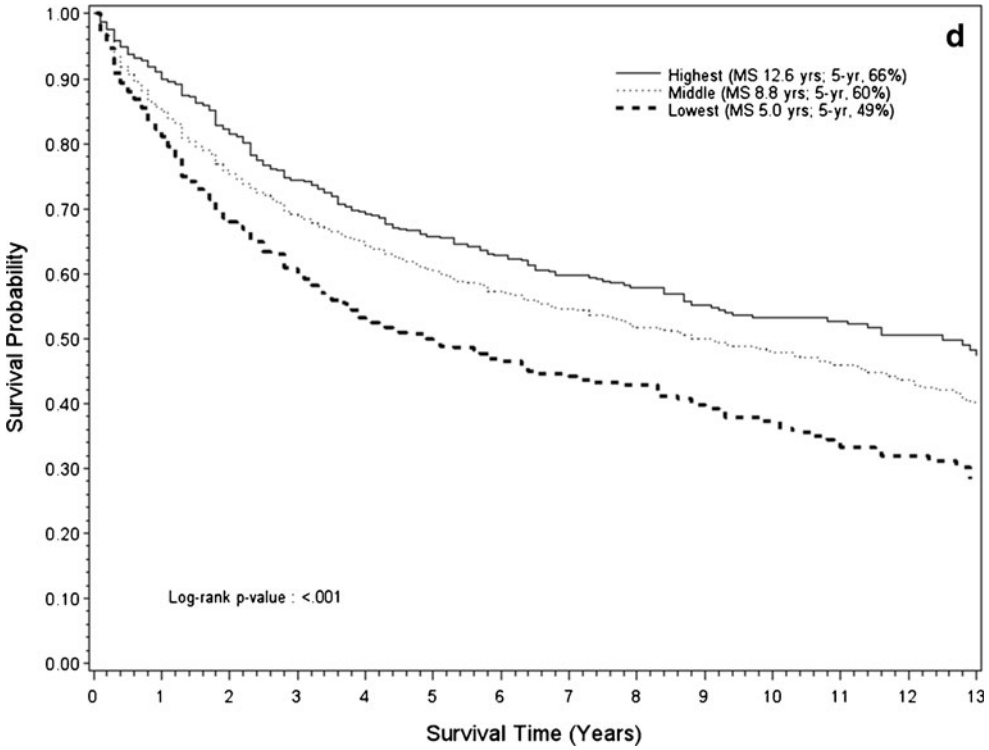




outcomes. A similar phenomenon was observed for the other racial and ethnic groups.

The socioeconomic disparities that we discovered within each of the major racial and ethnic groups may potentially be attributed to different utilization of chemotherapy in the adjuvant and metastatic setting according to SES level.[23] VanEenwyk et al. demonstrated that patients living in areas of lower income were less likely to receive adjuvant

Fig. 3 (continued)



chemotherapy even after consultation with a medical oncologist.[4] Among whites in our study, patients of the high and middle SES groups had higher rates of chemotherapy than patients of the low SES group (data not shown). Although the absolute difference in rates of chemotherapy between high SES and low SES patients varied across racial and ethnic groups, there was a consistent trend of increased utilization of chemotherapy for high SES patients.

Disparities for patients of the same racial and ethnic group may also be explained by differential access to colon cancer screening. Ananthakrishnan et al., found that screening by either fecal occult blood testing or colonoscopy was more common in patients with higher per capita income.[2] Since routine screening increases the likelihood of detecting malignancy at an earlier stage when cure can be obtained, it stands to reason that higher SES could lead to detection of earlier stage of disease. Consistent with this line of reasoning, we discovered that patients with high SES, who tended to be whites and Asians, were more likely than low SES patients to present with localized disease and receive surgery. Conversely, late stage of disease was more frequent in low SES patients, who may have reduced availability to screening and other healthcare resources.[2]

Our study confirms the disparities in survival of colon cancer patients between the major racial and ethnic groups that comprise the diverse LAC population. Furthermore, we discovered that the effects of SES are pronounced given that the disparities in survival according to SES exist within each race and ethnicity. These findings which demonstrate the influence of SES on the survival of colon cancer patients within same racial and ethnic groups, highlights the complexity of health disparities and the need to address healthcare inequities even within select populations.

Conclusion

As demonstrated in previous studies, racial and ethnic disparities for colon cancer are complex and persistent; this is consistent with the findings of our current study. Since these established disparities in outcome have been attributed to SES, much of the focus has centered on addressing healthcare inequities across the major racial and ethnic groups. However, we show that the effects of SES are also manifest within each racial and ethnic group. Although select racial and ethnic groups may have better overall prognosis, our study demonstrates that there are distinct disparities in survival, which we attribute in part to SES, even within these groups. These socioeconomic disparities exist within the broader spectrum of racial and ethnic disparities and underscore the complexity of health disparities. Further efforts are needed to investigate the causes of socioeconomic inequities within groups to improve outcomes for all colon cancer patients.

Conflicts of interest The authors have no conflicts of interest to disclose.

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