Research Article

Cancer Epidemiology, Biomarkers & Prevention

Colorectal Cancer Incidence Trends by Age, Stage, and Racial/Ethnic Group in California, 1990–2014

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Abstract

Background: The incidence of colorectal cancer in the United States declined substantially over the past 20 years, but evidence suggests that among younger adults (under 50 years at diagnosis), incidence is increasing. However, data on age- and stage-specific incidence trends across racial/ethnic groups are limited.

Methods: All incident cases of colorectal cancer diagnosed from 1990 through 2014 in adults aged 20 years and older were obtained from the California Cancer Registry. Incidence rates (per 100,000), incidence rate ratios, and triannual percent changes in incidence were estimated for each age group at diagnosis (20–49, 50–74, 75+ years), sex, stage, and race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and 7 Asian American groups).

Results: Of 349,176 incident colorectal cancer cases diagnosed from 1990 through 2014, 9% were in adults younger than 50 years. Increases in incidence of early-onset colorectal cancer, especially in regional/distant stage disease, were observed in most racial/ethnic groups (statistically significant for non-Hispanic whites and Hispanics, ranging from 0.9% to 2.9% every 3 years). Incidence also increased in Vietnamese and other Southeast Asian groups of screening age (50–74 years). The incidence of colorectal cancer in non-Hispanic blacks aged 50+ declined over the 25-year period, but remained significantly higher than in non-Hispanic whites.

Conclusions: Further research is needed to understand the causes of the increasing incidence of early-onset colorectal cancer. The rising incidence of colorectal cancer among Southeast Asians of screening age and the persistently high incidence in non-Hispanic blacks also warrant attention.

Impact: Our findings may have implications for revisiting screening guidelines in the United States. *Cancer Epidemiol Biomarkers Prev; 27(9); 1011–8. ©2018 AACR.*

Introduction

In the United States, colorectal cancer is the third most common malignancy and the second and third leading cause of cancer-related death among men and women, respectively (1). Over the past 20 years, there has been a substantial decline in the incidence of colorectal cancer, largely attributable to the introduction of screening for adults aged between 50 and 75 years and a reduction in modifiable risk factors such as smoking (2). However, recent evidence suggests that the incidence of early-onset colorectal cancer (i.e., in adults aged less than 50 years) is rising (3–6), prompting debate about the most effective starting age for colorectal cancer screening, and a call for investigation into the risks and benefits of screening before age 50 (6–10).

In the United States, colorectal cancer disproportionately affects the non-Hispanic (NH) black population, who consistently experience one of the highest incidence rates of all racial/ethnic groups. Over the period 2009 to 2013, the incidence of colorectal cancer among NH black men was 58 per 100,000 compared with 46 among NH white men, 43 among Hispanic men, and 38 among Asian American and Pacific Islander (AAPI) men (11). Although AAPI populations combined have a comparatively low incidence of colorectal cancer, ethnicities within this classification have very different cancer profiles. In 2004 to 2008, the incidence of colorectal cancer among Japanese men was 67 per 100,000, compared with 23 among Indian and Pakistani Asians (12). There is also evidence to suggest that colorectal cancer incidence rates in these populations are increasing, both in young adults (6, 13) and among those eligible for screening (12, 14).

California has the largest and most diverse racial/ethnic population in the United States: in 2016, the population was 39% Hispanic, 38% NH white, 15% AAPI, and 6% NH black. Using data from the California Cancer Registry (CCR), we examined trends in incidence of colorectal cancer among detailed racial/ethnic groups by age and stage over the 25-year period of 1990 to 2014, with a specific focus on young adults.

Materials and Methods

Study population

The CCR (www.ccrcal.org), a statewide population-based cancer surveillance system comprising three SEER registries, has collected detailed information on patients diagnosed with cancer in California since 1988. Data from the CCR were obtained on all

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Note: Supplementary data for this article are available at Cancer Epidemiology, Biomarkers & Prevention Online (http://cebp.aacrjournals.org/).

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cases of colorectal cancer diagnosed in adults aged 20 years and older from 1990 through 2014 ($N = 349,176$). Age group at diagnosis was defined as 20 to 49 years, 50 to 74 years (screening age), and 75 years or older. In supplementary analyses, tumor subsite was stratified as right colon (C18.0-C18.4), left colon (C18.5-C18.7), and rectum (C19.9, C20.9).

Stage at diagnosis was based on the Surveillance Epidemiology and End Results (SEER) Summary Stage (15) and categorized as: early stage (*in situ* and localized tumors) and late stage (regional and distant tumors). Race/ethnicity was obtained from medical records and categorized as: NH white, NH black, Hispanic, Chinese, Japanese, Filipino, Korean, South Asian (Indian and Pakistani), Vietnamese, and other Southeast Asian (Thai, Hmong, Cambodian, Laotian). Hispanic and Asian ethnicity were additionally coded based on birthplace and surnames using the validated North American Association of Central Cancer Registries (NAACCR) Hispanic Identification Algorithm (16) and Asian Pacific Islander Identification Algorithm (17). For Asian American groups, trends in colorectal cancer incidence in California were compared with national trends for the same time period (1990–2014) using specialized SEER incidence data for detailed Asian/Pacific Islander groups in SEER 9 registries (18).

Statistical analysis

Annual cancer incidence rates (per 100,000 population) for each strata defined by sex, age, race/ethnicity, and stage at diagnosis were calculated and age-adjusted to the 2000 U.S. standard population using the SEER*Stat software (version 8.3.4; ref. 19). A minimum of 5 incident cases per strata were required for incidence rate calculations. Annual population counts were estimated using linear interpolation and extrapolation of 1990, 2000, and 2010 Census counts. Incidence rates by sex, age, race/ethnicity, and stage are presented for the most recent 5-year period (2010–2014), and incidence rate ratios (IRR) reported for each racial/ethnic group compared with NH whites. Trends in incidence over the 25-year period of 1990 to 2014 are presented by sex, age, race/ethnicity, and stage. Joinpoint regression models (20) were used to characterize the magnitude and direction of incidence trends. The simplest Joinpoint models were fitted (zero joinpoints, linear trend), with one annual percentage rate change reported for the entire period (21). To accommodate for the small number of cases in some strata, 3-year cumulative incidence rates were used to improve the stability of annual percent change statistics.

Results

Of the 68,884 incident cases of colorectal cancer diagnosed in California in the period 2010 to 2014, 10.9% ($n = 7,572$) occurred in adults aged less than 50 years, but the proportion varied substantially by racial/ethnic group. Approximately 21% of South Asians and 20% of Southeast Asians were younger than 50 years at diagnosis, compared with 8.6% of NH whites and Japanese. Patients younger than 50 years were more likely to present with late-stage disease: approximately 66% of early-onset colorectal cancers were classified as late-stage (regional or distant disease) at diagnosis, compared with 54% of cases in adults aged 50 years and older.

Incidence rates and IRRs (2010–2014)

The incidence of colorectal cancer varied dramatically across age and racial/ethnic groups (Table 1). In the 20- to 49-year age group, there was no difference in incidence between NH blacks and NH whites for either early- or late-stage disease (Table 2). In Hispanics, the incidence of early-onset colorectal cancer (early and late stage) was 20% to 30% lower than in NH whites, and in several Asian American groups (Korean and South Asian men and women, and Chinese women), the incidence of late-stage colorectal cancer was 30% to 60% lower.

In the screening age group (50–74 years), the high incidence of colorectal cancer in NH blacks was particularly evident. Compared with NH whites, NH black men had 50% higher incidence of early-stage colorectal cancer [IRR, 1.5; 95% confidence interval (CI) 1.4–1.6] and 40% higher incidence of late-stage disease (IRR, 1.4; 95% CI, 1.3–1.5), whereas NH black women had 60% higher incidence of early-stage (IRR, 1.6; 95% CI, 1.4–1.7) and 40% higher incidence of late-stage colorectal cancer (IRR, 1.4; 95% CI, 1.3–1.5).

Trends in colorectal cancer incidence (1990–2014)

Over the period 1990 to 2014, the incidence of early-onset colorectal cancer increased in nearly all racial/ethnic groups in California, and was most pronounced for regional/distant stage. Increases were statistically significant in NH white men (by +0.9% every 3 years for early stage; +1.9% for late stage) and Hispanic men (+1.6% for early stage; +2.2% for late stage; Table 3; Figs. 1A and B). Similarly, the incidence of early-onset colorectal cancer in women increased significantly in NH whites (by +1.9% every 3 years for early stage; +2.4% for late stage), Hispanics (+2.1% for early stage; +0.7% for late stage), and Southeast Asians (+2.7% for late stage; Table 3; Fig. 1C and D). At the national level, as represented by SEER data, the incidence of early-onset colorectal cancer increased significantly in South Asian, Filipino, Vietnamese, and other Southeast Asian men (Supplementary Fig. S1A and S1B), and South Asian women (Supplementary Fig. S1C and S1D). There were statistically significant increases in incidence for all subsites (left colon, right colon, and rectum), with the largest increases seen for left colon and rectal cancer in NH whites and Hispanics (Supplementary Table S1).

There were large declines in the incidence of colorectal cancer in adults aged 50 and older in California over the period 1990 to 2014. For screening-aged adults, significant decreases in the incidence of early-stage colorectal cancer were seen for NH white men (by −1.9% every 3 years), NH white women (−1.3%), and Japanese men (−2.2%; Table 3; Supplementary Fig. S2A and S2C). More widespread declines were found for late-stage colorectal cancer, with significant decreases for NH white, NH black, Hispanic, Chinese, and Japanese men and women, by approximately −1% to −3% every 3 years. Declines in incidence in adults aged 50 and older were most notable for left colon and rectal cancers (Supplementary Table S1). In contrast, the incidence of early-stage colorectal cancer increased in Vietnamese women by +1.5% every 3 years, and the incidence of late-stage colorectal cancer increased in Southeast Asian men by +4.1% every 3 years, and in Southeast Asian women by +2.7% every 3 years (Table 3; Supplementary Fig. S2B–S2D). The increasing trend in colorectal cancer incidence for Vietnamese and other Southeast Asian women of screening age was also seen at a national level (Supplementary Fig. S3C and S3D), along with an increasing trend for Vietnamese and South Asian men (Supplementary Fig. S3A and S3B).

Table 1. Number of cases[a] and 5-year cumulative age-adjusted incidence rates of colorectal cancer by sex, age at diagnosis, stage at diagnosis, and race/ethnicity: California 2010–2014

	Early stage						Late stage					
	20–49 years		50–74 years		75+ years		20–49 years		50–74 years		75+ years	
	n	IR (95% CI)	*n*	IR (95% CI)	*n*	IR (95% CI)	*n*	IR (95% CI)	*n*	IR (95% CI)	*n*	IR (95% CI)
Men												
Chinese	45	3.2 (2.4–4.4)	404	47.8 (43.2–52.8)	233	117.7 (103.1–133.8)	93	6.6 (5.3–8.1)	440	51.5 (46.8–56.7)	262	132.4 (116.8–149.4)
Japanese	16	5.0 (2.8–8.2)	123	60.2 (49.8–72.1)	63	88.6 (67.2–114.4)	26	8.2 (5.3–12.1)	151	68.2 (57.5–80.3)	93	129.8 (103.7–160.4)
Filipino	47	3.6 (2.7–4.8)	387	52.0 (46.8–57.5)	96	86.8 (70.2–106.1)	84	6.5 (5.2–8.0)	402	54.1 (48.8–59.8)	133	121.5 (101.6–144.1)
Korean	24	4.7 (3.0–7.0)	139	49.4 (41.5–58.3)	60	130.7 (99.6–168.6)	17	3.3 (1.9–5.3)	172	60.9 (52.1–70.7)	64	142.7 (109.7–182.5)
South Asian	20	2.4 (1.4–3.7)	91	29.5 (23.6–36.3)	26	66.0 (42.7–97.8)	36	4.5 (3.1–6.2)	99	32.6 (26.4–39.8)	37	103.0 (71.8–143.3)
Vietnamese	29	4.0 (2.7–5.8)	217	60.5 (52.6–69.3)	57	98.2 (74.1–127.8)	54	7.6 (5.7–9.9)	226	63.6 (55.4–72.6)	75	133.9 (104.9–168.6)
Southeast Asian	≤10	3.7 (1.7–6.9)	38	32.3 (22.5–44.8)	≤10	44.7 (16.4–97.8)	25	9.9 (6.4–14.6)	92	77.1 (61.5–95.3)	≤10	74.3 (35.6–137.2)
NH white	588	3.8 (3.5–4.1)	5,848	47.2 (46.0–48.5)	3,110	114.7 (110.7–118.8)	1,245	8.1 (7.7–8.6)	6,748	53.8 (52.5–55.1)	3,741	136.8 (132.4–141.3)
NH black	96	4.0 (3.2–4.8)	891	68.9 (64.4–73.7)	286	145.6 (129.1–163.5)	204	8.4 (7.3–9.6)	967	74.7 (70.0–79.7)	317	163.6 (146–182.7)
Hispanic	401	2.8 (2.5–3.0)	2,092	43.5 (41.6–45.5)	658	94.2 (87.2–101.7)	895	6.1 (5.7–6.5)	2,611	53.8 (51.7–56.0)	894	128.4 (120.1–137.1)
Women												
Chinese	56	3.3 (2.5–4.3)	332	32.8 (29.3–36.6)	168	66.3 (56.5–77.1)	76	4.4 (3.5–5.5)	334	32.4 (28.9–36.1)	276	106.2 (93.9–119.6)
Japanese	21	4.7 (2.9–7.3)	98	36.3 (29.4–44.3)	118	76.7 (63.2–92.1)	26	6.1 (4.0–9.0)	116	43.1 (35.6–51.8)	185	121.9 (104.7–141.1)
Filipino	46	2.8 (2.1–3.8)	333	32.0 (28.6–35.7)	140	67.0 (56.4–79.1)	99	6.2 (5.0–7.5)	353	33.7 (30.3–37.5)	162	77.6 (66.1–90.5)
Korean	17	2.7 (1.6–4.4)	119	33.6 (27.8–40.2)	60	85.2 (65.0–109.6)	27	4.3 (2.9–6.3)	162	45.3 (38.6–52.9)	60	85.0 (64.9–109.4)
South Asian	18	2.6 (1.5–4.1)	43	15.6 (11.2–21.0)	19	46.5 (27.8–73.0)	35	5.4 (3.7–7.5)	62	22.4 (17.1–28.8)	24	58.0 (36.9–86.8)
Vietnamese	27	3.6 (2.3–5.2)	157	38.4 (32.5–45.1)	50	74.7 (55.4–98.5)	62	8.2 (6.3–10.5)	194	48.5 (41.8–55.9)	67	100.3 (77.7–127.3)
Southeast Asian	≤10	1.7 (0.6–3.9)	43	30.4 (21.7–41.4)	≤10	44.8 (20.3–85.1)	29	9.0 (6.0–12.9)	75	50.7 (39.4–64.1)	12	55.0 (28.1–97.0)
NH white	589	4.0 (3.6–4.3)	4,294	33.1 (32.1–34.1)	3,627	91.9 (88.9–95.1)	1,078	7.4 (6.9–7.8)	5,160	39.4 (38.3–40.5)	4,532	111.9 (108.6–115.3)
NH black	95	3.9 (3.1–4.8)	765	51.6 (47.9–55.4)	284	89.5 (79.4–100.6)	171	7.3 (6.2–8.5)	837	55.9 (52.1–59.9)	394	126.5 (114.3–139.7)
Hispanic	425	3.0 (2.7–3.3)	1,717	30.7 (29.3–32.3)	677	64.3 (59.6–69.4)	716	5.1 (4.7–5.5)	1,976	35.1 (33.5–36.7)	919	86.9 (81.3–92.7)

[a]Cells with 10 or fewer cases have been suppressed.

Table 2. Five-year cumulative age-adjusted IRRs (compared with NH whites) of colorectal cancer by sex, age at diagnosis, stage at diagnosis, and race/ethnicity: California 2010–2014

	Early stage			Late stage		
	20–49 years IRR (95% CI)	**50–74 years IRR (95% CI)**	**75+ years IRR (95% CI)**	**20–49 years IRR (95% CI)**	**50–74 years IRR (95% CI)**	**75+ years IRR (95% CI)**
Men						
Chinese	0.9 (0.6–1.2)	1.0 (0.9–1.2)	1.0 (0.9–1.2)	0.8 (0.6–1.0)	1.0 (0.8–1.1)	1.0 (0.8–1.1)
Japanese	1.3 (0.8–2.2)	1.3 (1.0–1.6)	0.8 (0.6–1.0)	1.0 (0.7–1.5)	1.3 (1.0–1.5)	0.9 (0.8–1.2)
Filipino	1.0 (0.7–1.3)	1.1 (0.9–1.3)	**0.8 (0.6–0.9)**	0.8 (0.6–1.0)	1.0 (0.9–1.2)	0.9 (0.7–1.1)
Korean	1.3 (0.8–1.9)	1.0 (0.9–1.3)	1.1 (0.9–1.5)	**0.4 (0.3–0.7)**	1.1 (0.9–1.4)	1.0 (0.8–1.3)
South Asian	0.6 (0.4–1.0)	**0.6 (0.5–0.8)**	**0.6 (0.4–0.8)**	**0.6 (0.4–0.8)**	**0.6 (0.5–0.8)**	0.8 (0.5–1.0)
Vietnamese	1.1 (0.7–1.6)	**1.3 (1.1–1.5)**	0.9 (0.7–1.1)	0.9 (0.7–1.2)	1.2 (1.0–1.4)	1.0 (0.8–1.2)
Southeast Asian	1.0 (0.5–1.9)	0.7 (0.5–1.0)	**0.4 (0.2–0.9)**	1.2 (0.8–1.8)	**1.4 (1.1–1.8)**	0.5 (0.3–1.0)
NH white	Ref	Ref	Ref	Ref	Ref	Ref
NH black	1.1 (0.8–1.3)	**1.5 (1.4–1.6)**	**1.3 (1.1–1.4)**	1.0 (0.9–1.2)	**1.4 (1.3–1.5)**	**1.2 (1.1–1.3)**
Hispanic	**0.7 (0.6–0.9)**	0.9 (0.8–1.0)	**0.8 (0.8–0.9)**	**0.7 (0.7–0.8)**	1.0 (0.9–1.1)	0.9 (0.8–1.0)
Women						
Chinese	0.8 (0.6–1.1)	1.0 (0.8–1.2)	**0.7 (0.6–0.8)**	**0.6 (0.5–0.8)**	0.8 (0.7–1.0)	0.9 (0.8–1.1)
Japanese	1.2 (0.8–1.9)	1.1 (0.9–1.4)	0.8 (0.7–1.0)	0.8 (0.6–1.2)	1.1 (0.9–1.4)	1.1 (0.9–1.3)
Filipino	0.7 (0.5–1.0)	1.0 (0.8–1.1)	**0.7 (0.6–0.9)**	0.8 (0.7–1.1)	0.9 (0.7–1.0)	**0.7 (0.6–0.8)**
Korean	0.7 (0.4–1.1)	1.0 (0.8–1.3)	0.9 (0.7–1.2)	**0.6 (0.4–0.9)**	1.2 (0.9–1.4)	0.8 (0.6–1.0)
South Asian	0.7 (0.4–1.1)	**0.5 (0.3–0.6)**	**0.5 (0.3–0.8)**	**0.7 (0.5–0.9)**	**0.6 (0.4–0.7)**	**0.5 (0.3–0.8)**
Vietnamese	0.9 (0.6–1.4)	1.2 (1.0–1.4)	0.8 (0.6–1.1)	1.1 (0.8–1.5)	1.2 (1.0–1.5)	0.9 (0.7–1.2)
Southeast Asian	0.4 (0.2–1.1)	0.9 (0.7–1.3)	**0.5 (0.3–0.9)**	1.2 (0.8–1.8)	1.3 (1.0–1.7)	**0.5 (0.3–0.9)**
NH white	Ref	Ref	Ref	Ref	Ref	Ref
NH black	1.0 (0.8–1.2)	**1.6 (1.4–1.7)**	1.0 (0.9–1.1)	1.0 (0.8–1.2)	**1.4 (1.3–1.5)**	1.1 (1.0. 1.3)
Hispanic	**0.8 (0.6–0.9)**	0.9 (0.8–1.0)	**0.7 (0.6–0.8)**	**0.7 (0.6–0.8)**	0.9 (0.8–1.0)	**0.8 (0.7–0.9)**

NOTE: Figures in bold represent a statistically significant difference in colorectal cancer incidence rates compared to NH whites.

Discussion

We leveraged high-quality contemporary data from the CCR to investigate trends in the incidence of colorectal cancer over a 25-year period (1990–2014) by race/ethnicity, including seven Asian American ethnic groups, with attention to examining trends among young adults. In California, the most populous and racially/ethnically diverse state in the United States, we found increases in the incidence of advanced stage early-onset colorectal cancer among nearly all racial/ethnic groups, with statistically significant increases for NH white and Hispanic adults. Although the incidence of colorectal cancer among adults of screening age has declined in most racial/ethnic groups, we observed increasing incidence among Vietnamese and other Southeast Asian groups (Thai, Hmong, Cambodian, and Laotian). The high incidence of colorectal cancer in screening-age and older NH blacks persisted

Table 3. Triannual percentage change in colorectal cancer incidence in California over the period 1990–2014, by sex, age group, stage at diagnosis, and race/ethnicity

	Early stage			Late stage		
	20–49 years tAPC (95% CI)	**50–74 years tAPC (95% CI)**	**75+ years tAPC (95% CI)**	**20–49 years tAPC (95% CI)**	**50–74 years tAPC (95% CI)**	**75+ years tAPC (95% CI**
Men						
Chinese	0.4 (−2.0–2.9)	−0.5 (−1.4–0.4)	**−1.9 (−3.2 to −0.6)**	0.9 (−0.8–2.6)	**−2.0 (−2.9 to −1.1)**	**−3.6 (−4.6 to −2.6)**
Japanese	1.5 (−2.0–5.0)	**−2.2 (−3.4 to −1.0)**	−2.5 (−6.2–1.4)	0.9 (−2.4–4.5)	**−2.7 (−3.8 to −1.7)**	**−3.1 (−6.0 to −0.1)**
Filipino	1.1 (−1.1–3.3)	1.2 (−0.2–2.5)	−0.1 (−2.6–2.4)	0.5 (−0.9–1.8)	−0.9 (−2.0–0.2)	**−1.9 (−3.4 to −0.3)**
Korean	0.7 (−1.8–3.3)	0.2 (−2.3–2.7)	0.8 (−2.4–4.1)	0.0 (−6.8–7.3)	−0.7 (−2.0–0.6)	−1.5 (−4.5–1.4)
South Asian	−0.9 (−5.7–4.2)	0.0 (−2.5–2.7)	−1.6 (−6.4–3.5)	0.2 (−3.2–3.8)	−1.2 (−3.9–1.6)	0.8 (−2.2–3.9)
Vietnamese	1.1 (−3.9–6.2)	2.1 (−0.1–4.3)	−1.3 (−4.1–1.7)	1.8 (−1.9–5.7)	0.4 (−0.3–1.0)	−1.8 (−4.2–0.5)
Southeast Asian	−1.0 (−3.8–1.9)	1.4 (−1.4–4.2)	—[a]	2.7 (−0.7–6.2)	**4.1 (1.9–6.3)**	—[a]
NH white	**0.9 (0.4–1.4)**	**−1.9 (−2.6 to −1.1)**	**−3.0 (−3.7 to −2.3)**	**1.9 (1.4–2.4)**	**−2.6 (−2.9 to −2.3)**	**−3.4 (−3.6 to −3.1)**
NH black	−0.9 (−2.2–0.4)	−0.6 (−1.7–0.5)	**−1.2 (−2.4 to −0.1)**	−0.1 (−1.3–1.2)	**−1.9 (−2.6 to −1.2)**	**−2.5 (−3.4 to −1.5)**
Hispanic	**1.6 (0.3–2.9)**	−0.5 (−1.2–0.1)	−1.4 (−3.1–0.4)	**2.2 (1.6–2.7)**	**−0.9 (−1.5 to −0.3)**	**−1.9 (−2.7 to −1.1)**
Women						
Chinese	0.1 (−2.1–2.4)	−0.4 (−1.4–0.7)	**−2.4 (−4.7 to −0.1)**	−1.8 (−3.6–0.1)	**−2.1 (−3.7 to −0.5)**	**−2.9 (−4.3 to −1.5)**
Japanese	0.5 (−3.1–4.1)	−1.5 (−3.2–0.3)	−2.1 (−4.9–0.8)	1.7 (−2.3–5.8)	**−3.0 (−4.8 to −1.1)**	**−2.2 (−4.2 to −0.2)**
Filipino	−0.6 (−3.5–2.4)	1.4 (−0.1–2.9)	0.6 (−1.7–2.9)	0.7 (−0.4–1.8)	−0.7 (−2.1–0.7)	−1.4 (−3.9–1.1)
Korean	0.8 (−3.8–5.5)	0.4 (−2.5–3.5)	1.3 (−1.5–4.2)	−1.9 (−4.8–1.2)	0.9 (−0.7–2.6)	−1.4 (−4.0–1.2)
South Asian	4.3 (−2.0–10.9)	−1.3 (−4.9–2.5)	1.0 (−3.0–5.1)	2.2 (−1.7–6.2)	−0.8 (−2.9–1.5)	—[a]
Vietnamese	−0.5 (−3.1–2.2)	**1.5 (0.6–2.5)**	−1.5 (−4.0–1.1)	1.8 (−1.5–5.2)	−0.4 (−1.9–1.1)	**−2.4 (−4.3 to −0.4)**
Southeast Asian	—[a]	3.1 (−0.9–7.3)	—[a]	**2.7 (0.5–4.9)**	2.7 (1.2–4.2)	0.9 (−6.8–9.3)
NH white	**1.9 (0.8–2.9)**	**−1.3 (−1.9 to −0.6)**	**−1.9 (−2.5 to −1.3)**	**2.4 (1.9–3.0)**	**−2.4 (−2.7 to −2.0)**	**−2.8 (−3.4 to −2.2)**
NH black	0.3 (−0.7–1.4)	−0.4 (−1.3–0.6)	**−2.1 (−3.2 to −1.0)**	−0.3 (−1.8–1.2)	**−1.8 (−2.8 to −0.7)**	**−2.3 (−3.7 to −0.9)**
Hispanic	**2.1 (1.2–3.1)**	0.3 (−0.3–1.0)	−1.2 (−2.7–0.2)	**0.7 (0.1–1.3)**	**−1.2 (−1.5 to −0.8)**	**−2.2 (−2.8 to −1.6)**

NOTE: Figures in bold represent a statistically significant change in colorectal cancer incidence over the period 1990–2014.
Abbreviation: tAPC, Triannual percentage change.
[a]Triannual percent change could not be calculated due to fewer than 5 cases diagnosed in at least one triannual period.

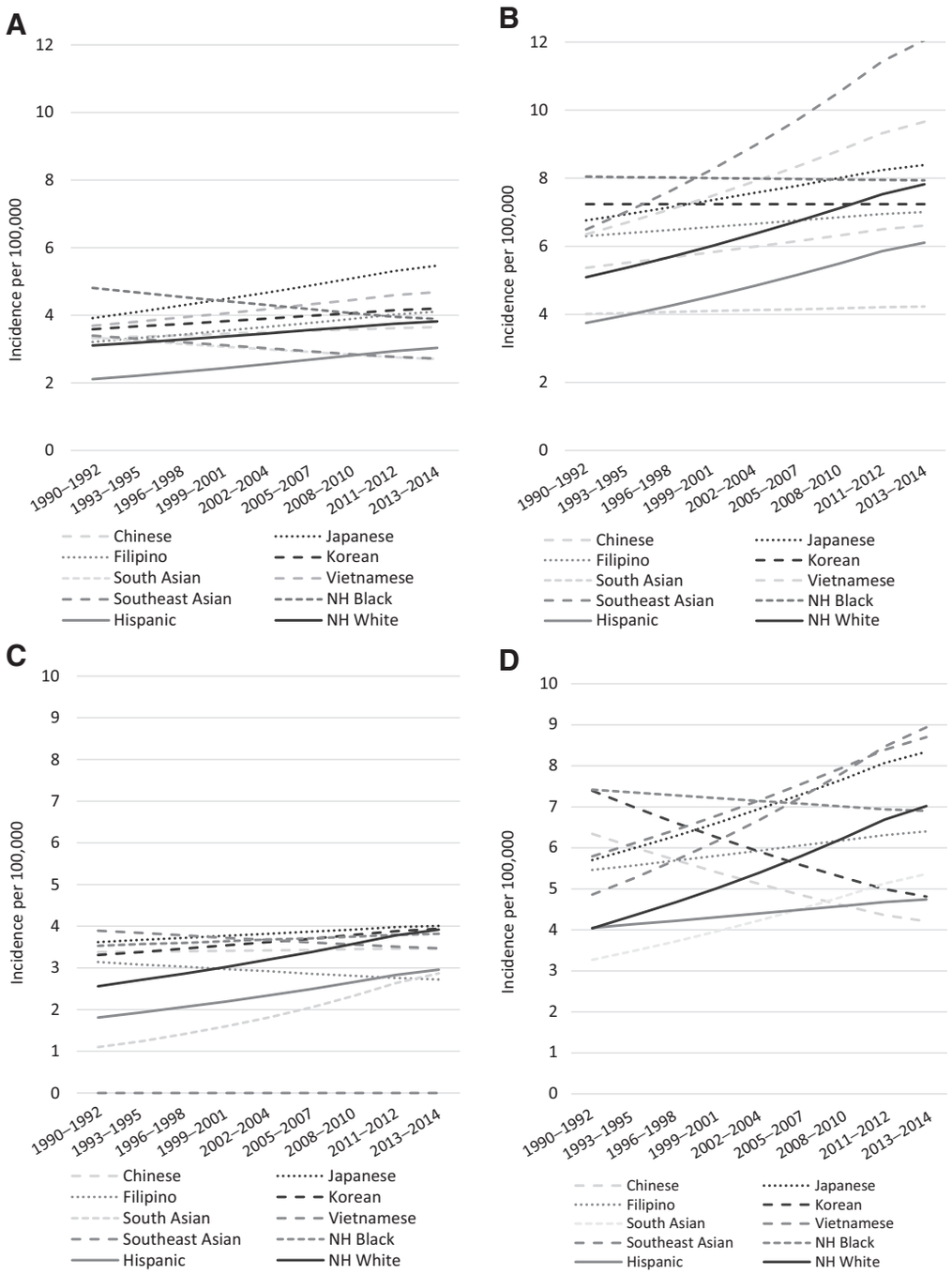

Figure 1.

Trends in the incidence of early-onset colorectal cancer by race/ethnicity in California, 1990–2014: **A,** Men, early stage. **B,** Men, late stage. **C,** Women, early stage. **D,** Women, late stage. Solid line indicates a statistically significant linear trend, and dashed line indicates a nonstatistically significant trend. Trend for Southeast Asians (women aged 20–49, early stage) could not be calculated due to ≤5 cases diagnosed in at least one triannual period.

over this 25-year period, although there is evidence of a decline in these age groups.

Reports of rising colorectal cancer incidence among young adults in the United States, as well as among vulnerable populations such as immigrants (22), are mounting. In our study, statistically significant increases in the incidence of early-onset colorectal cancer were limited to NH white and Hispanic populations, the two largest racial/ethnic groups in California. Although the number of colorectal cancer cases in young adults remains small compared with older adults, long-term projections suggest

that by 2030, 11% of colon cancers and 23% of rectal cancers in the United States will occur in individuals younger than 50 years (11). The rising incidence of early-onset colorectal cancer does not appear to be unique to the United States (23), with similar patterns reported in Canada (24), Australia (25, 26), and Asia (27, 28). The underlying causes of the increasing incidence in this age group are unclear, although poor diet, sedentary lifestyles, and increasing rates of obesity are likely to be contributing (29).

There is robust evidence that effective screening strategies can reduce the incidence of and mortality from colorectal cancer through early diagnosis and removal of precancerous lesions (adenomatous polyps; refs. 30–32), and eliminate racial/ethnic disparities (33). The U.S. Preventive Services Task Force (34) currently recommends that average-risk adults aged 50 to 75 years have either a high-sensitivity fecal occult blood test, fecal immunochemical test (FIT), or multitargeted stool DNA test (FIT-DNA) every year; flexible sigmoidoscopy every 5 years, or every 10 years with FIT every year; or colonoscopy every 10 years. Except for those at increased risk of the disease (e.g., those with inflammatory bowel disease, history of familial adenomatous polyposis or hereditary nonpolyposis, a previous adenomatous polyp, or a family history of colorectal cancer), adults under 50 are not included in these guidelines. Some reports suggest that screening initiated at age 45 years is cost effective (35), and could achieve a more favorable balance between benefit (life-years gained) and burden (36), but the debate on the risks and benefits of screening before age 50 for asymptomatic average-risk adults continues.

For adults aged 50 to 75 years, colorectal cancer screening recommendations have been in place in some form since the mid-1990s, but uptake has been lower than expected (22, 37) and varies considerably by race/ethnicity (22, 37–38). In 2008, only 55% of the U.S. population was up-to-date with colorectal cancer screening (39). Although there has been some improvement over time, a report by the U.S. Centers for Diseases Control and Prevention (CDC) found that by 2015, only 62% of screening eligible adults were up-to-date with colorectal cancer screening, still short of the Healthy People 2020 target of 70.5% (40).

Yet, we found widespread declines in the incidence of colorectal cancer among screening-aged adults in most racial/ethnic groups in California commensurate with improved screening uptake over time. Two notable exceptions were in screening-aged Vietnamese and other Southeast Asian men and women, for whom there has been an increase in colorectal cancer incidence. In non-Vietnamese Southeast Asians, the increase of 3% to 4% every 3 years is striking; by 2000 to 2014, the incidence of late-stage colorectal cancer in men was higher than in NH black men. The reasons behind this increase are unclear, and could be partially explained by a low uptake of screening (39), in addition to increases in colorectal cancer risk factors including obesity. Klabunde and colleagues identified a number of population groups with consistently low uptake of colorectal cancer screening, such as recent immigrants (those who have been in the United States for less than 10 years), and those with poor education, low income, and lack of health insurance (22), but the relevance of these factors to Southeast Asian populations is difficult to assess, due to the lack of information specific to this Asian American ethnic group.

The incidence of colorectal cancer in NH blacks aged 50 and over was consistently high throughout the study period. In addition to a high prevalence of lifestyle-related risk factors, it has been postulated that a low uptake of screening in this population could be the underlying cause of this trend, although data from the California Health Interview Survey (41) and CDC Behavioral Risk Factor Surveillance System (42) report equivalent screening rates for NH black and NH white populations (78% and 72%, respectively, in 2014; ref. 42). Although our finding of declining incidence in NH blacks of screening age is a positive one, the faster rate of decline in NH whites means black/white disparities persist. In 2017, in response to the higher incidence and younger mean age of colorectal cancer onset in African Americans, the U.S. Multi-Society Task Force on Colorectal Cancer recommended beginning screening at age 45 in this population (43). It is worth noting that in our study, the incidence of early-onset colorectal cancer in 2010 to 2014 was similar for NH black and NH white populations, and even higher for some Asian American ethic groups.

Our study has several limitations that are inherent to cancer registry data. We did not have access to important information on family history of colorectal cancer or other lifestyle-related risk factors (obesity, smoking, diet, physical activity), clinical data such as microsatellite instability, or genetic data (KRAS mutation). We also lacked data on Hispanic country of origin, nativity, and immigration history. It has been suggested that the acculturation of recent immigrants may result in a higher prevalence of risk factors for colorectal cancer, including obesity, lack of physical activity, smoking, and alcohol consumption (44, 45). We found increases in the incidence of early-onset colorectal cancer in most racial/ethnic groups in California, but due to the small number of cases in some strata, especially for the AAPI groups, increases were only statistically significant for NH white and Hispanic groups. To assess whether the incidence of colorectal cancer is increasing in AAPI groups at the national level, we examined SEER incidence data for AAPI groups over the period 1990 to 2014 (18), and found statistically significant increases in colorectal cancer incidence for South Asian men and women, and Filipino, Vietnamese, and other Southeast Asian men aged under 50, and non-significant increases for Japanese, Chinese, and Koreans.

In summary, our results emphasize the need to investigate the causes of the rising incidence rates of colorectal cancer among young adults and among Southeast Asians of screening age, as well as the persistently high incidence among screening age and older NH blacks. The heterogeneity of incidence rates across Asian American ethnic groups reinforces the need to disaggregate cancer statistics for this population. Improvements in colorectal cancer awareness among patients and physicians, the promotion and availability of recommended screening test, and the early initiation of screening for high-risk populations are crucial to decrease the burden of colorectal cancer.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Authors' Contributions

Conception and design: J. Yang, M. Somsouk, L. Le Marchand, S.L. Gomez, S. Shariff-Marco

Development of methodology: J. Yang, S. Shariff-Marco

Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): S.L. Gomez, S. Shariff-Marco

Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): L. Ellis, M. McKinley, J. Yang, M. Somsouk, I. Cheng, S. Shariff-Marco, R. Abrahão

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Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): M. McKinley, S. Shariff-Marco
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References

1. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2017. CA Cancer J Clin 2017;67:7–30.
2. Edwards BK, Ward E, Kohler BA, Eheman C, Zauber AG, Anderson RN, et al. Annual report to the nation on the status of cancer, 1975-2006, featuring colorectal cancer trends and impact of interventions (risk factors, screening, and treatment) to reduce future rates. Cancer 2010;116:544–73.
3. Siegel RL, Fedewa SA, Anderson WF, Miller KD, Ma J, Rosenberg PS, et al. Colorectal cancer incidence patterns in the United States, 1974–2013. J Natl Cancer Inst 2017;109:djw322.
4. Austin H, Henley SJ, King J, Richardson LC, Eheman C. Changes in colorectal cancer incidence rates in young and older adults in the United States: what does it tell us about screening. Cancer Causes Control 2014; 25:191–201.
5. Siegel RL, Jemal A, Ward EM. Increase in incidence of colorectal cancer among young men and women in the United States. Cancer Epidemiol Biomarkers Prev 2009;18:1695–8.
6. Singh KE, Taylor TH, Pan CG, Stamos MJ, Zell JA. colorectal cancer incidence among young adults in California. J Adolesc Young Adult Oncol 2014;3:176–84.
7. Murphy CC, Sandler RS, Sanoff HK, Yang YC, Lund JL, Baron JA. Decrease in incidence of colorectal cancer among individuals 50 years or older after recommendations for population-based screening. Clin Gastroenterol Hepatol 2017;15:903–9.
8. Ahnen DJ, Wade SW, Jones WF, Sifri R, Mendoza Silveiras J, Greenamyer J, et al. The increasing incidence of young-onset colorectal cancer: a call to action. Mayo Clin Proc 2014;89:216–24.
9. Bailey CE, Hu CY, You YN, Bednarski BK, Rodriguez-Bigas MA, Skibber JM, et al. Increasing disparities in the age-related incidences of colon and rectal cancers in the United States, 1975–2010. JAMA Surg 2015;150:17–22.
10. Abdelsattar ZM, Wong SL, Regenbogen SE, Jomaa DM, Hardiman KM, Hendren S. Colorectal cancer outcomes and treatment patterns in patients too young for average-risk screening. Cancer 2016;122:929–34.
11. Siegel RL, Miller KD, Fedewa SA, Ahnen DJ, Meester RGS, Barzi A, et al. Colorectal cancer statistics, 2017. CA Cancer J Clin 2017;67:177–93.
12. Gomez SL, Noone AM, Lichtensztajn DY, Scoppa S, Gibson JT, Liu L, et al. Cancer incidence trends among Asian American populations in the United States, 1990–2008. J Natl Cancer Inst 2013;105:1096–10.
13. Rahman R, Schmaltz C, Jackson CS, Simoes EJ, Jackson-Thompson J, Ibdah JA. Increased risk for colorectal cancer under age 50 in racial and ethnic minorities living in the United States. Cancer Med 2015;4:1863–70.
14. Giddings BH, Kwong SL, Parikh-Patel A, Bates JH, Snipes KP. Going against the tide: increasing incidence of colorectal cancer among Koreans, Filipinos, and South Asians in California, 1988–2007. Cancer Causes Control 2012;23:691–702.
15. Young J, Roffers S, Ries L, Fritz A, Hurlbut A. SEER Summary Staging Manual - 2000 Codes and coding instructions. Bethesda, MD: NIH; 2000.
16. NAACCR Race and Ethnicity Work Group. NAACCR guideline for enhancing Hispanic/Latino identification: revised NAACCR Hispanic/Latino Identification Algorithm [NHIA v2.2.1]. Springfield, IL: North American Association of Central Cancer Registries; 2011.
17. NAPIIA NAACCR Race and Ethnicity Work Group. NAACCR Asian Pacific Islander Identification Algorithm [NAPIIA v1.2.1]. Springfield, IL: North American Association of Central Cancer Registries; 2010.
18. National Cancer Institute Surveillance, Epidemiology, and End Results Program (SEER). Incidence Data for Detailed Asian/Pacific Islander Groups (1990–2014). Bethesda, MD: NIH.
19. National Cancer Institute. Surveillance Research Program, SEER*Stat software version 8.3.4. 2017.
20. National Cancer Institute. Statistical Research and Applications Branch. Joinpoint Regression Program Version 4.4.0.0. 2017.
21. Kim HJ, Fay MP, Feuer EJ, Midthune DN. Permutation tests for joinpoint regression with applications to cancer rates. Stat Med 2000;19:335–51.
22. Klabunde CN, Cronin KA, Breen N, Waldron WR, Ambs AH, Nadel MR. Trends in colorectal cancer test use among vulnerable populations in the United States. Cancer Epidemiol Biomarkers Prev 2011; 20:1611–21.
23. Arnold M, Sierra MS, Laversanne M, Soerjomataram I, Jemal A, Bray F. Global patterns and trends in colorectal cancer incidence and mortality. Gut 2017;66:683–91.
24. Patel P, De P. Trends in colorectal cancer incidence and related lifestyle risk factors in 15–49-year-olds in Canada, 1969–2010. Cancer Epidemiol 2016;42:90–100.
25. Haggar FA, Preen DB, Pereira G, Holman CD, Einarsdottir K. Cancer incidence and mortality trends in Australian adolescents and young adults, 1982-2007. BMC Cancer 2012;12:151.
26. Young JP, Win AK, Rosty C, Flight I, Roder D, Young GP, et al. Rising incidence of early-onset colorectal cancer in Australia over two decades: report and review. J Gastroenterol Hepatol 2015;30:6–13.
27. Sung JJ, Lau JY, Goh KL, Leung WK. Increasing incidence of colorectal cancer in Asia: implications for screening. Lancet Oncol 2005;6: 871–6.
28. Chong VH, Telisinghe PU, Bickle I, Abdullah MS, Lim E, Chong CF. Increasing incidence of colorectal cancer, starting at a younger age for rectal compared to colon cancer in brunei darussalam. Asian Pac J Cancer Prev 2015;16:5063–7.
29. Huxley RR, Ansary-Moghaddam A, Clifton P, Czernichow S, Parr CL, Woodward M. The impact of dietary and lifestyle risk factors on risk of colorectal cancer: a quantitative overview of the epidemiological evidence. Int J Cancer 2009;1251:171–80.
30. Zauber AG, Lansdorp-Vogelaar I, Knudsen AB, Wilschut J, van Ballegooijen M, Kuntz KM, U.S. Preventive Services Task Force Evidence Syntheses, formerly Systematic Evidence Reviews. Evaluating Test Strategies for Colorectal Cancer Screening-Age to Begin, Age to Stop, and Timing of Screening Intervals: A Decision Analysis of Colorectal Cancer Screening for the US Preventive Services Task Force from the Cancer Intervention and Surveillance Modeling Network (CISNET). Rockville, MD: Agency for Healthcare Research and Quality; 2009.
31. Mandel JS, Bond JH, Church TR, Snover DC, Bradley GM, Schuman LM, et al. Reducing mortality from colorectal cancer by screening for fecal occult

blood. Minnesota colon cancer control study. N Engl J Med 1993;328: 1365–71.
32. Lin JS, Piper MA, Perdue LA, Rutter CM, Webber EM, O'Connor E, et al. Screening for colorectal cancer: updated evidence report and systematic review for the US Preventive Services Task Force. JAMA 2016;315:2576–94.
33. Grubbs SS, Polite BN, Carney J, Bowser W, Rogers J, Katurakes N, et al. Eliminating racial disparities in colorectal cancer in the real world: it took a village. J Clin Oncol 2013;31:1928–30.
34. Bibbins-Domingo K, Grossman DC, Curry SJ, Davidson KW, Epling JW Jr, García FAR, et al. Screening for colorectal cancer: US Preventive Services Task Force recommendation statement. JAMA 2016;315:2564–75.
35. Barzi A, Siegel R, Fedewa S, Lenz HJ, Quinn DI, Jemal A, et al. Comparative effectiveness of initiating colorectal cancer (CRC) screening (Scr) at age 45. J Clin Oncol 35:4s, 2017 (suppl; abstr 531).
36. Knudsen AB, Zauber AG, Rutter CM, Naber SK, Doria-Rose VP, Pabiniak C, et al. Estimation of benefits, burden, and harms of colorectal cancer screening strategies. Modelling study for the US Preventive Services Task Force. JAMA 2016;315:2595–609.
37. White A, Thompson TD, White MC, Sabatino SA, de Moor J, Doria-Rose PV, et al. Cancer screening test use - United States, 2015. MMWR Morb Mortal Wkly Rep 2017;66:201–6.
38. Hwang H. Colorectal cancer screening among Asian Americans. Asian Pac J Cancer Prev 2013;14:4025–32.
39. Steinwachs D, Allen JD, Barlow WE, Duncan RP, Egede LE, Friedman LS, et al. National institutes of health state-of-the-science conference statement: enhancing use and quality of colorectal cancer screening. Ann Intern Med 2010;152:663–7.
40. U.S. Department of Health and Human Services. Healthy People 2020 - Improving the Health of Americans. Washington, DC: U.S. Department of Health and Human Services; 2012.
41. California Health Interview Survey. CHIS 2009 Adult Public Use File. Los Angeles, CA: UCLA Centre for Health Policy Research.
42. Centers for Disease Control and Prevention. Behavioual Risk Factor Surveillance System Prevalence and Trends Data [online]. Atlanta, GA: Centers for Disease Control and Prevention; 2015.
43. Rex DK, Boland CR, Dominitz JA, Giardiello FM, Johnson DA, Kaltenbach T, et al. Colorectal cancer screening: recommendations for physicians and patients from the U.S. multi-society task force on colorectal cancer. Am J Gastroenterol 2017;112:1016–30.
44. Gomez SL, Glaser SL, Kelsey JL, Lee MM, Sidney S. Immigration and acculturation in relation to health and health-related risk factors among specific Asian subgroups in a health maintenance organization. Am J Public Health 2004;94:1977–84.
45. Frisbie WP, Cho Y, Hummer RA. Immigration and the health of Asian and Pacific Islander adults in the United States. Am J Epidemiol 2001;153:372–80.