

# Conditional Colon Cancer Survival in the United States

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## Abstract

**Purpose:** As long-term colon cancer survivors increase, there is a growing need for subgroup-specific analysis of conditional survival. This paper presents five-year conditional relative survival rates of colon cancer, with emphasis placed on subgroup-specific estimates by age, sex, race, ethnicity, marital status, year of diagnosis, and stage at diagnosis.

**Methods:** Analyses are based on 96,022 males and 101,793 females diagnosed with colon cancer during 2000 through 2008, followed through 2012, using data from the National Cancer Institute Surveillance, Epidemiology, and End Results program.

**Results:** Mean five-year conditional relative survival increased for years already survived for local staged disease by 2.3% per year ( $p < 0.05$ ), 5.0% per year ( $p < 0.05$ ) for regional staged disease, and 10.7% ( $p < 0.05$ ) per year for distant staged disease. Five-year conditional relative survival rates were significantly lower in those less than 65 years of age ( $p < 0.05$ ), more so in unstaged cases; among Blacks ( $p < 0.05$ ), more so in distant and unstaged cases; and other race ( $p < 0.05$ ), more so in local and regional staged cases. The rates were significantly higher in females ( $p < 0.05$ ), more so in regional and distant staged cases; non-Hispanics ( $p < 0.05$ ); and married patients ( $p < 0.05$ ), more so for local and regional staged cases.

**Conclusion:** These results provide further useful prognostic information for patients, their families, and physicians tailored to the time already survived since diagnosis. This can be informative in terms of shared decision making and time to "cure."

**Keywords:** Colon cancer; Conditional survival; Relative survival; Population-based; Prognosis; SEER

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## Introduction

Carcinomas of the colon and rectum account for 8% of all cancer cases and 8% of all cancer deaths in the United States, preceded only by prostate, lung and bronchus in males and breast, lung and bronchus in females [1]. In the year 2016, it is estimated there will be 134,490 new cases of colorectal cancer (CRC) (70,820 males and 63,670 females) and 49,190 CRC associated deaths (26,020 males and 23,170 females) [1]. The incidence and mortality rates of CRC have steadily declined over the past twenty years, increasing the amount of survivors [2]. Researchers have suggested the increase in the number of long-term colorectal cancer survivors warrants a need for subgroup-specific analysis of conditional survival [3]. As the numbers of CRC survivors increase, conditional survival data

becomes increasingly important in order to help determine the changing prognosis for cancer survivors.

Conditional survival is the probability that an individual will survive a health related condition after having already survived a certain time. It is a useful prognostic indicator for cancer patients, tailored to the time already survived since diagnosis [4]. This can be informative in regards to determining time to "cure." and influencing treatment decisions. For this reason, conditional survival rates can contribute to a more complete guide for colon cancer patients and their families.

Estimating conditional survival rates requires long-term follow-up in order to accurately update survival likelihoods after initial diagnosis of the disease. The National Cancer Institute Surveillance, Epidemiology, and End Results Program (SEER)

has continually collected and maintained cancer data, including time to death, since 1973 [5]. These data are obtained through medical records at hospitals and facilities by population-based cancer registries. The registries routinely collect data on patient demographics, primary tumor site, specific cancer markers, cancer stage at diagnosis, first course of treatment, and patient survival [6]. The SEER Program is the only comprehensive source of population-based cancer information in the United States that includes stage of disease at the time of diagnosis and patient survival [7]. Cancer coding is in accordance with the International Classification of Diseases for Oncology Third Edition (ICD-O-2) [8]. The SEER program was created in response to the National Cancer Act of 1971, which mandated public health surveillance of cancer in the United States for use in the prevention, diagnosis, and treatment of cancer. Precisely 28% of the United States population is covered by these population-based cancer registries [9].

This study presents five-year conditional survival estimates for patients diagnosed with colon cancer and followed for vital status and cause of death. Subgroup-specific conditional survival estimates by age, sex, race, ethnicity, marital status, year of diagnosis, and stage at diagnosis are also addressed.

## Methods

Analyses are based on 96,022 males and 101,793 females diagnosed with colon cancer during 2000 through 2008 and followed through 2012 using data from the National Cancer Institute SEER program. The cancer registries represented in this study include: San Francisco, Connecticut, Detroit (Metropolitan), Hawaii, Iowa, New Mexico, Seattle (Puget Sound), Utah, Atlanta (Metropolitan), San Jose-Monterey, Los Angeles, Alaska Natives, Rural Georgia, California (excluding San Francisco, San Jose-Monterey, Los Angeles), Kentucky, Louisiana, New Jersey, and Greater Georgia.

The conditional survival probabilities and their association with selected variables were estimated using the SEER Survival System (SEER\*Stat) through multiple regression analyses. Age, sex, race, ethnicity, marital status, and stage at diagnosis can influence conditional survival estimates and were analyzed as potential confounders; additional emphasis is placed on how these variables can influence five-year conditional survival rates.

This study uses relative survival [10]. Relative survival is a net survival measure that indicates cancer survival in the absence of other causes of death. It is the ratio of the proportion of observed survivors among a cohort of cancer cases to the proportion of expected survivors in a similar, but cancer free population with similar characteristics.

## Results

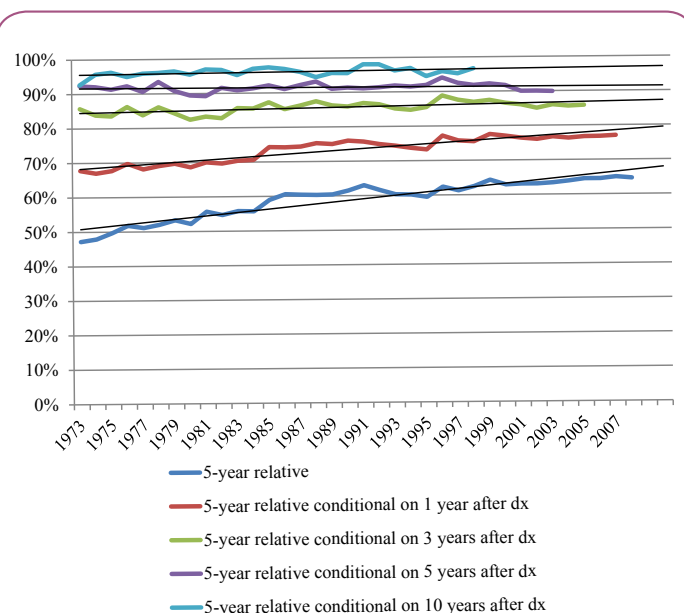
The distribution of colon cancer cases is presented by age, sex, race, ethnicity, marital status, stage at diagnosis, and year of diagnosis (Table 1). Five- and ten-year relative survival decreases with age, stage of diagnosis, and is lower among Blacks and those who were single at the time of diagnosis. Five-year conditional

relative survival rates for time periods after diagnosis are presented (Figure 1). As the time period after diagnosis (in years)

**Table 1** Colon Cancer Cases Diagnosed During 2000-2008 and Relative Survival through 2012 According to Selected Variables.

Variable	No	%	5-year survival %	10-year survival %
<b>Age</b>				
<65 years	71,425	36	67	60
≥ 65 years	126,390	64	62	56
<b>Sex</b>				
Male	96,022	49	64	57
Female	101,793	51	64	58
<b>Race</b>				
White	159,191	80	65	59
Black	23,817	12	56	50
Other	14,807	7	66	59
<b>Ethnicity</b>				
Hispanic	15,787	8	64	57
Non-Hispanic	182,028	92	64	58
<b>Marital Status</b>				
Married	105,530	53	69	64
Single	92,285	47	58	51
<b>Stage at Diagnosis</b>				
Local	76,231	39	90	85
Regional	71,044	36	70	62
Distant	41,802	21	12	8
Unknown	8,738	4	31	24
<b>Year of Diagnosis</b>				
2000-02	67,806	34	63	57
2003-05	65,413	33	64	58
2006-08	64,596	33	65	

Source Surveillance, Epidemiology and End Results Program, 18 registries.



**Figure 1** 5 year relative survival rates by year, conditioned on already having survived 0, 1, 3, 5 and 10 years.

increases, the probability of survival increases. The potential for improvement in five-year conditional relative survival is greatest among those less than 65 years of age, females, Whites, non-Hispanics, married at time of diagnosis, and with locally staged disease (**Figure 2**). As five-year conditional relative survival rates increase towards 100%, the survival of the general population is reached. For example, the relative survival rate at the time of diagnosis is 39% for patients with locally staged disease, but for those who have survived five years, their five-year relative survival rate is 90%.

Five-year relative survival, conditioned on 0-5 years already survived, are presented by age, sex, race, ethnicity, marital status, and year of diagnosis, stratified by stage at diagnosis (**Table 2**). In an unadjusted regression model, mean five-year conditional relative survival increased with years already survived for local staged disease by 2.3% per year ( $p < 0.05$ ), 5.0% per year ( $p < 0.05$ ) for regional staged disease, and 10.7% ( $p < 0.05$ ) per year for distant staged disease; the adjusted model yielded similar results.

Five-year conditional relative survival rates were significantly lower in those less than 65 years of age ( $p < 0.05$ ), among Blacks ( $p < 0.05$ ), and other race ( $p < 0.05$ ). The rates were significantly higher in females ( $p < 0.05$ ) and in non-Hispanics ( $p < 0.05$ ). Those who were married at the time of diagnosis also had significantly higher five-year conditional survival rates ( $p < 0.05$ ). Significant interaction terms were identified between stage at diagnosis and age ( $p < 0.05$ ), sex ( $p < 0.05$ ), race ( $p < 0.05$ ), and marital status ( $p < 0.05$ ). For example, better conditional relative survival rates in married individuals were more pronounced among local and regional staged cases.

## Discussion

This study presented five-year conditional relative survival rates for colon cancer patients diagnosed during 2000-2008 and followed through 2012, according to age, sex, race, ethnicity, marital status, year of diagnosis, and stage at diagnosis. In general, five-year relative survival, conditioned on already having



**Figure 2** Relative survival through 10 years (left side of each panel) and five-year relative survival conditioned on having survived 0-5 years (right side of each panel).

**Table 2** 5 year Relative Survival Conditioned on (0-5) Years Already Survived (YAS).

Tumor Stage Variable	Local	Regional	Distant	Unstaged
	%	%	%	%
<b>Unadjusted Model</b>				
Intercept	<b>90.6</b>	<b>70.6</b>	<b>11.6</b>	<b>31.3</b>
YAS	<b>2.3</b>	<b>5.0</b>	<b>10.7</b>	<b>17.9</b>
YAS × YAS	<b>-0.4</b>	<b>-0.3</b>	-0.1	<b>-2.1</b>
<b>Adjusted Model</b>				
Intercept	<b>86.6</b>	<b>63.1</b>	<b>10.9</b>	<b>42.6</b>
YAS	<b>2.5</b>	<b>5.1</b>	<b>10.7</b>	<b>17.4</b>
YAS × YAS	<b>-0.4</b>	<b>-0.4</b>	0.1	<b>-2.1</b>
<b>Age</b>				
<65 years	0.0	0.0	0.0	0.0
≥ 65 years	<b>-1.7</b>	<b>-1.0</b>	<b>-1.5</b>	<b>-18.6</b>
<b>Sex</b>				
Male	0.0	0.0	0.0	0.0
Female	<b>2.6</b>	<b>4.9</b>	<b>4.4</b>	1.9
<b>Race</b>				
White	0.0	0.0	0.0	0.0
Black	<b>-4.7</b>	<b>-4.4</b>	<b>-6.9</b>	<b>-10.8</b>
Other	<b>-2.4</b>	<b>-1.8</b>	0.4	1.6
<b>Hispanic</b>				
Yes	0.0	0.0	0.0	0.0
No	1.0	<b>1.5</b>	-0.7	<b>5.0</b>
<b>Marital Status</b>				
Single	0.0	0.0	0.0	0.0
Married	<b>5.9</b>	<b>7.1</b>	<b>2.3</b>	<b>9.0</b>
<b>Year</b>				
2000-2002	0.0	0.0	0.0	<b>0.0</b>
2003-2005	-0.1	<b>0.8</b>	-0.7	<b>-4.6</b>
2006-2008	0.4	<b>0.2</b>	0.1	<b>-7.4</b>

**Source:** Surveillance, Epidemiology, and End Results Program, 18 registries research data, 2000-2008 diagnosed cases and followed through 2012. Estimates for each model were simultaneously calculated, adjusted for the other variables in the model. Bolded variables are statistically significant,  $P < 0.05$ .

survived five years, exceeded 90-95%, thus nearing survival rates of the general population [9]. The prognosis for colon cancer survivors improved with each additional year of survival following diagnosis, with the exception of those with locally staged disease, for whom there was no excess mortality during follow-up.

Stage of disease at diagnosis had the largest effect on conditional relative survival rates, as consistent with previous research [11]. The five-year relative survival conditioned on 0-5 years already survived presented a change in rate of 2.5% within the locally staged cases, 5.1% within the regionally staged cases, and 10.7% within the distantly staged cases; the greater the severity of the stage of cancer at diagnosis, the higher the change in rate of conditional survival. Although the relative survival rate for later staged cases is initially lower, the longer the patient survives, the better their prognosis for survival.

Older age had a slightly negative effect on conditional relative survival among patients for all stages of diagnosis, with locally

staged cases having the greatest change in rates. This is also consistent with previous studies [12,13]. Researchers have suggested that this may be due to the elderly being less likely to receive curative treatment than younger patients, and also to the increase in the proportion of younger patients in recent years opting to undergo surgery [12].

Blacks had poorer conditional relative survival rates compared with Whites and other racial groups for all stages of diagnosis, but more so for patients with distant staged or unstaged disease. The comparatively poor survival for Black patients is consistent with previous research [14,15]. The lower conditional survival rates for Blacks could be attributed to later stage at diagnoses, poorer access to care, suboptimal treatment, lower socioeconomic status, and colon cancer biology [16]. Studies have found that Blacks are more likely than Whites to report physician non-recommendation, lack of knowledge, low perceived risk, and negative attitudes regarding screening [17-19]. In the future, focused screening campaigns and education regarding colon cancer might be beneficial towards the improvement of conditional survival within this subgroup.

Females had a greater positive effect on conditional relative survival compared with males, especially for regional and distant staged cases. Although an improvement of survival has been observed in both sexes, females have consistently had a greater survival rate for colon cancer [20,21]. This can be attributed to negative perceptions and fears that men have regarding screening and treatment and the proactive actions women take regarding their health, especially because of social support [22,23]. However, proactive treatment actions of females have varied in the literature depending on geographical region, stage at diagnosis, and age, so more studies need to assess the reasons for colon cancer survival differences among sexes in the United States to further understand this result [22].

Non-Hispanics experienced a slightly greater positive effect on conditional relative survival compared with Hispanics. Although Hispanics are the largest and fastest growing ethnic group in the United States, they often face challenges regarding assimilation, language barriers, reverse migration, and misperceptions regarding colon cancer, especially among older Hispanics, which can contribute to lower survival rates [24,25]. These challenges often contribute to and are associated with lower screening, not having a usual source of care, absence of health insurance, and lower socioeconomic status [24]. These cultural barriers need to be overcome if the overall health outcome of this subgroup is to be improved.

Lastly, marital status had an effect on conditional relative survival across each stage category, but more so in local and regional staged cases. This further supports previous hypotheses of marriage having a beneficial effect on health outcomes. The beneficial effect of marriage may be attributed to, at least in part, to social support. Married individuals are often more aggressive in cancer screening, are diagnosed with an earlier stage of cancer, have higher probabilities of surgery and more aggressive treatment options due to their spouse's encouragement, and perhaps have more to live for due to having a committed life partner [26].

## Conclusion

The results provide subgroup-specific prognostic information tailored to the time already survived since diagnosis, which may serve as a resource to colon cancer patients, their families, and physicians. Presenting the age, sex, race, ethnicity, marital status,

and year of diagnosis specific information according to stage at diagnosis is a unique contribution of this study. The modifying influence of stage on the effects of these selected variables on conditional relative survival warrants the importance of stratifying such analyses by stage.

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