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Increasing Rates of Colorectal Cancer Among Young People in California, 1988–2017

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Abstract: Background: Colorectal cancer (CRC) incidence among persons older than 50 years has decreased in California and nationally, but incidence rates have increased among persons younger than 50 years. Previous studies present incidence rates among younger persons using a wide age group of 20–49 years. However, previous population-based studies did not analyze CRC incidence in subgroups defined by age, sex, race/ethnicity, and stage at diagnosis to better understand incidence trends among younger persons. Methods/Approach: We identified all people diagnosed with CRC at the age of 20–49 years from the California Cancer Registry (n = 39,298; 1988–2017). We used SEER*Stat and Joinpoint software to calculate average annual percentage changes (AAPCs) in incidence rates by age at diagnosis, sex, race/ethnicity, and stage. Age was divided into 10-year intervals (20–29, 30–39, and 40–49 years), stage was categorized as early- and late-stage, and race/ethnicity as non-Hispanic White, non-Hispanic Black, Hispanic, Asian/Pacific Islander, and American Indian groups. Results: Statistically significant increases in early-stage CRC incidence rates were observed among the 20–29, 30–39, and 40–49-year age groups in male and female non-Hispanic White populations (AAPC, 6.3%, 3.3%, and 1.9%, respectively) and Hispanic populations (AAPC, 4.9%, 3.5%, and 2.3%, respectively). Statistically significant increases in late-stage CRC incidence rates were observed among all 3 age groups of male and female non-Hispanic White people (AAPC, 2.8%, 3.1%, and 1.7%, respectively) and Hispanic females (AAPC, 4.2%, 2.3%, and 1.1%, respectively). Statistically significant increases in late-stage CRC incidence rates were also seen in the 30–39 and 40–49-year age groups among non-Hispanic White females (AAPC, 3.4% and 1.8%, respectively), Hispanic males (AAPC, 3.6% and 1.6%, respectively), and Asian/Pacific Islander females (AAPC, 1.9% and 0.7%, respectively). Statistically significant increases in late-stage CRC incidence were observed among 40- to 49-year-old Asian/Pacific Islander males (AAPC, 1.4%) and American Indian males and females (AAPC, 5.5%). Conclusion: CRC is increasing among several young age groups. Because evidence suggests that younger adults present with more advanced disease, these results may be useful for educating health care providers about CRC risk and suggest that CRC screening recommendations should be developed for this population. Continued surveillance of CRC incidence rates among young adults is warranted.

Key words: *colorectal cancer, incidence, race/ethnicity, stage, young people*

Introduction

Colorectal cancer (CRC) is the third most common cancer among men and women in the United States.[1] For the last 20 years, CRC incidence among persons older than 50 years has decreased.[2] Screening and reduction of risk factors have been decreasing the overall incidence rate of CRC at an average annual rate of 3%.[1,3] However, this decrease is not uniform across all age groups, as incidence rates continue to increase among persons younger than 50 years.[4,5]

In California, CRC incidence among adults aged 60–74 years decreased by 30% from 2008 to 2017, but increased by 4% among adults aged 45–59 years and by 40% among adults aged 20–44 years.[6] Studies considering age groups in this younger population found statistically significant increases in CRC rates among younger adults for whom screening has not been indicated (age groups 20–29, 30–39, and 40–49 years).[7,8] In addition, previous studies found that adults younger than 50 years are more likely to be diagnosed with late-stage CRC, with an estimated 66% diagnosed at a late stage compared to 54% in adults older than 50 years.[2,5,9] However, no recent studies have considered incidence rates in groups defined by age, sex, race/ethnicity, and stage in this young population.

Understanding the trends in early- and late-stage CRC incidence by race/ethnicity, sex, and clearly defined younger age groups will help health practitioners and health policy makers towards accurate screening recommendations for CRC. Both the American Cancer Society (ACS; 2018) and the United States Preventive Service Task Force (USPSTF; 2021) have recently reduced their recommended CRC screening

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age from 50 to 45.[10,11] The US Multi-Society Task Force on Colorectal Cancer (MSTF) recommends screening starting at age 45 years for African American populations, and age 50 years for all other average-risk persons.[12] In addition, the MSTF recommends persons with a family history of CRC or advanced adenoma to undergo screening every 5 years beginning 10 years before the age of diagnosis of the youngest affected relative or at age 40 years, depending on which occurs first.[12] Because incidence rates for such wide age ranges do not provide enough detail about the risk among specific segments of the population, nor allow for tailored screening recommendations for CRC screening among younger adults, we sought to evaluate CRC risk at more granular levels of age, sex, race/ethnicity, and stage at diagnosis. We analyzed CRC incidence rates among adults aged 20 to 49 years in the nation's largest and most diverse state to address gaps in prior research on CRC incidence among people younger than 50 years.

Materials and Methods

Study Population

The California Cancer Registry (CCR) is a statewide population-based cancer surveillance system and has collected cancer diagnoses in California since 1988, with reporting guidelines similar to those of the Surveillance, Epidemiology, and End Results (SEER) database. Data from the CCR were selected on all CRC patients diagnosed in adults aged 20 to 49 years from 1988 to 2017. CRC tumor sites were selected based on *International Classification of Diseases for Oncology*, 3rd edition/World Health Organization (ICD-O-3/WHO) 2008 site codes for *colon and rectum* as follows: C180 (cecum), C181 (appendix), C182 (ascending colon), C183 (hepatic flexure), C184 (transverse colon), C185 (splenic flexure), C186 (descending colon), C187 (sigmoid colon), C188–C189 and C260 (large intestine, NOS), C199 (rectosigmoid junction), and C209 (rectum).[13] Ages were grouped into the following categories: 20–29, 30–39, and 40–49 years. Sex was categorized as male and female, with unknown/other categories excluded. Race/ethnicity was categorized as non-Hispanic White, non-Hispanic Black, Hispanic, Asian/Pacific Islander, American Indian, and other/unknown based on the North American Association of Central Cancer Registries' Hispanic and Asian/Pacific Islander Identification Algorithm (NHAPIIA).[14] Stage at diagnosis was based on the SEER Summary Stage variable and defined as early-stage (in situ and localized) and late-stage (regional and distant). Health insurance was obtained at time of diagnosis or initial treatment. Health insurance type was divided into 4 groups:

(1) Medicaid, including Medicaid and Medicaid administered through a Managed Care plan

(2) Not insured

(3) Private, including insurance not otherwise specified, managed care, health maintenance organization (HMO) or preferred provider organization (PPO) private insurance, fee-for-service private insurance, Medicare with supplement not otherwise specified, and Medicare with private supplement

(4) Other, including Medicare without supplement or not otherwise specified, Medicare administered through a managed care plan

The CCR contains reliable data on health insurance dating back to 1996; as such, we included insurance data from 1996 to 2017.

Statistical Analyses

SEER*Stat software (version 8.3.8) was used to analyze annual cancer incidence rates per 100,000 and age-adjusted to the 2000 US Standard Population, with strata defined by age, sex, race/ethnicity and stage. Joinpoint software (version 4.8.0.1) was used to estimate piecewise-log linear trends and derive average annual percentage changes (AAPCs) in incidence trends since 1988. The software produces graphs in which several different lines reflecting trend data connect together at "Joinpoints."[15] AAPC is a summary measure of the trend over a specified time interval and generates a single percentage to describe AAPCs over a period of multiple years.[16] To accommodate for the small number of cases in some groups, years of diagnoses from 1988–2017 were grouped into 3-year cumulative incidence rates (1988–1990, 1991–1993, 1994–1996, 1997–1999, 2000–2002, 2003–2005, 2006–2008, 2009–2011, 2012–2014, 2015–2017), with 1 Joinpoint allowed and 1 AAPC reported for the entire 1988–2017 study period. To alleviate errors arising from a standard error of zero in some of the stage categories observed in the SEER*Stat rates files, we assumed a constant variance of errors in Joinpoint stage analyses.

Results

From 1988 to 2017, there were 428,250 CRC diagnoses in California among people aged 20 years or older; 39,298 and 388,952 CRC diagnoses were among people aged 20–49 years and ≥50 years, respectively. In all 3 age groups for those 20-49 years, males (52.8%) had higher percentages of CRC diagnoses compared to females (47.2%). The greatest proportion of CRC patients were non-Hispanic White (Table 1; 41.9% of the 20–29-year age group, 45.5% of the 30–39-year age group, 52.1% of the 40–49-year age group). The 20–29-year age group had the highest percentage of patients with Medicaid (26.5%) and patients who were not insured (6.5%). The 40–49-year age group had the highest percentage of private insurance (78.2%).

Over time, there was a statistically significant increase in CRC incidence rates by race/ethnicity for all age groups in each of the race categories, with a few exceptions (Table 2). For the 20–29-year Asian/Pacific Islander group, and the 40–49-year non-Hispanic Black group, we observed decreasing incidence rates of CRC, although the AAPCs in CRC incidence were not statistically significant (Figure 1). For the 20–29-year American Indian group, we were unable to accurately calculate rates due to low case counts.

We observed an increase in CRC incidence for both early- and late-stage diagnoses for all age groups over time (Figure 2). A decrease in CRC incidence was observed from 1988 to 1996 among 40–49-year-old patients diagnosed with late-stage CRC, but this pattern changed, with increasing incidence rates observed from 1997 to 2017. Early-stage

Table 1. Characteristics of Patients with Colorectal Cancer by Age Groups in California, 1988–2017

	Total		Age group (y)					
			20–29		30–39		40–49	
	N = 39,298		n = 2,042		n = 8,720		n = 28,536	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Sex								
Male	20,736	52.8	1,079	52.8	4,597	52.7	15,060	52.8
Female	18,562	47.2	963	47.2	4,123	47.3	13,476	47.2
Race/ethnicity								
American Indian	238	0.6	16	0.8	58	0.7	164	0.6
Asian/Pacific Islander	5,588	14.2	266	13.0	1,266	14.5	4,056	14.2
Hispanic	10,077	25.6	754	36.9	2,670	30.6	6,653	23.3
Non-Hispanic Black	3,318	8.4	118	5.8	673	7.7	2,527	8.9
Non-Hispanic White	19,687	50.1	855	41.9	3,968	45.5	14,864	52.1
Other/Unknown	390	1.0	33	1.6	85	1.0	272	1.0
Year of diagnosis								
1988–1990	2,554	6.5	149	7.3	637	7.3	1,768	6.2
1991–1993	2,792	7.1	151	7.4	643	7.4	1,998	7.0
1994–1996	2,942	7.5	133	6.5	723	8.3	2,086	7.3
1997–1999	3,543	9.0	156	7.6	807	9.3	2,580	9.0
2000–2002	3,846	9.8	166	8.1	850	9.7	2,830	9.9
2003–2005	4,185	10.6	166	8.1	875	10.0	3,144	11.0
2006–2008	4,511	11.5	208	10.2	885	10.1	3,418	12.0
2009–2011	4,714	12.0	247	12.1	909	10.4	3,558	12.5
2012–2014	4,772	12.1	263	12.9	1,109	12.7	3,400	11.9
2015–2017	5,439	13.8	403	19.7	1,282	14.7	3,754	13.2
Stage at diagnosis								
Early	12,336	31.4	677	33.2	2,614	30.0	9,045	31.7
Late	25,452	64.8	1,254	61.4	5,732	65.7	18,466	64.7
Unknown	1,510	3.8	111	5.4	374	4.3	1,025	3.6
Insurance type (includes cases diagnosed from 1996–2017)								
	n = 29,259		n = 1,477		n = 6,352		n = 21,430	
Medicaid	4,903	16.8	391	26.5	1,225	19.3	3,287	15.3
Not insured	1,309	4.5	96	6.5	303	4.8	910	4.2
Private	22,462	76.8	975	66.0	4,729	74.4	16,758	78.2
Other	585	2.0	15	1.0	95	1.5	475	2.2

CRC incidence rates increased for all 3 age groups, with the highest increases observed among the 20–29-year-old patients, with statistically significant AAPCs of 5.2% for the 20–29-year age group, 2.3% for the 30–39-year age group, and 1.6% for the 40–49-year age group (Table 2).

Overall, and in all 3 age groups separately, late-stage diagnoses were more commonly observed than early-stage diagnoses of CRC (Table 1). Approximately two-thirds of diagnoses were late-stage in all 3 age groups, with the highest percentage of late-stage diagnoses observed among 30–39-year-old patients (65.7%) (Table 1). For males and females combined, the increasing late-stage CRC incidence was more pronounced in younger age groups, with an AAPC of 2.3% for the 20–29-year age group, 2.5% for the 30–39-year age group, and 1.1% for the 40–49-year age group (Table 2).

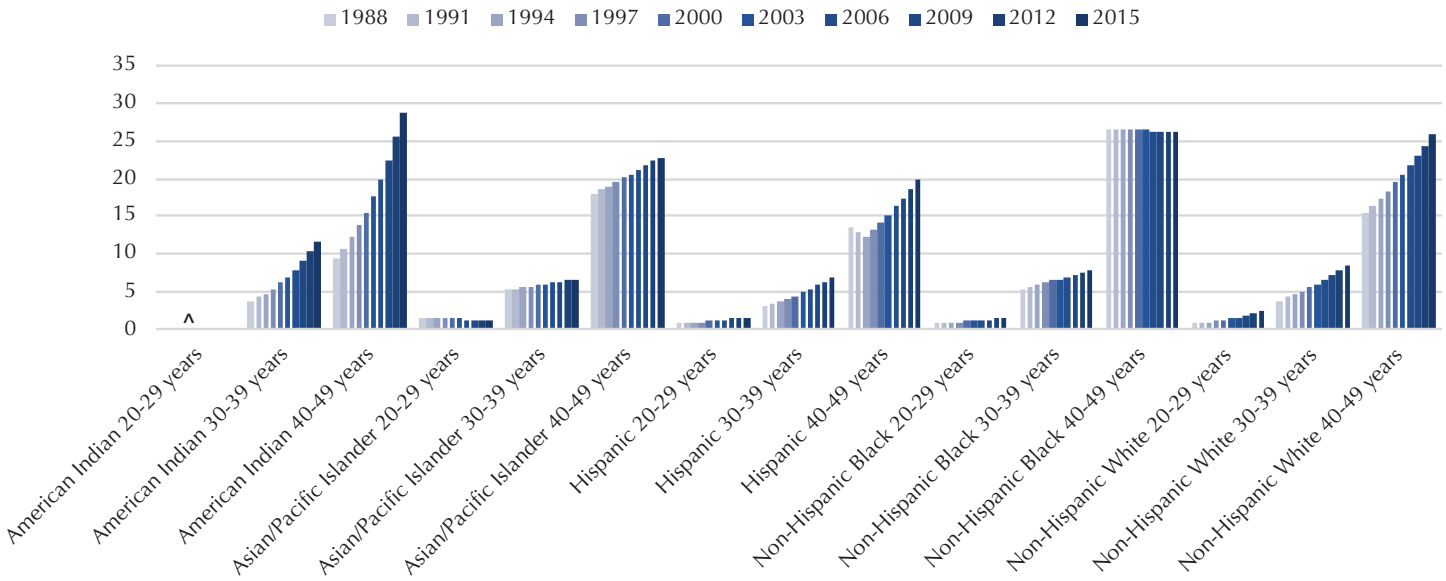
Among early-stage CRC diagnoses, increases in CRC incidence rates were observed for non-Hispanic White and Hispanic patients among all age groups, with the 20–29-year age group experiencing the most notable increases in

Table 2. Average Annual Percent Change (AAPC) of Colorectal Cancer Incidence Rates by Age, Sex, Race/Ethnicity, and Stage at Diagnosis, 1988–2017

	Age group (y)					
	20–29		**30–39**		**40–49**	
	AAPC	95% CI	AAPC	95% CI	AAPC	95% CI
Sex						
Male and female	3.7*	(2.9–4.6)	2.6*	(1.9–3.3)	1.4*	(1.1–1.8)
Male	3.2*	(2.5–3.9)	2.4*	(1.9–2.9)	1.4*	(1.0–1.8)
Female	3.5*	(1.9–5.1)	2.6*	(2.0–3.1)	1.5*	(1.1–1.8)
Race/ethnicity						
American Indian	^	^	4.4*	(0.8–8.1)	4.2*	(2.3–6.1)
Asian/Pacific Islander	–0.4	(–2.3–1.6)	0.8	(–0.4–2.1)	0.9*	(0.1–1.6)
Hispanic	3.2*	(1.8–4.6)	3.1*	(2.2–3.9)	1.5*	(0.0–2.9)
Non-Hispanic Black	2.0*	(0.0–4.0)	1.4*	(0.3–2.6)	–0.1	(–0.5–0.4)
Non-Hispanic White	4.6*	(3.3–5.9)	3.0*	(2.5–3.6)	1.9*	(1.5–2.3)
Stage at diagnosis~						
Early	5.2*	(0.5–10.1)	2.3*	(1.8–2.7)	1.6*	(0.9–2.2)
Late	2.3*	(1.8–2.7)	2.5*	(2.0–2.9)	1.1*	(0.4–1.8)

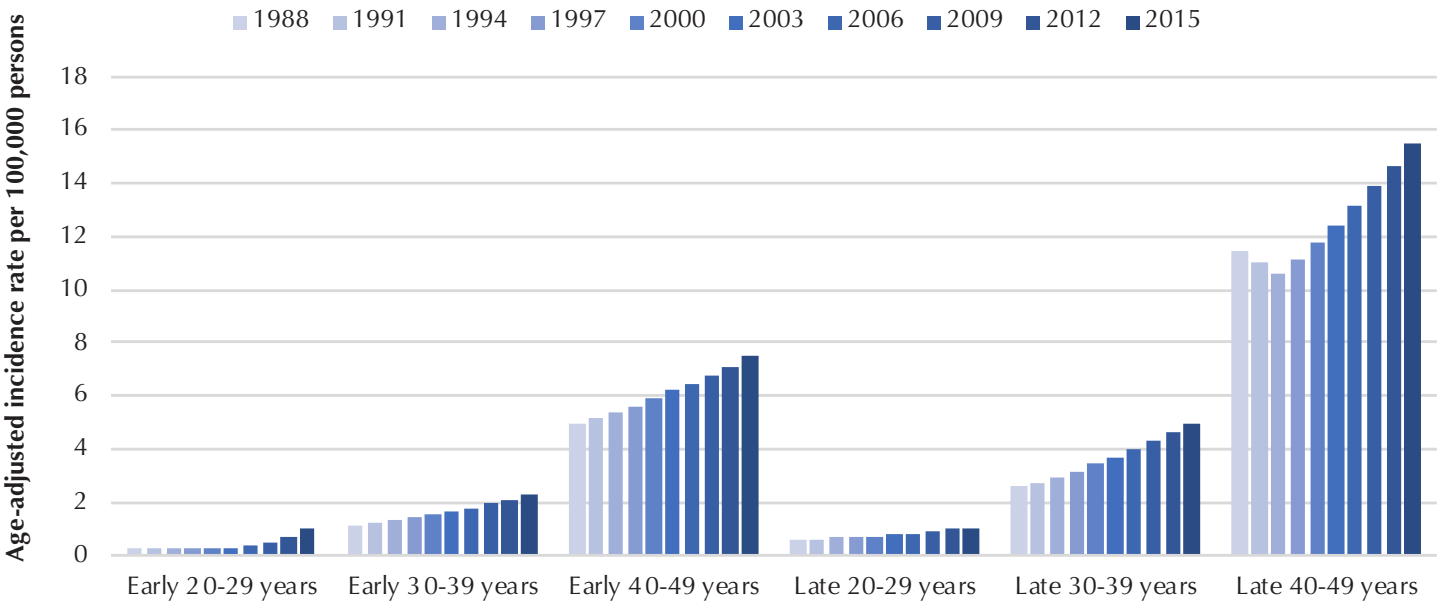
*Indicates that the AAPC is significantly different from zero at the α = 0.05 level.
~ Assumed constant variance in error for Joinpoint analysis.
^ AAPCs not calculated due to insufficient data.
Rates are per 100,000 and age-adjusted to the 2000 US Standard Population.
Rates were modeled using Joinpoint software.

Figure 1. Colorectal Cancer Trends by Age and Race/Ethnicity, 1988–2017



^Rate unable to be calculated due to insufficient data.
Rates are per 100,000 and age-adjusted to the 2000 US Standard Population.
Rates were modeled using Joinpoint software.

Figure 2. Colorectal Cancer Trends by Age and Early and Late Stage at Diagnosis, 1988–2017



Rates are per 100,000 and age-adjusted to the 2000 US Standard Population.
Rates were modeled using Joinpoint software.

both males and females, with statistically significant AAPCs of 6.3% among non-Hispanic White 20–29-year-olds and 4.9% among Hispanic 20–29-year-olds (Table 3). For non-Hispanic Black patients, no statistically significant increases in CRC incidence were observed. Due to insufficient data, we were not able to calculate AAPCs in CRC incidence for the 20–29-year age group. For the Asian/Pacific Islander and American Indian groups where there were sufficient data, AAPCs in CRC incidence were not statistically significant over the study period.

Among late-stage CRC diagnoses, we observed increasing CRC incidence rates in all 3 age groups for non-Hispanic White patients, with statistically significant AAPCs of 2.8% for the 20–29-year age group, 3.1% for the 30–39-year age group, and 1.7% for the 40–49-year age group (Table 4). Non-Hispanic White males had notably higher increases in CRC incidence among the 20–29-year age group, with an AAPC of 4.1%, while non-Hispanic White females had higher increases in CRC incidence among the 30–39-year age group, with an AAPC of 3.4%. Among Hispanic people, there was a notable increase in CRC incidence among females in the 20–29-year age group, with a statistically significant AAPC of 4.2%. Among the Hispanic 30–39-year age group, both males and females had increases in CRC incidence rates, with statistically significant AAPCs of 3.6% and 2.3%, respectively. A similar pattern was observed in the Hispanic 40–49-year age group, but increases in CRC incidence were lower compared to those observed among the 30–39-year age group. Late-stage CRC incidence rates for non-Hispanic Black men significantly increased for the 30–39-year age group (AAPC, 2.5%) and were not statistically significant for the other 2 age groups. Decreasing late-stage CRC incidence rates were observed among 20–29-year-old Asian/Pacific Islander males, with a statistically significant AAPC of 1.7%. Among the Asian/Pacific Islander 30–39-year age group, only females had statistically significant increases in CRC incidence (AAPC, 1.9%), but both males and females had statistically significant increases in incidence among the 40–49-year age group, with an AAPC of 1.0%. For the American Indian group, we observed statistically significant increases in CRC incidence rates of late-stage disease among 40–49-year-old males (AAPC, 4.3%) and were unable to assess trends among both male and female 20–29- and 30–39-year age groups and the 40–49-year female group due to insufficient numbers.

Discussion

While the absolute incidence of CRC among young adults is lower than older adults, the rising incidence over the last few decades is concerning.[1] We observed increases among the 20–29-, 30–39-, and 40–49-year age groups, with the largest increase observed among the 20–29-year age group at an estimated 12.4% increase, compared to a 7.4% and 7.0% increase among the 30–39- and 40–49-year age groups, respectively. To date, multiple studies have analyzed the increasing rates of CRC among young people,[8,9,17] but ours is the first to consider the rates within groups defined by age, sex, race/ethnicity, and stage. Additionally, while previous studies showed increases in early-stage CRC for non-Hispanic White and Hispanic 20-49-year age groups, results were not presented separately for the 20–29-, 30–39-, and 40–49-year age groups, leaving a gap in knowledge.[1,2] Notable findings we discuss further include increases in the following:

(1) Late-stage CRC for Hispanic females in the 20–29-year age group and males in the 30–39-year age group

(2) Early-stage CRC for the non-Hispanic White 20–29-year age group

Table 3. Average Annual Percent Change (AAPC) of Early-Stage Colorectal Cancer Incidence Rates by Age, Race/Ethnicity, and Sex, 1988–2017

	Age group (y)					
	20–29		**30–39**		**40–49**	
Race/ethnicity	AAPC	95% CI	AAPC	95% CI	AAPC	95% CI
American Indian						
Male and female	^	^	3.2~	(–1.0–7.5)	3.5~	(–2.0–9.4)
Male	^	^	^	^	^	^
Female	^	^	^	^	2.9~	(–0.9–6.8)
Asian/Pacific Islander						
Male and female	–0.4~	(–5.3–4.8)	1.0	(–0.6–2.5)	0.4	(–1.5–2.4)
Male	2.8~	(–1.9–7.8)	1.2	(–0.7–3.2)	0.9	(–0.1–2.0)
Female	–1.6	(–7.2–4.4)	0.8	(–1.4–2.9)	0.1	(–2.8–3.1)
Hispanic						
Male and female	4.9*~	(1.3–8.7)	3.5*	(2.3–4.6)	2.3*	(1.5–3.1)
Male	4.1*~	(0.6–7.7)	3.4*	(2.4–4.4)	2.0*	(0.8–3.2)
Female	5.3*~	(1.4–9.3)	3.5*	(1.5–5.4)	2.7*	(1.4–4.1)
Non-Hispanic Black						
Male and female	2.4~	(–2.3–7.2)	1.4	(–1.7–4.5)	0.4	(–0.3–1.0)
Male	^	^	1.0~	(–2.6–4.8)	–0.1	(–1.4–1.2)
Female	^	^	1.7~	(–2.2–5.8)	0.7	(–0.5–2.0)
Non-Hispanic White						
Male and female	6.3*	(3.2–9.5)	3.3*	(2.4–4.2)	1.9*	(1.1–2.6)
Male	6.4*~	(3.7–9.3)	3.3*	(2.0–4.7)	1.5*	(0.7–2.4)
Female	6.4*~	(0.7–12.3)	3.3*	(2.4–4.1)	2.2*	(1.5–3.0)

*Indicates that the AAPC is significantly different from zero at the $\alpha = 0.05$ level.
^AAPCs not calculated due to insufficient data.
~Interpret with caution; fewer than 8 case counts for some years.
Note: Assumed Constant Variance in Error for Joinpoint Regression Analysis.
Rates are per 100,000 and age-adjusted to the 2000 US Standard Population.
Rates were modeled using Joinpoint software.

(3) Late-stage CRC for the 30–39- and 40–49-year American Indian groups

(4) Early- and late-stage CRC for the 40–49-year age group in the context of recent national screening recommendation changes

Our results showing the significant increases of late-stage CRC observed, most notably among Hispanic females in the 20–29-year age group, are consistent with previous findings.[8] While previous studies have shown increasing CRC rates for the 30–39-year Hispanic male group, our study also highlights the substantial increase of late-stage disease for this group, contributing more evidence for the need for targeted care for this specific population group in California.[2,8]

The largest statistically significant increases in AAPCs in CRC incidence during the study period were observed in the early-stage CRC non-Hispanic White 20–29-year age group. Whether this increase is suggestive of better access to care among the 20–29-year age group is worthy of discussion. In the United States, steep increases in CRC incidence trends were observed in patients aged 20–29 years from 2011–2013, following the early provisions of the Affordable Care Act (ACA) in 2010.[18] A study comparing colorectal cancer screening prevalence before and after the full implementation of the ACA in 2014 showed that pre-ACA screening was lowest among non-Hispanic White patients in states with Medicaid expansion.[19] After 2014, screening prevalence increased by 9% for non-Hispanic White patients who had Medicaid.[19] In our study, the 20–29-year age group had the highest percentage of Medicaid insurance among the 3 age groups.

Given the notable increases observed in our study among both non-Hispanic White and Hispanic groups for both early- and late-stage CRC, it is worth further examination of underlying causes that may be attributable to these increases observed among the youngest age group included in our study. We also observed statistically significant increases of AAPCs in CRC incidence among the

Table 4. Average Annual Percent Change (AAPCs) of Late-Stage Colorectal Cancer Incidence Rates by Age, Race/Ethnicity, and Sex, 1988–2017

	Age Group (Years)					
	20–29		**30–39**		**40–49**	
Race/Ethnicity	AAPC	95% CI	AAPC	95% CI	AAPC	95% CI
American Indian						
Male and Female	^	^	4.8~	(–0.7–10.6)	5.5*~	(1.8–9.4)
Male	^	^	^	^	4.3*~	(1.3–7.5)
Female	^	^	^	^	^	^
Asian/Pacific Islander						
Male and Female	–1.2	(–3.3–1.0)	1.1	(–0.3–2.5)	1.0*	(0.5–1.6)
Male	–1.7*~	(–3.2 to –0.1)	0.3	(–1.1–1.7)	1.4*	(0.5–2.3)
Female	–0.6	(–3.9–2.9)	1.9*	(0.1–3.8)	0.7*	(0.1–1.2)
Hispanic						
Male and Female	3.0*	(1.7–4.2)	2.9*	(2.1–3.8)	1.2	(–0.1–2.4)
Male	1.9	(–0.1–3.9)	3.6*	(2.2–5.0)	1.6*	(0.6–2.6)
Female	4.2*	(3.0–5.4)	2.3*	(1.4–3.2)	1.1*	(0.0–2.1)
Non-Hispanic Black						
Male and Female	2.7	(–1.3–6.8)	1.7*	(0.2–3.3)	–0.2	(–0.9–0.5)
Male	^	^	2.5*	(0.9–4.1)	–0.2	(–1.3–1.0)
Female	0.8~	(–3.5–5.3)	0.9	(–1.5–3.4)	–0.3	(–0.8–0.3)
Non-Hispanic White						
Male and Female	2.8*	(2.1–3.5)	3.1*	(2.3–3.9)	1.7*	(1.1–2.4)
Male	4.1*	(2.7–5.5)	2.8*	(1.9–3.6)	1.9*	(1.1–2.6)
Female	1.7	(–0.3–3.7)	3.4*	(2.3–4.5)	1.8*	(1.0–2.6)

*Indicates that the AAPC is significantly different from zero at the alpha=0.05 level.
^AAPCs not calculated due to insufficient data.
~Interpret with caution, less than 8 case counts for some years.
Note: Assumed Constant Variance in Error for Joinpoint Regression Analysis.
Rates are per 100,000 and age-adjusted to the 2000 US Standard Population.
Rates were modeled using Joinpoint software.

30–39-year and 40–49-year age groups among American Indian patients, and our stage analyses suggest that these significant increases are seen in late-stage CRC. In the United States, CRC incidence rates among the American Indian population have been increasing significantly among those aged 49 years and younger, with a reported 2.2% AAPC in CRC incidence from 1995 to 2016.[1]

We observed CRC incidence rates increasing among the 40–49-year age groups in all race/ethnicities, except for the non-Hispanic Black group, where decreasing AAPCs in CRC incidence were observed. This suggests that screening opportunities may need to be directed at communities where CRC rates are continuing to increase among the 40–49-year age group. Multiple studies have confirmed the benefits and the cost-effectiveness of screening starting at age 45 years.[20,21] Some insurance companies now cover screening costs beginning at age 45 years.[22] The steep CRC incidence increases observed between ages 49 and 50 years as shown in previous research suggests undetected CRC among those younger than 50 years, and suggests that the current reexamination of screening recommendations is warranted.[23] Furthermore, a study conducted after the ACS guideline was implemented reported a 44% increase in CRC incidence among people aged 49-50 years, demonstrating that a large proportion of cases would have been missed if the screening guideline had not been reduced to age 45.[22,23]

Access to health insurance plays a significant role in the timing, quality, and type of care received, as well as in decreasing the likelihood of late-stage cancer diagnoses.[24] Among the 3 age groups, the 20–29-year age group had the highest percentages of Medicaid insurance and no insurance. Previous research has observed this pattern, with adolescent and young adult groups consistently having the highest uninsured rates compared to children and older adults.[25] Access to reliable health care and screening has also been attributed to lower overall incidence rates of CRC.[1] Further, there is a strong connection between socioeconomic

disparities and the diagnosis of CRC in the United States.[26] For example, people from low-income or low-education backgrounds are less likely to undergo screening, and screening is a proven intervention for reducing CRC incidence and mortality.[26] Consistent access to care and to health care providers who discuss CRC screening is associated with increased screening.[26] Geographic proximity to reliable health care providers is another important factor to consider. Cancer screening among rural populations in the United States is lower than elsewhere, suggesting that interventions in rural areas can help disadvantaged populations access CRC screening.[27]

Diets high in animal fat and low in fruit and vegetable access have been presented as possible reasons for higher cancer incidence, including the incidence of CRC.[1] Previous studies have attributed more than half of CRC cases to modifiable risk factors such as smoking and obesity, while others suggest that most CRC development among this young population is not explained by diet or obesity.[1,28] Active research studies are investigating stool bacterial compositions to better understand the pathogenesis of CRC.[28] However, making positive changes in behavioral risk factors may help the younger population lower their risk for developing CRC.[29]

Suggested risk-adaptive screening methods among young people include selecting younger patients for earlier screening based on above-normal CRC risk and considering factors such as a personal history of CRC, family history of CRC, inflammatory bowel disease (IBD), polyps, or a hereditary CRC syndrome.[28] There is research evidence showing that CRC patients with IBD are diagnosed at a younger age compared to CRC patients without IBD.[30] A national study showed that obesity was associated with increasing CRC in younger adults aged 18–19 years, but not in adults aged 50 years or older.[31] Obesity is associated with changes in gut flora, irritation, and inflammation of intestines and increasing evidence shows the role of microbiota as a mediator in the relationship between obesity and CRC.[31,32] Further, the issue of overtreatment of young CRC patients has been discussed previously, calling for further research towards safe and targeted screening and CRC treatment methods for the 20–49-year age group.[28]

The notable increasing CRC rates among the 20–29-, 30–39-, and 40–49-year age groups warrant further exploration of current screening guidelines, education, and awareness. The majority late-stage diagnoses are also concerning among all 3 age groups, especially considering that the 20–29-year age group has the highest percentage of being uninsured. While early-stage CRC diagnoses are increasing at a higher rate for the 20–29-year age group, the majority of diagnoses are still late-stage, calling for more education and awareness about how access to health care may be contributing to the late-stage majority of CRC diagnoses. The significantly increasing late-stage CRC diagnoses among the American Indian 30–39- and 40–49-year populations also raise important points concerning health insurance, access to screening, and the current USPSTF and ACS guidelines for screening age.[11,33] Previous research has shown access to health care and a physician are the 2 most consistent predictors of cancer screening adherence among the American Indian population in California.[34]

In some health care systems, such as in Austria, screening from the age of 40 years has been shown to decrease the incidence of CRC cases among those aged 40 years and above.[11,35] Such observations of other health care systems may help policymakers reconsider current CRC screening guidelines in California, specifically given the state's uniquely diverse population and screening disparities observed by race/ethnicity.[34,36]

Our study is subject to some limitations. First, the very small numbers for the American Indian 20–29- and 30–39-year age groups prevented us from calculating some of the CRC rates for this population. While the lack of data may be due to low occurrence of CRC in this population, our other analyses suggest that missing data may be more likely due to lack of accurate screening, diagnosing, and reporting CRC among these groups.[34,36] Second, for stage-specific analyses where we had smaller numbers, we had to assume a constant variance (homoscedasticity) to calculate a regression line. Therefore, this may have led to a more conservative estimate of trends.[15]

Our study results support the need for further review of screening guidelines pertaining to younger age groups. Although the USPSTF recently lowered the screening age recommendation for all average-risk adults,[37] more focused screening in younger adults may be warranted. The observation of increasing CRC rates and late-stage diagnoses among younger people in California, as presented in our study, is suggestive that more education and awareness on this topic is needed. We hope that our detailed analyses and observation of risk factors among the younger population in California can contribute towards a clearer understanding behind the alarming increases of CRC and serve as a basis for future studies.

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