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Compliance with Cancer Quality Measures Over Time and Their Association with Survival Outcomes: The Commission on Cancer's Experience with the Quality Measure Requiring at Least 12 Regional Lymph Nodes to be Removed and Analyzed with Colon Cancer Resections

Lawrence N. Shulman, MD[1,2], Amanda E. Browner, MS[2], Bryan E. Palis, MA[2], Katherine Mallin, PhD[2], Sumedh Kakade, MD[3], Ned Carp, MD[2,3], Ryan McCabe, PhD[2], David Winchester, MD[2], Sandra L. Wong, MD, MS[2,4], and Daniel P. McKellar, MD[2,5]

[1]Abramson Cancer Center, University of Pennsylvania, Philadelphia, PA; [2]American College of Surgeons, Commission on Cancer, Chicago, IL; [3]Lankenau Medical Center, Wynnewood, PA; [4]Dartmouth Hitchcock Medical Center, Lebanon, NH; [5]Wright State University, Dayton, OH

ABSTRACT

Background. Many quality measures in cancer care are process measures. The rates of compliance for these measures over time have not been well described, and the relationships between measure compliance and survival are not well understood.

Methods. The National Cancer Database, representing cancer registry data from approximately 1500 Commission on Cancer (CoC) cancer programs, was queried to determine the rates of compliance, with the CoC's colon cancer quality measure requiring 12 regional lymph nodes be removed at resection. Data were assessed in 2003, before the measure was reported to programs, through 2015. Measure compliance and risk-adjusted survival were examined by hospital type.

Results. From 2003 to 2015, 544,018 cases of colon cancer were analyzed for number of nodes removed. In 2003, compliance was 52.8% and National Cancer Institute (NCI) centers had the highest compliance rate (69.0%), followed by academic cancer centers (61.9%), comprehensive community hospitals (50.9%), and community hospitals (44.0%). Between 2003 and 2015, compliance improved for all hospital types, although differences remained. Risk-adjusted survival in 2009 was better at NCI centers [hazard ratio (HR) 0.76] than at academic cancer centers (HR 0.90), which had better survivals than comprehensive community programs (HR 0.93) when compared with patients treated at community hospitals.

Conclusion. After introduction of this quality measure, performance at CoC-accredited hospitals improved over the subsequent 13 years, and survival by hospital type paralleled measure compliance by hospital type. This demonstrated measurement may be associated with improvements in performance, and that there are differences in performance and outcome by hospital type.

Over the past 2 decades, various groups have developed quality measures to assess the current state of cancer care in the US and to drive improvement. Most quality measures have been related to processes of care determined to have an influence on patient outcomes. In the early 2000s, the American College of Surgeons (ACS) Commission on Cancer (CoC) instituted quality measures that all accredited hospital cancer programs were assessed against, on an annual basis.[1] During the same time period, the American Society of Clinical Oncology (ASCO) launched the Quality Oncology Practice Initiative (QOPI), which also developed measures of quality, also largely comprised of process

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L. N. Shulman, MD
e-mail: Lawrence.shulman@uphs.upenn.edu

measures.[2] The compliance with these measures, over time, by hospital type, and their relationship to patient outcomes such as survival is not well known.

Multiple observational studies have demonstrated the association between adequate lymph node examination and improved survival for patients undergoing resection for colon carcinoma.[3–12] A minimum of 12 lymph nodes removed and examined has been advocated by several groups, including the American Joint Committee on Cancer (AJCC), College of American Pathology, ASCO, National Cancer Institute (NCI) Panel of Experts, American Society of Colon and Rectal Surgeons, National Comprehensive Cancer Network, and the CoC.

The CoC accomplishes its mission by setting standards for cancer programs and collecting data on all patients evaluated and treated in CoC-accredited hospital cancer programs. Approximately 1500 CoC-accredited hospitals submit cancer registry data to the National Cancer Database (NCDB), co-supported by the ACS and the American Cancer Society, and these data are used to analyze and evaluate treatments and outcomes of patients with cancer, and for quality improvement. These data represent approximately 70% of newly diagnosed cancer cases nationwide and currently include more than 36 million patient records.

In 2003, the CoC began a quality measure program with the goal of improving cancer care outcomes at its accredited programs. As part of the CoC accreditation process, the NCDB analyzes facility-level compliance of each quality measure and reports these data back to the individual facility as an accountability tool for quality assessment and improvement. The NCDB collects the clinical data variables for every cancer patient in each hospital, and a computational algorithm determines whether the patient is compliant or non-compliant with the quality measure (i.e. patients are not sampled and quality measures are not directly coded by registrars). One of the initial six quality measures developed required that at least 12 lymph nodes be removed surgically and pathologically examined for colon cancer resections, and we chose this metric to study.

The purpose of this study was to determine the rates of compliance with this measure, over time, to assess determinants of compliance and to explore whether an association exists between compliance and survival by hospital type.

METHODS

This study analyzed 544,018 newly diagnosed unique cases of colon cancer eligible for the 12 lymph node measure diagnosed at 1642 facilities between 2003 and 2015 (Electronic Supplementary Table 1) from all programs that submitted data to the NCDB, excluding hospitals from the US Department of Veterans Affairs and Department of Defense. Colon cancer was identified using the International Classification of Diseases for Oncology (ICD-O) primary site codes of C18.0 and C18.2 through C18.9. The study cohort was limited to the 12 lymph node measure-eligible cases: diagnosis of colon cancer, male or female, 18 years of age or older, epithelial tumor histology with invasive tumor, stages I, II and III, and all or part of the first course of treatment, including surgical resection performed at the reporting facility, and any known sequence of malignant primaries. The 12 lymph node colon measure was developed for hospital-level assessment of accredited CoC programs, and therefore only cases that underwent surgical resection at the reporting facility were included. Cases were staged using the 6th (2003–2009) and 7th (2010–2015) editions of the AJCC Cancer Staging Manual. Compliance was defined as having at least 12 regional lymph nodes removed and pathologically examined.

The variables of interest included in this study are measure compliance, age at diagnosis, sex, insurance status, race, comorbidity score, pathologic stage, patient location, site of the tumor, hospital category, cancer sequence, coordination of care, median income, and percentage with no high-school diploma. Measure compliance indicates whether the case was compliant with the 12 lymph node measure. For analytic purposes, insurance status was grouped into four categories, consisting of not insured and Medicaid; private insurance and other government; Medicare; other/unknown. Race was reported regardless of ethnicity status. The comorbidity score is a cumulative value weighted by the burden of disease using criteria developed by Charlson–Deyo.[13] For analytic purposes, the index was collapsed into four categories: none, one, two, or three or more. Patient location was determined using the US Department of Agriculture, Economic Research Service's Rural-Urban Continuum Codes and the patient's zip code.[14] Site of the tumor was categorized as right (cecum, ascending colon, and hepatic flexure), transverse, left (splenic flexure, descending colon, and sigmoid colon), and overlapping lesion of colon and colon site not otherwise specified (NOS). The five hospital categories defined by the CoC are as follows: community cancer program (100–500 newly diagnosed cancer cases per year); comprehensive community program (500+ newly diagnosed cancer cases per year); academic cancer program (500+ newly diagnosed cancer cases per year and associated with a medical education program), NCI-designated Comprehensive Cancer Center Program (no minimum caseload; includes Prospective Payment System-exempt hospitals, including one that does not have NCI

Comprehensive Cancer Center status), and other/unknown. Cancer sequence was grouped into 'only malignant primary in a patient's lifetime' versus 'one of multiple malignant primaries'. A binary coordination of care covariate was used to identify the presence of treatment at more than one accredited program. Zip code-level data from the 2012 American Community Survey were used to derive area-based median income quartile estimates, as well as percentage with no high-school diploma quartile estimates.

Factors associated with compliance were investigated using multivariate GLIMMIX models, with hospital as a random effect, for cases diagnosed in 2003, 2009, and 2015. Diagnosis year 2003 was prior to the measure implementation, 2009 was the midpoint, and 2015 was the most current diagnosis year of data in the NCDB. Multivariate risk-adjusted survival hazard ratios (HR) were calculated with both fixed-effects Cox proportional hazards regression and random effects of hospital shared frailty models for diagnosis years 2003 and 2009, both of which model time to event, given that the analytic cohort selected from the NCDB contains censored cases lost to follow-up, as well as at least 5 years of follow-up. The NCDB does not collect data on the cause of death; mortality is death due to all causes. The multivariate analyses were conducted on age at diagnosis, sex, insurance status, race, comorbidity score, pathologic stage, patient location, site of the tumor, hospital category, cancer sequence, coordination of care, median income, and percentage with no high-school diploma; the survival models also included measure compliance. All analyses were conducted using SAS 9.4 statistical software (SAS Institute, Inc., Cary, NC, USA) using a significance level of $p < 0.05$.

RESULTS

Overall, 44,923 patients were eligible for the 12 regional lymph node colon measure in 2003, 40,115 patients in 2009, and 39,834 patients in 2015.

Percentage compliance for each variable evaluated at the patient level is noted in Table 1. At the hospital level, compliance with the 12 lymph node measure in colon cancer significantly increased in CoC-accredited hospitals over the observed period (52.8% in 2003 to 92.1% in 2015, $p < 0.0001$). For each factor, there was an increase in compliance from 2003 to 2015. Odds ratios (ORs) of compliance were calculated from diagnosis year-specific multivariate GLIMMIX models (Table 2). For the diagnosis years 2003, 2009, and 2015, consistent determinates of compliance were age at diagnosis, sex, comorbidity score, pathologic stage, site of tumor, and hospital category, whereas coordination of care and percentage with no high-school diploma were not determinates of compliance. Insurance status was a determinate of compliance in 2003 but not in 2009 and 2015, whereas both race and cancer sequence were not determinates in 2003 but were determinates in 2009 and 2015. Patient location was a determinate of measure compliance in 2009 but not in 2003 and 2015; median income was not a determinate in 2003 and 2009 but was in 2015. In general, increasing age and increasing comorbidity score were associated with lower odds of compliance. Right-sided tumors had a much higher compliance rate when compared with left-sided tumors, with an OR of 2.91 in 2015 [95% confidence interval (CI) 2.67–3.18], and for transverse colon tumors compared with left-sided, the OR was 1.12 (95% CI 1.00–1.25).

Between 2003 and 2015, on average (mean values), NCI hospitals saw 52 eligible colon cancer patients/year, academic hospitals saw 43, comprehensive community hospitals saw 36, and community hospitals saw 15. NCI hospitals had the highest compliance rates for all years assessed, followed by academic hospitals, comprehensive community hospitals, and then community hospitals. The compliance for each hospital category improved over the 13-year time period studied, and the magnitude of difference among the hospital types decreased over time, but interhospital differences remain (Fig. 1).

Risk-adjusted survival HRs are shown in Table 3, for 2003 and 2009, by variables. Cases compliant with the colon 12 node measure had better survival than cases that were non-compliant (2009 HR 0.78, 95% CI 0.74–0.81). HRs also showed better survival at NCI centers (2009 HR 0.76, 95% CI 0.68–0.86) than at academic programs (2009 HR 0.90, 95% CI 0.83–0.96), than at comprehensive community hospitals (2009 HR 0.93, 95% CI 0.88–0.99), when compared with community hospitals.

DISCUSSION

This study describes several important findings. When the quality measure requiring at least 12 regional lymph nodes to be assessed with colon cancer resections was released to all CoC programs in 2005, compliance was modest for all hospital types. In the subsequent 13 years, compliance improved considerably across all hospital types. Performance was reported back to the programs routinely. Whether the improvement was due to the CoC standard being measured and reported back to CoC-accredited programs cannot be known. However, the principle that the first step to improvement is measurement, supports the concept that audit and feedback is an important strategy. Explanations for improvement of compliance rates could include surgeons performing more complete lymphadenectomies, pathologists performing more

TABLE 1 Colon 12 node measure percentage of cases that were compliant by demographic and clinical variables for cases diagnosed in 2003, 2009, and 2015

Variable	Group	Percentage compliant (*n*)		
		2003	2009	2015
Overall	Overall	52.8 (44,923)	84.3 (40,115)	92.1 (39,834)
Age at diagnosis, years	18–59	60.4 (8993)	87.9 (9231)	93.4 (9737)
	60–69	52.9 (9575)	84.2 (9173)	92.2 (9967)
	70–79	50.9 (14,436)	83.5 (11,003)	91.8 (10,604)
	80+	49.1 (11,919)	82.1 (10,708)	90.8 (9526)
Sex	Male	51.4 (21,278)	82.9 (19,069)	91.6 (19,520)
	Female	54.0 (23,645)	85.5 (21,046)	92.5 (20,314)
Insurance status	Not insured, medicaid	57.2 (1368)	86.7 (1919)	92.7 (2596)
	Private, other government	57.1 (14,475)	86.3 (13,608)	93.0 (13,355)
	Medicare	50.0 (27,961)	82.9 (24,040)	91.5 (23,395)
	Other/unknown	59.5 (1119)	86.0 (548)	91.8 (488)
Race	White	52.5 (38,672)	84.5 (33,861)	92.2 (32,908)
	Black	53.5 (4640)	82.5 (4523)	90.7 (4736)
	Asian/Pacific Islander	57.5 (993)	84.6 (1073)	92.9 (1373)
	Other/unknown	57.3 (618)	84.7 (658)	92.5 (817)
Comorbidity score	0	53.7 (32,153)	84.9 (27,035)	92.3 (26,878)
	1	51.1 (9754)	83.5 (9428)	91.7 (8644)
	2	49.2 (2423)	82.3 (2624)	91.9 (2751)
	3+	46.0 (593)	80.9 (1028)	89.8 (1561)
Pathologic stage	I	40.9 (12,586)	76.1 (10,906)	87.1 (10,459)
	II	55.4 (17,220)	86.8 (15,152)	93.7 (14,770)
	III	59.6 (15,117)	87.9 (14,057)	93.9 (14,605)
Patient location	Metro	53.9 (36,057)	84.9 (32,215)	92.3 (32,195)
	Urban	47.2 (5804)	81.6 (5653)	91.0 (5822)
	Rural	49.5 (761)	84.6 (835)	91.5 (809)
	Other/unknown	50.7 (2301)	81.1 (1412)	90.7 (1008)
Site of tumor	Right	60.9 (22,951)	89.5 (20,861)	95.0 (20,827)
	Transverse	48.0 (4461)	79.0 (4264)	88.5 (4409)
	Left	42.4 (16,280)	78.1 (13,970)	88.6 (13,516)
	Overlapping lesion of colon and colon NOS	55.7 (1231)	84.5 (1020)	92.2 (1082)
Hospital category	Community	44.0 (5404)	79.0 (5237)	89.2 (5034)
	Comprehensive community	50.9 (20,506)	83.8 (18,298)	91.8 (19,548)
	Academic	61.9 (8104)	86.9 (7501)	93.3 (8108)
	NCI	69.0 (1866)	92.1 (1994)	95.6 (2548)
	Other/unknown	50.6 (9043)	84.3 (7085)	92.4 (4596)
Cancer sequence	Only malignant primary	53.0 (31,779)	85.0 (29,037)	92.7 (30,175)
	One of multiple malignant primaries	52.2 (13,144)	82.5 (11,078)	90.1 (9659)
Coordination of care	All treatment occurred at the reporting hospital	52.6 (39,974)	84.3 (37,342)	92.1 (39,452)
	Partial treatment occurred at the reporting hospital	54.4 (4949)	83.8 (2773)	90.6 (382)
Median income	< $38,000	50.9 (8055)	82.0 (7102)	90.5 (7017)
	$38,000–$47,999	50.1 (10,354)	83.7 (9559)	91.4 (9396)
	$48,000–$62,999	53.7 (11,507)	84.6 (10,731)	92.4 (10,631)
	$63,000+	55.2 (13,390)	86.0 (12,136)	93.1 (12,673)
	Other/unknown	52.2 (1617)	80.9 (587)	94.9 (117)
Percentage with no high-school diploma	< 7	55.7 (10,227)	86.5 (9119)	93.0 (9244)
	7–12.9	52.9 (14,458)	84.4 (13,248)	92.1 (13,006)
	13–20.9	50.9 (11,389)	83.3 (10,246)	91.3 (10,455)
	21+	51.3 (7255)	82.8 (6932)	91.7 (7041)
	Other/unknown	52.1 (1594)	81.2 (570)	97.7 (88)

NOS not otherwise specified, *NCI* National Cancer Institute

TABLE 2 Multivariate adjusted odds ratio for compliance with the colon 12 node measure by diagnosis year

Variable	Group	2003 [OR (95% CI)]	2009 [OR (95% CI)]	2015 [OR (95% CI)]
Age at diagnosis, year	18–59	1.80 (1.66–1.95)	1.87 (1.67–2.09)	1.81 (1.57–2.09)
	60–69	1.29 (1.21–1.38)	1.38 (1.26–1.51)	1.46 (1.30–1.64)
	70–79	1.16 (1.10–1.23)	1.25 (1.15–1.35)	1.31 (1.18–1.45)
	80+	Ref.	Ref.	Ref.
Sex	Male	Ref.	Ref.	Ref.
	Female	1.10 (1.05–1.14)	1.16 (1.10, 1.23)	1.10 (1.02, 1.19)
Insurance status[a]	Medicare	Ref.	Ref.	Ref.
	Private, other government	1.11 (1.05–1.19)	1.07 (0.98–1.16)	1.02 (0.91–1.14)
	Not insured, medicaid	1.15 (1.01–1.31)	1.13 (0.96–1.32)	1.00 (0.83–1.19)
	Other/unknown	1.05 (0.90–1.23)	1.17 (0.88–1.55)	0.92 (0.64–1.32)
Race[a]	White	Ref.	Ref.	Ref.
	Black	0.96 (0.89–1.03)	0.83 (0.75–0.92)	0.75 (0.66–0.85)
	Asian/Pacific Islander	1.08 (0.92–1.27)	0.96 (0.79–1.18)	0.95 (0.76–1.20)
	Other/unknown	0.98 (0.81–1.18)	0.91 (0.72–1.16)	0.94 (0.71–1.24)
Comorbidity score	0	1.36 (1.13–1.63)	1.24 (1.04–1.48)	1.38 (1.15–1.65)
	1	1.24 (1.03–1.50)	1.17 (0.98–1.40)	1.31 (1.08–1.59)
	2	1.14 (0.93–1.39)	1.10 (0.90–1.34)	1.34 (1.07–1.68)
	3+	Ref.	Ref.	Ref.
Pathologic stage	I	Ref.	Ref.	Ref.
	II	2.00 (1.90–2.10)	2.34 (2.18–2.51)	2.47 (2.25–2.71)
	III	2.25 (2.13–2.37)	2.49 (2.31–2.67)	2.44 (2.22–2.68)
Patient location[a]	Metro	1.04 (0.96–1.12)	1.14 (1.03–1.26)	1.01 (0.90–1.14)
	Urban	Ref.	Ref.	Ref.
	Rural	0.97 (0.82–1.16)	1.11 (0.89–1.39)	1.12 (0.84–1.48)
	Other/unknown	0.94 (0.78–1.13)	0.95 (0.76–1.19)	0.81 (0.61–1.06)
Site of tumor	Right	2.53 (2.42–2.65)	2.90 (2.72–3.10)	2.91 (2.67–3.18)
	Transverse	1.39 (1.29–1.50)	1.19 (1.08–1.30)	1.12 (1.00–1.25)
	Left	Ref.	Ref.	Ref.
	Overlapping lesion of colon and colon NOS	1.89 (1.66–2.16)	1.68 (1.39–2.03)	1.64 (1.29–2.08)
Hospital category	Community	Ref.	Ref.	Ref.
	Comprehensive community	1.30 (1.13–1.49)	1.30 (1.13–1.51)	1.38 (1.19–1.60)
	Academic	1.81 (1.53–2.15)	1.59 (1.32–1.90)	1.76 (1.45–2.12)
	NCI	2.50 (1.84–3.41)	2.72 (1.95–3.79)	2.68 (1.94–3.71)
	Other/unknown	1.21 (1.04–1.42)	1.26 (1.06–1.49)	1.47 (1.19–1.81)
Cancer sequence[a]	Only malignant primary	0.99 (0.94–1.04)	1.15 (1.08–1.24)	1.37 (1.26–1.50)
	One of multiple malignant primaries	Ref.	Ref.	Ref.
Coordination of care[a]	All treatment occurred at the reporting hospital	Ref.	Ref.	Ref.
	Partial treatment occurred at the reporting hospital	1.08 (1.00–1.17)	1.10 (0.96–1.25)	1.01 (0.68–1.49)
Median income[a]	< $38,000	Ref.	Ref.	Ref.
	$38,000–$47,999	0.98 (0.91–1.05)	1.09 (0.99–1.21)	1.14 (1.00–1.30)
	$48,000–$62,999	1.04 (0.96–1.13)	1.07 (0.96–1.19)	1.27 (1.10–1.46)
	$63,000+	1.02 (0.93–1.13)	1.07 (0.93–1.22)	1.34 (1.14–1.58)
	Other/unknown	1.09 (0.44–2.71)	0.59 (0.19–1.85)	0.99 (0.31–3.13)

TABLE 2 continued

Variable	Group	2003 [OR (95% CI)]	2009 [OR (95% CI)]	2015 [OR (95% CI)]
Percentage with no high-school diploma[a]	< 7	1.02 (0.92–1.12)	1.13 (0.98–1.29)	0.87 (0.73–1.03)
	7–12.9	1.02 (0.93–1.11)	1.04 (0.93–1.16)	0.85 (0.74–0.98)
	13–20.9	0.98 (0.91–1.06)	0.99 (0.89–1.09)	0.86 (0.76–0.98)
	21+	Ref.	Ref.	Ref.
	Other/unknown	0.90 (0.36–2.29)	1.84 (0.57–6.00)	3.88 (0.62–24.42)

Each diagnosis year represents an adjusted multivariate GLIMMIX model

OR odds ratio, *CI* confidence interval, *NOS* not otherwise specified, *NCI* National Cancer Institute

[a]All variables were significant each year at $p < 0.05$ unless otherwise indicated; the p values for insurance status in 2009 and 2015 were 0.2300 and 0.9373, respectively; for race in 2003 was 0.5006; for patient location in 2003 and 2015 was 0.4967 and 0.3069, respectively; for cancer sequence in 2003 was 0.7060; for coordination of care in 2003, 2009, and 2015 was 0.0667, 0.1715, and 0.9679, respectively; for median income in 2003 and 2009 was 0.4854 and 0.4138, respectively; and for percentage with no high-school diploma in 2003, 2009, and 2015 was 0.8428, 0.1924 and 0.0775, respectively

complete nodal analyses, or some combination of both. In terms of determinates of compliance, consistent determinates for diagnosis years 2003, 2009, and 2015 were age at diagnosis, sex, comorbidity score, pathologic stage, site of tumor, and hospital category. Coordination of care and percentage with no high-school diploma were not determinates. Additionally, there were differences in compliance rates by type of hospital; NCI centers had the highest compliance rates followed by academic cancer programs, comprehensive community cancer programs, and, finally, community hospitals. These differences were most pronounced in 2003, and while compliance improved over time at all hospital types, differences remained in 2015. The reasons for differences by hospital type are not known.

The second important finding is that risk-adjusted survival by hospital type followed the same trend as compliance with the 12 lymph node count measure and hospital case volume. NCI centers had the greatest average number of measure-eligible new colon cancer cases per year and their patients had the highest compliance and survival, followed by those treated at academic centers, followed by those treated at comprehensive community centers, compared with community hospitals, which had the lowest case count, survival, and compliance. At the patient-level, those compliant with the 12-node measure had better risk-adjusted survival than those who were noncompliant. It is unknown whether this relationship is causative or merely an association. It is possible that programs with higher compliance rates for the 12 lymph node measure also performed other aspects of care at higher standards than lower-performing programs. In addition, case volumes are known to be associated with outcomes in a number of circumstances, and how this relates to measure compliance and survival in this instance is unknown.

Using data from the NCDB, Shulman et al. reported differential survivals for patients with stage III breast cancer and stages IIIB/IV non-small cell lung cancer by hospital type, with findings similar to these.[15] Using Surveillance, Epidemiology, and End Results (SEER)/Medicare data and somewhat different methodology, Pfister et al. also found similar survival differentials by hospital type.[16] The data presented in this study showed, at least in the case of the 12 lymph node measure, a correlation between quality measure compliance rates and survival, with statistically higher survivals for patients treated at NCI centers compared with those treated at community hospitals.

While compliance with the 12 lymph node measure improved with time at all hospital categories, differences exist at all time points. This is concerning because, as seen in Table 1, approximately two-thirds of colon cancer patients treated at CoC programs are cared for at comprehensive community hospitals and community hospitals. Patients should expect to receive high-quality care and have an equal chance for survival regardless from which hospital or hospital type they receive treatment. It is impractical and inappropriate for all patients to be cared for in NCI centers. Patients should expect high-quality care near home, and interventions to improve quality of care in all low-performing hospitals should be investigated.

The quality measures program of the CoC now encompasses a wide array of quality measures, including, but not limited to, colon and rectum, breast, gynecologic cancers, lung, gastric, and melanoma. These quality data are reported back to programs routinely and it is required that programs address low performance with focused interventions. It will be important to assess compliance with these measures over time, and the relationship with survival.

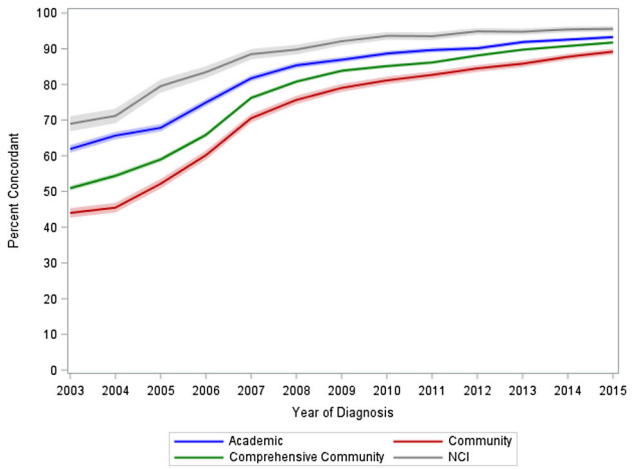

FIG. 1 Percentage of compliant cases by hospital category, with 95% CIs (cases diagnosed in 2003–2015). *NCI* National Cancer Institute

LIMITATIONS

This study included only CoC-accredited programs. It relies on the accuracy of data submitted by certified tumor registrars at these CoC-accredited programs. Although the database is prospectively maintained and regular feedback is provided to individual facilities, this is still a retrospective analysis. Attributing the improved survival to the improved compliance with the 12 lymph node quality measure is not possible and other factors may be involved. It is possible that hospitals with higher compliance rates also performed other aspects of care better.

CONCLUSIONS

Utilizing quality measures in CoC-accredited facilities is an effective tool to improve the quality of cancer care in all hospital categories, irrespective of type or size. By reporting measure compliance and holding cancer programs accountable to meet a threshold of compliance, programs must address their results on the measure. Overall, compliance with the 12 lymph node measure significantly improved from 52.8 to 92.1% in the 13-year time period studied, illustrating the effectiveness of assessing an approved quality measure to improve

TABLE 3 Adjusted survival HR for eligible cases by diagnosis year

Variable	Group	2003 [HR (95% CI)]	2009 [HR (95% CI)]
Measure compliance	Compliant	0.86 (0.84–0.88)	0.78 (0.74–0.81)
	Non-compliant	Ref.	Ref.
Age at diagnosis, years	18–59	0.21 (0.20–0.23)	0.23 (0.22–0.25)
	60–69	0.30 (0.29–0.31)	0.32 (0.31–0.34)
	70–79	0.51 (0.50–0.53)	0.47 (0.46–0.49)
	80+	Ref.	Ref.
Sex	Male	Ref.	Ref.
	Female	0.83 (0.80–0.85)	0.82 (0.79–0.85)
Insurance status	Not insured, medicaid	1.29 (1.18–1.40)	1.25 (1.15–1.37)
	Private, other government	0.81 (0.78–0.84)	0.79 (0.75–0.83)
	Medicare	Ref.	Ref.
	Other/unknown	1.05 (0.96–1.15)	0.97 (0.84–1.13)
Race	White	Ref.	Ref.
	Black	1.11 (1.06–1.17)	1.09 (1.03–1.15)
	Asian/Pacific Islander	0.82 (0.74–0.91)	0.78 (0.69–0.88)
	Other/unknown	0.91 (0.81–1.03)	0.88 (0.77–1.02)
Comorbidity score	0	0.38 (0.35–0.42)	0.43 (0.39–0.46)
	1	0.53 (0.48–0.58)	0.53 (0.49–0.58)
	2	0.72 (0.65–0.79)	0.72 (0.66–0.79)
	3+	Ref.	Ref.
Pathologic stage	I	Ref.	Ref.
	II	1.34 (1.30–1.39)	1.42 (1.36–1.48)
	III	2.01 (1.94–2.08)	2.29 (2.19–2.39)

TABLE 3 continued

Variable	Group	2003 [HR (95% CI)]	2009 [HR (95% CI)]
Patient location[a]	Metro	1.02 (0.98–1.06)	1.00 (0.95–1.05)
	Urban	Ref.	Ref.
	Rural	1.07 (0.97–1.19)	0.98 (0.87–1.10)
	Other/unknown	1.13 (1.02–1.24)	1.09 (0.97–1.22)
Site of tumor	Right	1.03 (1.00–1.06)	1.03 (1.00–1.07)
	Transverse	1.04 (1.00–1.09)	1.08 (1.02–1.14)
	Left	Ref.	Ref.
	Overlapping lesion of colon and colon NOS	1.15 (1.06–1.24)	1.18 (1.07–1.31)
Hospital category	Community	Ref.	Ref.
	Comprehensive community	0.95 (0.90–1.00)	0.93 (0.88–0.99)
	Academic	0.96 (0.90–1.02)	0.90 (0.83–0.96)
	NCI	0.82 (0.74–0.91)	0.76 (0.68–0.86)
	Other/unknown	1.01 (0.95–1.07)	0.99 (0.93–1.07)
Cancer sequence	Only malignant primary	0.79 (0.77–0.82)	0.76 (0.73–0.79)
	One of multiple malignant primaries	Ref.	Ref.
Coordination of care	All treatment occurred at the reporting hospital	Ref.	Ref.
	Partial treatment occurred at the reporting hospital	0.73 (0.69–0.76)	0.75 (0.70–0.81)
Median income	< $38,000	Ref.	Ref.
	$38,000–$47,999	0.96 (0.92–1.01)	0.99 (0.94–1.05)
	$48,000–$62,999	0.95 (0.91–1.00)	0.91 (0.86–0.97)
	$63,000+	0.92 (0.87–0.97)	0.89 (0.83–0.95)
	Other/unknown	1.18 (0.66–2.13)	1.34 (0.72–2.50)
Percentage with no high-school diploma	< 7	0.92 (0.87–0.97)	0.93 (0.87–1.00)
	7–12.9	0.97 (0.93–1.02)	0.99 (0.94–1.05)
	13–20.9	0.98 (0.94–1.03)	1.02 (0.97–1.08)
	21+	Ref.	Ref.
	Other/unknown	1.06 (0.58–1.93)	1.75 (0.93–3.32)

Each diagnosis year represents an adjusted Cox proportional hazards regression fixed and random effects shared frailty model

HR hazard ratio, *CI* confidence interval, *NOS* not otherwise specified, *NCI* National Cancer Institute

[a]All variables were significant each year at $p < 0.05$ unless otherwise indicated; p values for patient location in 2003 and 2009 were 0.0509 and 0.4076, respectively

performance. Compliance rates by hospital category differed significantly, as did patient survival, but hospitals in all categories improved over time. Continual investigation into programmatic differences that might account for compliance and survival differences will be important.

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