

Assessing Surveillance Utilization and Value in Commercially Insured Patients With Colorectal Cancer

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Colorectal cancer (CRC) is the third most commonly diagnosed cancer in both genders in the United States, with approximately 135,430 new cases annually.¹ Following primary treatment, patients continue to be at risk of recurrence, and 20% to 50% of those who initially present with stage II or stage III disease experience recurrence in the 5 years following treatment.²⁻⁴

Surveillance is a critical part of survivorship care, as asymptomatic recurrences may be curable if detected early.⁵⁻⁸ For early detection, the National Comprehensive Cancer Network (NCCN) guidelines recommend routine testing of the serum tumor marker carcinoembryonic antigen (CEA) every 3 to 6 months for 2 years followed by every 6 months for a total of 5 years, CT scans annually for up to 5 years, and a colonoscopy within 1 year.⁹

Previous studies have shown that adherence to recommendations was variable, with overutilization and underutilization of tests. However, most of these studies characterized surveillance patterns in the 1990s and early 2000s, focused on either 1 or 2 components of surveillance testing, and did not examine the frequency of CEA testing.¹⁰⁻¹³ More recent studies have shown that although overutilization was not uncommon, the value of frequent surveillance testing was unclear.^{12,14-16} Previous studies have measured the impact of intensive surveillance on recurrence detection and the frequency of treatment with curative intent,¹⁰⁻¹⁶ but these results have not been put in the context of costs incurred during the surveillance period by patients in the United States. Although 2 studies have measured CRC surveillance costs, both were done in Europe and among patients who received a diagnosis in the late 1990s.^{17,18} Furthermore, not much is known about younger patients with CRC, as previous studies focused on patients older than 65 years.

Our goal was to use the IBM MarketScan Commercial Claims and Encounters database to (1) characterize recent trends in utilization of surveillance tests (CEA, CT scan, colonoscopy) in patients with CRC and (2) examine the value of intensive surveillance by characterizing the impact of CEA surveillance intensity on receipt of potentially curative treatment for recurrence and costs.

To our knowledge, this is the first study to use the MarketScan database to study CRC surveillance. As the database generally

ABSTRACT

OBJECTIVES: Real-world patterns of surveillance testing in colorectal cancer (CRC) and the effects on health and cost outcomes are largely unknown. Our objectives were to (1) assess trends in carcinoembryonic antigen (CEA) testing, CT scans, and colonoscopy utilization and (2) examine the value of CEA testing intensity by characterizing receipt of curative treatment for recurrence and measuring direct medical costs.

STUDY DESIGN: Prospective cohort study.

METHODS: We used an IBM MarketScan database to identify patients with a diagnosis of and treatment for CRC between 2008 and 2015. We used a negative binomial model to assess utilization of CEA testing and logistic models to assess utilization of CT scans and colonoscopies. We used a Cox proportional hazards model to assess surveillance intensity and time to curative treatment. We estimated direct medical costs using the Kaplan-Meier sample average estimator to account for censored costs.

RESULTS: We identified 3197 eligible patients. The mean numbers of CEA tests, CT scans, and colonoscopies remained relatively constant in the study period, but adherence to guidelines varied by surveillance. When categorizing individuals by their CEA utilization adherence to guidelines (perfect utilizers and overutilizers), overutilizers had an HR for curative treatment of 2.11 [95% CI, 1.46-3.05] relative to perfect utilizers. Although overutilizers underwent potentially curative procedures for recurrence at higher rates compared with perfect utilizers, direct medical costs were much higher in the overutilizer group.

CONCLUSIONS: Higher intensity of surveillance, beyond what is recommended by guidelines, may lead to earlier recurrence detection and subsequent treatment, but this is associated with significantly higher direct medical costs.

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TAKEAWAY POINTS

- ▶ Surveillance after treatment for colorectal cancer varies in adherence according to the National Comprehensive Cancer Network guidelines across carcinoembryonic antigen (CEA) testing, CT scans, and colonoscopies.
- ▶ In this population, those who overutilized CEA testing had quicker times to receipt of treatment for recurrence but higher costs.
- ▶ These results suggest further studies need to be conducted to assess whether there is value in more posttreatment surveillance than is currently recommended.

contains a younger population compared with those in previous studies, our study provides important insights for a different patient population. Furthermore, our study is the first to characterize health care costs for this population and shed light on the value of surveillance testing intensity in the United States.

METHODS

Patient Population

Data from the IBM MarketScan Commercial Claims and Encounters database (January 1, 2008, through December 31, 2015) were used. We decided to use the MarketScan database because it contains medical and pharmacy claims information on approximately 30 million commercial enrollees annually and includes a patient population that has not been extensively studied in the CRC surveillance context. Patients included were 18 years or older and had a primary discharge diagnostic code for colon or rectal cancer (*International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM]* codes 153.X and 154.X). Because surveillance is intended to prolong survival for patients with disease at a curable stage, we excluded patients who did not undergo a colorectal resection or had the resection more than 120 days after diagnosis, as their procedures were likely not of curative intent.¹³ The date of the resection was used as the index date. Continuous enrollment 365 days preindex was required to calculate the Charlson Comorbidity Index (CCI) score for each patient, and continuous enrollment 365 days post index was required to assess the trends of surveillance testing.

The NCCN guidelines, which were used as a standard benchmark for appropriate surveillance, focus mainly on patients with stage II or III disease. However, because MarketScan does not include staging information, we excluded patients who had an *ICD-9-CM* code indicating metastasis (stage IV) in the 1-year period from their colorectal diagnosis date.¹⁹ For patients with stage I disease, the guidelines do not indicate CEA testing, only colonoscopy.⁹ Therefore, we also excluded patients who did not have at least 1 recorded CEA test in our 6-month exposure period (defined below), as these patients most likely had stage I disease. We excluded patients if they had a diagnosis code for any other cancer type in the 1-year preindex period to ensure that we evaluated tests that were for surveillance in CRC only and not for diagnostic or surveillance purposes for other cancers.¹³

Identification and Analysis of Surveillance Tests

We excluded the first 180 days after the index date to standardize the surveillance period between patients who do and do not receive adjuvant chemotherapy. A CEA test recorded within 7 days of a previous one was excluded because this was likely confirmatory, rather than for surveillance.²⁰ No adjustments were made for CT scan and colonoscopy.

A 1-year time frame, starting 180 days after the index date (days 181-546), was used to count CEA tests, CT scans, and colonoscopies (eAppendix Figure 1 [eAppendix available at ajmc.com]). We used a negative binomial regression model with robust standard errors (SEs) to assess trends of CEA tests throughout time, with number of CEA tests in the 1-year period as the outcome. Two separate logistic regression models with robust SEs were used to assess whether CT scans and colonoscopies were utilized, as the NCCN guidelines recommend that patients receive 1 of each within 1 year post surgery. In all models, index year was the predictor of interest, and we adjusted for age, gender, insurance type, receipt of adjuvant chemotherapy, CCI score (categorized into low, intermediate, and high CCI groups using values of 0-2, 3, and ≥ 4 , respectively), and geographic region. The age variable was rescaled from 1-year to 10-year increments. We used receipt of adjuvant chemotherapy within 90 days of the index date as a proxy for stage and risk level, as it allowed us to identify high-risk patients with stage II disease and all patients with stage III disease vs patients with stage I disease and low-risk patients with stage II disease. This was based on the NCCN recommendation that high-risk patients with stage II disease and all patients with stage III disease receive adjuvant chemotherapy.⁹

Impact of Surveillance Intensity on Receiving Curative Treatment

We categorized patients into 2 groups by utilization of CEA testing in the 6-month period (days 181-365) after the index date (eAppendix Figure 1). The groups were created relative to the NCCN guidelines, which recommend 2 to 4 CEA tests annually for 2 years post surgery.⁹ Because we used 6 months to assess utilization of CEA testing, we defined “perfect utilization” as 1 or 2 CEA tests and “overutilization” as 3 or more CEA tests. We used a 6-month exposure window instead of a 12-month window to have longer follow-up times for analysis after exposure. We used CEA testing frequency as a proxy for surveillance testing intensity for a few reasons. CEA testing may act as a surveillance checkpoint, as those with elevated levels may need earlier evaluations or testing outside the NCCN guidelines; continuously elevated levels also indicate the use of CT scans to check for recurrence, and with symptoms, colonoscopy is suggested.²¹ The recommended frequency of CEA testing also allowed us to create multiple levels of intensity (normal and high), even with a restricted 6-month exposure window. CT scans and colonoscopy, on the other hand, are recommended annually and thus cannot be evaluated using a 6-month time frame.

TABLE 1. Descriptive Characteristics by Year

Characteristics	2008 (n = 523)	2009 (n = 645)	2010 (n = 465)	2011 (n = 456)	2012 (n = 345)	2013 (n = 343)	2014 (n = 245)	2015 (n = 175)
Age in years, mean (SD)	53.51 (7.84)	53.59 (7.28)	53.50 (7.42)	53.68 (7.54)	53.39 (7.69)	53.31 (7.93)	53.66 (7.47)	53.66 (7.47)
Male, n (%)	282 (53.92)	348 (53.95)	262 (56.34)	241 (52.85)	193 (55.94)	187 (54.52)	132 (53.88)	104 (59.43)
FFS, n (%)	461 (88.15)	572 (88.68)	422 (90.75)	409 (89.69)	302 (87.53)	308 (89.80)	223 (91.02)	158 (90.29)
CCI score, mean (SD)	2.45 (0.85)	2.55 (1.09)	2.62 (1.17)	2.62 (1.21)	2.57 (0.99)	2.52 (1.03)	2.52 (0.97)	2.58 (1.13)
Geographic region, n (%)								
Northeast	47 (8.99)	97 (15.04)	79 (16.99)	65 (14.25)	43 (12.46)	49 (14.29)	43 (17.55)	30 (17.14)
North Central	130 (24.86)	142 (22.02)	110 (23.66)	123 (26.97)	95 (27.54)	75 (21.87)	53 (21.63)	36 (20.57)
South	281 (53.73)	287 (44.50)	206 (44.30)	203 (44.52)	147 (42.61)	154 (44.90)	112 (45.71)	88 (50.29)
West	63 (12.05)	103 (15.97)	68 (14.62)	56 (12.28)	52 (15.07)	54 (15.74)	37 (15.10)	21 (12.00)
Unknown	2 (0.38)	16 (2.48)	2 (0.43)	9 (1.97)	8 (2.32)	11 (3.21)	0 (0.00)	0 (0.00)
CEA tests, mean (SD)	3.54 (2.28)	3.50 (2.24)	3.69 (2.68)	3.72 (2.47)	4.15 (2.95)	3.60 (2.36)	3.75 (2.49)	3.42 (2.45)
CT scans, mean (SD)	1.35 (1.34)	1.25 (1.30)	1.41 (1.51)	1.52 (1.53)	1.54 (1.51)	1.55 (1.43)	1.52 (1.40)	1.36 (1.23)
Colonoscopies, mean (SD)	0.76 (0.51)	0.82 (0.52)	0.80 (0.58)	0.80 (0.61)	0.76 (0.53)	0.78 (0.51)	0.80 (0.50)	0.74 (0.49)

CCI, Charlson Comorbidity Index; CEA, carcinoembryonic antigen; FFS, fee-for-service.

To determine if more CEA surveillance testing resulted in quicker receipt of potentially curative treatment, we examined the relationship between CEA surveillance intensity and time to a second potentially curative treatment using a Cox proportional hazards regression model. We defined the second curative treatment as hepatic metastasectomy, radiofrequency ablation, lung resection, or subsequent colectomy 365 days after the final day for counting CEA tests. Patients who dropped out because of disenrollment or death were censored. The covariate of interest was CEA utilization group, and we adjusted for receipt of adjuvant chemotherapy, index year, age, gender, insurance type, CCI score, and geographic region.

Impact of Surveillance Intensity on Costs

We estimated mean inpatient, outpatient, chemotherapy, and nonchemotherapy pharmacy costs over 1, 2, and 3 years of surveillance after primary treatment among CEA utilization groups using the Kaplan-Meier sample average estimator.^{22,23} This nonparametric estimator accounts for censoring during the surveillance period of interest. Costs for each patient were divided into 30-day intervals over the study period of interest. The mean cost was calculated in each interval using those who were alive in that interval. Survival probabilities from the Kaplan-Meier estimator were used to weight the intervals, and the weighted mean costs were summed. We calculated 95% CIs using bootstrapping with replacement.

All analyses were performed using SAS 9.3 (SAS Institute) and Stata 13.1 (StataCorp LP).

RESULTS

We identified 3197 patients who fit our inclusion and exclusion criteria (eAppendix Figure 2). Patients had a mean (SD) age of 53.53 (7.57) years (Table 1). A majority of CEA perfect utilizers (77.3%;

1853/2398) and overutilizers (67.1%; 536/799) had at least 365 days of follow-up since their last CEA test. The median follow-up time for CEA perfect utilizers was 747 days compared with 633 days for overutilizers.

CEA testing increased gradually from a mean (SD) of 3.54 (2.28) tests per patient in 2008 to a peak of 4.15 (2.95) in 2012; afterward, testing decreased and remained below a mean of 4. After adjusting for covariates, index year resulted in an incidence rate ratio of 1.01 (Table 2). In other words, for each subsequent year in our study, the rate of CEA use increased by a factor of 0.01, while holding all other variables constant, and this was not significant (95% CI, 1.00-1.02).

CT scan use initially increased from a mean (SD) of 1.35 (1.34) scans per patient in 2008 to 1.52 (1.53) scans in 2011 and remained relatively steady until 2014; however, the mean (SD) number of CT scans in 2015 decreased to 1.36 (1.23). After adjusting for covariates, we found that in each subsequent index year starting from 2008, there was a greater likelihood of CT scan use (odds ratio, 1.08; 95% CI, 1.04-1.12) (Table 2).

The trend for receiving surveillance colonoscopy was relatively constant in the study period, from a mean (SD) of 0.76 (0.51) per patient in 2008 to 0.74 (0.49) in 2015. There was no significant association between index year and colonoscopy use (Table 2). Patients with high CCI scores tended to be less likely to receive each of the 3 tests compared with the low CCI group, as did older patients compared with younger patients.

There were 2398 and 799 patients in the CEA perfect utilization and overutilization groups, respectively (Table 3). In the perfect-utilization group, 77 patients received curative treatment at a rate of 1.1 per 10,000 person-years. In the overutilization group, 45 patients received curative treatment at a rate of 2.2 per 10,000 person-years. Compared with perfect utilizers, the estimated hazard for curative

TABLE 2. Factors Associated With Receiving Surveillance Testing

Factors	CEA tests		CT scans		Colonoscopy	
	IRR	95% CI	OR	95% CI	OR	95% CI
Index year	1.01	1.00-1.02	1.08**	1.04-1.12	0.99	0.95-1.03
Age	0.97	0.94-1.00	0.84*	0.76-0.94	0.99	0.89-1.10
Male gender	0.99	0.94-1.04	1.01	0.87-1.19	0.85*	0.72-0.99
CCI score category						
≥4	0.96	0.88-1.05	0.82	0.64-1.06	0.84	0.65-1.09
3	1.00	0.95-1.06	1.01	0.84-1.22	0.85	0.72-1.03
0-2	1		1		1	
Adjuvant chemotherapy	1.04	0.95-1.14	1.33	0.97-1.81	0.81	0.60-1.08
Plan type						
FFS	1.04	0.96-1.13	1.15	0.90-1.48	1.17	0.92-1.51
HMO	1				1	
Geographic region						
North Central	0.85**	0.79-0.91	0.84	0.64-1.10	1.29	0.99-1.69
South	0.94	0.88-1.01	0.86	0.67-1.10	1.01	0.80-1.28
West	0.96	0.88-1.05	0.66*	0.49-0.88	1.12	0.84-1.51
Northeast	1		1		1	

CCI, Charlson Comorbidity Index; CEA, carcinoembryonic antigen; FFS, fee-for-service; HMO, health maintenance organization; IRR, incidence rate ratio; OR, odds ratio.

P* < .05; *P* < .001.

treatment was more than twice as high in the overutilizers (HR, 2.11; 95% CI, 1.46-3.05) (Table 4). High-risk patients with stage II or III disease had similar likelihood of receiving curative treatment as low-risk patients (HR, 1.20; 95% CI, 0.65-2.24).

Over the 1-year period after primary treatment, mean total cost was higher among overutilizers (\$74,144; 95% CI, \$67,160-\$82,332) compared with perfect utilizers (\$31,696; 95% CI, \$29,555-\$34,306). Spending in each category was generally about twice as high among overutilizers compared with perfect utilizers. We found similar trends throughout the next 2 years (Table 5). The main driver of costs, regardless of utilization group and year, was outpatient services, which included surveillance costs.

DISCUSSION

NCCN recommendations for CEA testing, CT scans, and colonoscopy have remained constant throughout the study period (2008-2015), and we found generally stable trends for the utilization of each test in practice. As the guidelines recommend 2 to 4 CEA tests yearly, testing remained adherent to guidelines on average (besides 2012), although high variability was observed. In contrast, CT scans were found to have been overutilized, whereas colonoscopies were underutilized, on average. We saw slow overall upward trends for CEA and CT use, but these generally stabilized and went back toward the initial values in the study period. In the case of CT scans, index year had a positive and statistically significant association with utilization of surveillance testing, whereas older age had the opposite significant effect. Our analysis of mean health care costs

showed that CEA overutilizers had consistently higher spending across inpatient, outpatient, and pharmacy services in the first 3 years after surgery.

In our study, we used adjuvant chemotherapy as a proxy for stage and risk level. We were surprised to see that it did not lead to significantly higher intensity, as the guidelines recommend testing more frequently among higher-risk patients. Recently, a study assessed adherence to CRC surveillance at National Cancer Institute-designated Comprehensive Care Centers and found adherence to be less than 50% for all 3 surveillance tests.¹⁴ Those investigators stated that one-third of patients overutilized CEA testing, which is higher than what we found, but they used a 14-month window to capture testing, whereas we used 6 months. Also, in contrast to their results, we found older age to be associated with more CT scan surveillance. Interestingly, in our study, whereas the intensity of CT scan increased by CEA utilization group, colonoscopy was underutilized across both CEA utilization groups. These utilization patterns of CT scan and colonoscopy were in agreement with previous studies.^{24,25} However, it is possible that we underestimated the use of colonoscopy because those with obstructive CRC are recommended to receive colonoscopy 3 to 6 months after surgery and we excluded that time period.²⁶

Two other recent studies that assessed posttreatment surveillance and health outcomes had variable results.^{15,16} The study by Snyder et al categorized surveillance intensity not at the patient level but at the facility level, which made comparisons difficult.¹⁵ Furthermore, no facility had more than 10 patients. These reasons could have led to null results because a mean treatment intensity

TABLE 3. Descriptive Characteristics by CEA Utilization Category

Characteristics	Perfect utilization	Overutilization
	(n = 2398)	(n = 799)
Age, mean (SD)	53.75 (7.46)	52.89 (7.85)
Male, n (%)	1328 (55.38)	421 (52.69)
FFS, n (%)	2136 (89.07)	719 (89.99)
CCI score, mean (SD)	2.55 (1.03)	2.57 (1.14)
Geographic region, n (%)		
Northeast	319 (13.30)	134 (16.77)
North Central	615 (25.65)	149 (18.65)
South	1095 (45.66)	383 (47.93)
West	330 (13.76)	124 (15.52)
Unknown	39 (1.63)	9 (1.13)
Year of index date, n (%)		
2008	397 (16.56)	126 (15.77)
2009	503 (20.98)	142 (17.77)
2010	345 (14.39)	120 (15.02)
2011	330 (13.76)	126 (15.77)
2012	234 (9.76)	111 (13.89)
2013	271 (11.30)	72 (9.01)
2014	182 (7.59)	63 (7.88)
2015	136 (5.67)	39 (4.88)
Adjuvant chemotherapy, n (%)	172 (7.17)	71 (8.89)
CT scans, mean (SD)	1.21 (1.23)	2.04 (1.73)
≥ 1 CT scan, n (%)	1661 (69.27)	657 (82.23)
Colonoscopies, mean (SD)	0.82 (0.51)	0.71 (0.61)
≥ 1 colonoscopy, n (%)	1838 (76.65)	521 (65.21)

CCI, Charlson Comorbidity Index; CEA, carcinoembryonic antigen; FFS, fee-for-service.

TABLE 4. Factors Associated With Time to Potentially Curative Treatment

Factors	HR	95% CI
CEA utilization category		
Overuse	2.11*	1.46-3.05
Perfect use	1	
Adjuvant chemotherapy	1.20	0.65-2.24
Age	1.03	0.80-1.31
Male gender	1.24	0.86-1.77
Index year	1.01	0.92-1.11
CCI score category		
≥ 4	1.06	0.56-2.00
3	1.21	0.80-1.83
0-2	1	
Plan type		
FFS	0.88	0.51-1.52
HMO	1	
Geographic region		
North Central	1.09	0.60-2.00
South	1.14	0.66-1.95
West	1.04	0.53-2.04
Northeast	1	

CCI, Charlson Comorbidity Index; CEA, carcinoembryonic antigen; FFS, fee-for-service; HMO, health maintenance organization.

**P* < .001.

at the facility level was assigned to patients, regardless of their true surveillance intensity. Another study by Hines et al found variable results depending on the survival assessed (cancer-specific, non-cancer-specific, and overall).¹⁶

Our results on CEA surveillance intensity and time to curative treatment need to be interpreted with caution to prevent misinformed conclusions. In a time in which the value of cancer care and costs are emphasized, our study findings suggest that more care (and costs) beyond what is recommended has mixed signals.^{27,28} We found that CEA overutilizers had an HR of 2.11 compared with perfect utilizers, which suggests that at any given time an overutilizer was twice as likely to receive curative treatment compared with a perfect utilizer. However, CEA overutilizers had more than double the health care costs. Both inpatient and outpatient health care costs were much higher among overutilizers compared with perfect utilizers. When we looked more closely into costs for surveillance and radiology services, the trends remained similar. Because up to two-thirds of recurrences are asymptomatic, appropriately scheduled surveillance testing is important to detect recurrence.^{26,29}

Combined surveillance of laboratory tests, endoscopy, and imaging has shown to be potentially cost-effective compared

with these as stand-alone surveillance procedures.³⁰ However, the data used to estimate cost-effectiveness were dated and have not been replicated to our knowledge. Future studies using more current data could provide better insight into whether the costs of increased surveillance are associated with greater health benefits. Because we are not able to measure the intensity of surveillance on survival, it is difficult to definitively state whether overutilization is associated with health. Finally, because this is an observational study, our results are not meant to be interpreted in a causal manner.

One possible explanation for the greater spending among CEA overutilizers is that they reached their out-of-pocket maximum and moral hazard took effect. The RAND Health Insurance Experiment demonstrated the idea of moral hazard by showing that individuals will utilize more services when faced with lower co-pays. Similarly, it is possible that once overutilizers reached their out-of-pocket maximum and had 0% co-pay, it led to high moral hazard in demand and they utilized more health care resources.^{31,32} Another possible explanation for higher spending among overutilizers was provider variation in testing and other health care services. Although we controlled for region effects, we were not able to control for variation in testing at the provider level.

TABLE 5. Mean Health Care Costs by CEA Utilization Group

Costs	Perfect utilizers	Overutilizers
	(n = 2398)	(n = 799)
1-year costs, mean (95% CI)		
Inpatient	\$8755 (\$6808-\$11,150)	\$17,734 (\$12,429-\$24,748)
Outpatient	\$20,862 (\$18,773-\$23,124)	\$52,898 (\$46,841-\$59,467)
Surveillance	\$2900 (\$2576-\$3251)	\$3994 (\$3270-\$4770)
Radiology services	\$4343 (\$3789-\$4979)	\$9898 (\$8511-\$11,460)
Chemotherapy	\$251 (\$162-\$354)	\$911 (\$606-\$1261)
Nonchemotherapy pharmacy	\$1828 (\$1482-\$2261)	\$2601 (\$2045-\$3242)
Total	\$31,696 (\$29,555-\$34,306)	\$74,144 (\$67,160-\$82,332)
2-year costs, mean (95% CI)		
Inpatient	\$14,554 (\$10,714-\$19,432)	\$26,572 (\$17,356-\$39,142)
Outpatient	\$32,905 (\$29,075-\$37,089)	\$78,257 (\$67,354-\$90,290)
Surveillance	\$4332 (\$3773-\$4940)	\$6004 (\$4797-\$7330)
Radiology services	\$6829 (\$5819-\$8032)	\$14,618 (\$12,145-\$17,559)
Chemotherapy	\$442 (\$257-\$658)	\$1329 (\$851-\$1875)
Nonchemotherapy pharmacy	\$3164 (\$2513-\$3994)	\$4438 (\$3320-\$5793)
Total	\$51,065 (\$46,679-\$56,688)	\$110,596 (\$98,789-\$125,540)
3-year costs, mean (95% CI)		
Inpatient	\$17,723 (\$12,343-\$24,763)	\$31,335 (\$19,727-\$46,547)
Outpatient	\$40,822 (\$35,444-\$46,764)	\$91,790 (\$77,143-\$108,322)
Surveillance	\$5102 (\$4383-\$5892)	\$7083 (\$5546-\$8790)
Radiology services	\$8366 (\$6974-\$10,091)	\$16,925 (\$13,712-\$20,833)
Chemotherapy	\$584 (\$323-\$889)	\$1746 (\$1025-\$2563)
Nonchemotherapy pharmacy	\$4136 (\$3219-\$5322)	\$5974 (\$4228-\$8172)
Total	\$63,265 (\$56,511-\$71,056)	\$130,845 (\$114,858-\$151,615)

CEA, carcinoembryonic antigen.

Limitations

Because of the limitations in MarketScan, we were unable to directly assess survival outcomes. Instead, we captured treatment for recurrence that had curative intent because patients identified as receiving potentially curative treatment should have survival benefits. Further work is needed to understand how the greater frequency of curative treatment among CEA overutilizers compared with perfect utilizers translates to survival. As our population is younger, their condition may improve compared with older patients with quicker detection of recurrence. Another limitation in the study was that we may have excluded underutilizers with stage II or III disease because of our identification method. If we were able to include these patients, our testing patterns may have had different results. Similarly, using adjuvant chemotherapy as a proxy for high risk may also be a limitation, as there was likely high provider heterogeneity with regard to adhering to guidelines and treatment use. Finally, if longer follow-up were available for the perfect utilization group, we may have found more receipt of curative treatment. However, we were constrained by the data to follow patients until the end of the study period or continuous enrollment.

Our study population consisted of commercially insured patients; results may not be generalizable to other populations

such as those in Medicare or from single-payer systems. Because of the nature of database population, the mean age in our study (53.53 years) was much lower than that of the general US population with CRC (median diagnosis age of 68 years in men and 72 years in women). As such, although our results may not be generalizable to other populations, they do shed light on utilization trends and outcomes in younger patients; this population has not been extensively studied. As mentioned previously, the characterization of CEA utilization groups should apply only to patients with stage II and III disease, and although we put forth our best efforts in limiting patients with stage I and IV disease, it is possible that these patients were included.

CONCLUSIONS

In general, CEA tests are used in accordance with the NCCN guidelines, whereas CT scans and colonoscopies tend to be overutilized and underutilized, respectively. These trends remained consistent. Although higher utilizers of CEA surveillance testing received more potentially curative treatments for recurrence, this came at a much higher cost. Future studies assessing surveillance intensity and survival end points should be conducted. ■

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Supplementary Online Content

Assessing surveillance test utilization and value in commercially insured patients with colorectal cancer

The American Journal of Managed Care

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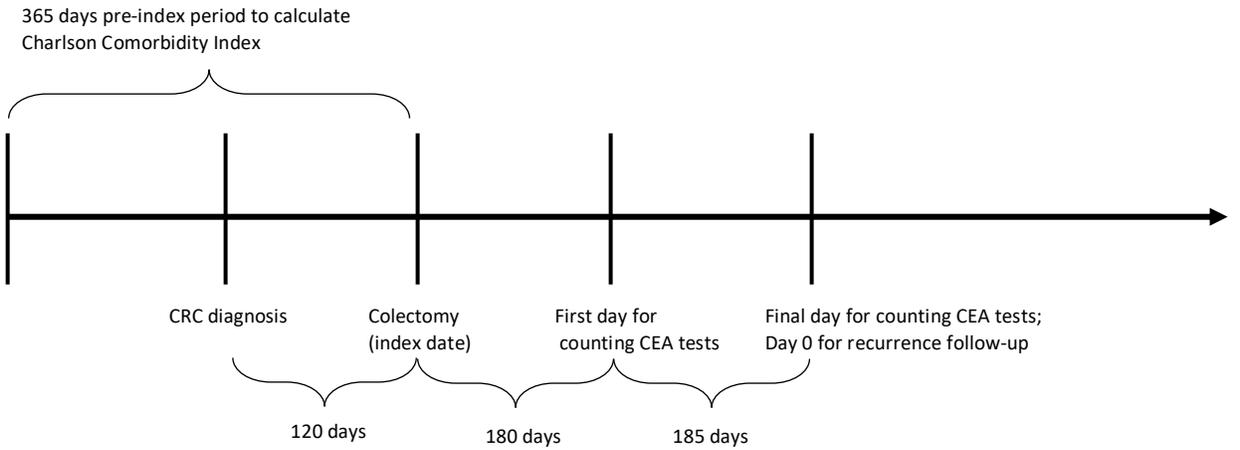
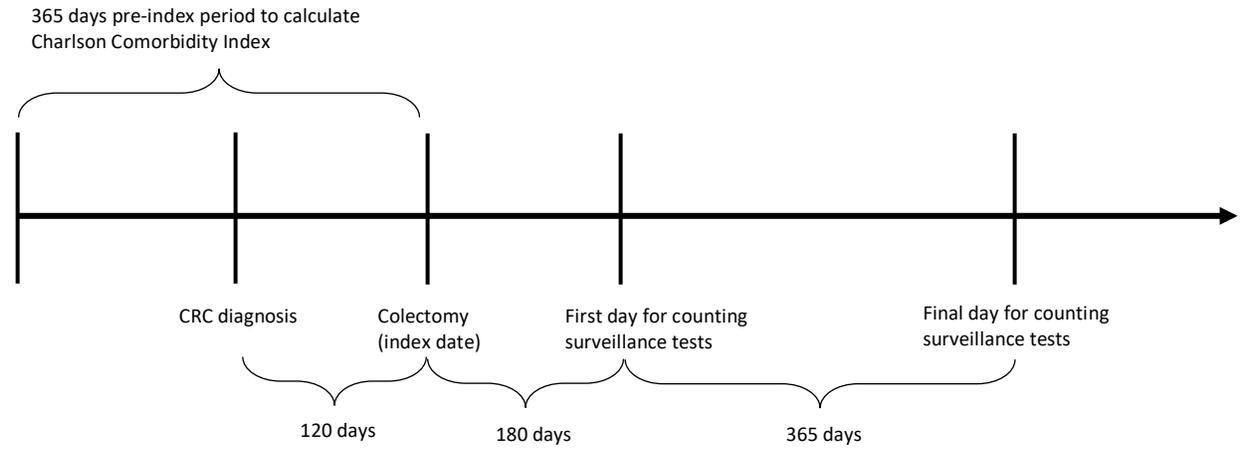
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eAppendix Figure 1. Study design for analysis of surveillance test trends and for analysis of CEA utilization and time to recurrence

eAppendix Figure 2. Flowchart of sample selection

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eAppendix Figure 2. Flowchart of sample selection

