Lymph Node Evaluation for Colon Cancer in an Era of Quality Guidelines: Who Improves?

By Helen M. Parsons, PhD, MPH, James W. Begun, PhD, Karen M. Kuntz, ScD, Todd M. Tuttle, MD, Patricia M. McGovern, PhD, and Beth A. Virnig, PhD

University of Texas Health Science Center at San Antonio, San Antonio, TX; University of Minnesota; and Masonic Cancer Center, Minneapolis, MN

Abstract

Introduction: In the 1990s, several organizations began recommending evaluation of > 12 lymph nodes during colon resection because of its association with improved survival. We examined practice implications of multispecialty quality guidelines over the past 20 years recommending evaluation of ≥ 12 lymph nodes during colon resection for adequate staging.

Materials and Methods: We used the 1988 to 2009 Surveillance, Epidemiology, and End Results program to conduct a retrospective observational cohort study of 90,203 surgically treated patients with colon cancer. We used Cochran-Armitage tests to examine trends in lymph node examination over time and multivariate logistic regression to identify patient characteristics associated with guideline-recommended lymph node evaluation.

Results: The introduction of practice guidelines was associated with gradual increases in guideline-recommended

lymph node evaluation. From 1988 to 1990, 34% of patients had > 12 lymph nodes evaluated, increasing to 38% in 1994 to 1996 and to > 75% from 2006 to 2009. Younger, white patients and those with more-extensive bowel penetration (T3/4 nonmetastatic) and high tumor grade saw more-rapid increases in lymph node evaluation ($P < .001$). Multivariate analyses demonstrated a significant interaction between year of diagnosis and both T stage and grade, indicating that those with higher T stage and higher grade were more likely to receive guideline-recommended care earlier.

Conclusion: The implementation of lymph node evaluation guidelines was accepted gradually into practice but adopted more quickly among higher risk patients. By identifying patients who are least likely to receive guideline-recommended care, these findings present a starting point for promoting targeted improvements in cancer care and further understanding underlying contributors to these disparities.

Introduction

Several studies have identified an association between more-extensive lymph node evaluation and improved survival in surgically treated patients with colon cancer.^{1,2} As a result, several practice organizations and consensus panels now recommend the multidisciplinary evaluation of ≥ 12 lymph nodes as a quality indicator for appropriate staging of patients with colon cancer.³⁻⁸ The first recommendation was issued by the Working Party Report to the World Congress of Gastroenterology in 1990. Subsequently, several organizations, including the American Society for Clinical Oncology, the American College of Surgeons, and a National Cancer Institute consensus panel, issued benchmarks, which call for no fewer than 12 nodes for quality surveillance (Appendix Table A1, online only). However, although these guidelines published a consistent message over the past 20 years, their greatest variation was the target audience.

Historically, innovation has spread through different groups at varying rates, reflected first in practitioners with access to specialized knowledge and resources.⁹⁻¹¹ When published, guidelines may initially alert clinicians about practice innovations, but questions may often arise about the necessity or appropriateness of applying these guidelines. This is particularly true when the published lymph node guidelines apply equally to all patients, regardless of their risk for lymph node positiv-

ity.^{3,4,7,12} In this respect, studies suggest that clinicians often deal with uncertainty by seeking information and opinions from peers in their networks.¹³ However, with the publication of the guidelines, opinion leaders themselves began questioning the validity of lymph node evaluation target because of uncertainty surrounding the mechanism behind lymph node evaluation and improved survival.^{1,2,14-16} To date, no study has systematically evaluated at a population level whether, after guideline release, rates of lymph node evaluation increased.

The purpose of our study was to evaluate how lymph node evaluation changed in an era of quality guidelines and identify which patients experienced guideline-recommended care first. We examined trends over time in the number of lymph nodes examined across patient tumor and demographic characteristics.

Materials and Methods

Data

For this study, we used the 1988 to 2009 Surveillance, Epidemiology, and End Results (SEER 9 registries) cancer registry data. Sponsored by the National Cancer Institute, SEER currently collects and publishes cancer incidence, treatment, and survival data from population-based cancer registries. The SEER 9 registries were used because they consistently collected

data on cancer incidence in representative geographic areas throughout the United States during the study period, covering approximately 14% of the US population. Variables include patient and tumor characteristics, staging information, and first course of treatment (including surgery and radiation therapy). SEER collects information on patient age, race, sex, year of diagnosis, tumor registry, and number of lymph nodes evaluated. Tumor characteristics include size, T stage (ie, depth of bowel penetration), histologic grade, histologic type, and presence of metastasis.

Patients

Included in our study were patients age > 18 years who were diagnosed with their first invasive adenocarcinoma of the colon from January 1, 1988, through December 31, 2009. We included only patients who underwent radical resection of their colon cancer as the first course of treatment according to SEER and, therefore, were eligible for nodal evaluation. Excluded from our study were patients whose cancer was diagnosed by autopsy or first cited on the death certificate ($n = 124$), patients who underwent preoperative irradiation ($n = 224$),¹⁷ and patients with an unknown number of nodes evaluated ($n = 3,531$). Our final study population included 90,203 surgically treated patients with colon cancer.

Assessment of Lymph Node Evaluation

SEER has recorded the number of nodes pathologically examined for each patient since 1988. Using this information, we categorized patients according to their receipt (yes or no) of guideline-recommended lymph node evaluation (at least 12 nodes evaluated).

Statistical Analyses

For our analyses, we evaluated differences in nodal evaluation across patient characteristics based on their year of diagnosis, which we categorized into seven groups: 1988 to 1990, 1991 to 1993, 1994 to 1996, 1997 to 1999, 2000 to 2002, 2003 to 2005, and 2006 to 2009. First, we used the Cochran-Armitage test to evaluate unadjusted trends over time in the proportion of patients receiving guideline-recommended lymph node evaluation. Analyses were stratified by patient demographic, tumor, and stage characteristics to identify whether there were differential trends in lymph node evaluation across patient subgroups. After assessing this unadjusted relationship, we used logistic regression to examine the association between patient characteristics and receipt of guideline-recommended lymph node evaluation over time (yes or no). Each model was adjusted for patient age at diagnosis, race, sex, T stage, tumor grade, years of diagnosis and SEER registry, metastatic disease, and type of surgery. We then tested for interactions between year of diagnosis and patient characteristics to identify whether the impact of demographic or tumor factors on guideline-recommended lymph node evaluation changed over time. Because American Joint Committee on Cancer staging classifications have changed over time,¹⁸ we focused on T stage as our staging indicator to provide information on how lymph node evalua-

tion changed among patients with similar a extent of bowel wall penetration.

In all models, we performed several sensitivity analyses (eg, alternative category groupings, removal of nonsignificant factors, interaction analyses) to ensure that the observed effects were not an artifact of our modeling decisions. We used SAS software (version 9.2; SAS Institute, Cary, NC) for all analyses. P values $\leq .05$ were considered statistically significant. This study was approved by the University of Minnesota Institutional Review Board.

Results

We identified 90,203 patients diagnosed with invasive colon cancer between 1988 and 2009 in the SEER 9 program. The majority of patients were women (53.0%), white (81.3%), and diagnosed after age 70 years (53.8%; Appendix Table A2, online only). These patients were most predominately diagnosed with low-grade (grade 1 or 2, 75.6%), T-stage 3 (52.1%), and proximal (59.3%) tumors. Over the 20-year study period, the number of surgically treated patient cases of colon cancer included in our study remained relatively stable over time, ranging between approximately 3,000 and 4,000 per year.

Changes in Lymph Node Evaluation Across Patient and Tumor Characteristics

Guideline-recommended lymph node evaluation for colon cancer increased significantly from 1990 to 2009, but it increased more rapidly among patients at higher risk for node positivity (Fig 1). Directly after the first guideline publication in 1990, recommended evaluation remained relatively stable, with only a 5% increase in guideline-recommended care compared with the period before the first guideline release (36% v 34%, respectively; Appendix Table A2). By 1994 to 1996, 38% of patients had > 12 lymph nodes evaluated. Although the percentage of patient cases with guideline-recommended lymph node evaluation exceeded 75% in 2006 to 2009, it is important to note that the majority ($> 50\%$) of surgically treated patients with colon cancer did not receive guideline-recommended evaluation until > 10 years after the first published recommendation (Appendix Table A2). Furthermore, from 2006 to 2009, approximately 25% of surgically treated patients were still not receiving guideline-recommended lymph node evaluation.

Overall, the increase in guideline-recommended lymph node evaluation was implemented differentially across patient groups (Appendix Table A2). Younger patients, those with high-grade (3 or 4) disease, and those with T stage of 2 to 3 saw more rapid increases in guideline-recommended lymph node evaluation after the guidelines were published. Notably, a majority of patients with T-stage 3 disease and T4/nonmetastatic tumors were receiving guideline-recommended lymph node evaluation within 10 years of the first published guideline, whereas $> 40\%$ of patients with T1 tumors still had < 12 nodes evaluated in 2006 to 2007—almost 20 years after the first guidelines were released (Fig 1). Although less pronounced, 27% of patients with T4/metastatic tumors were not receiving

Figure 1. Percentage of patients receiving guideline-recommended lymph node evaluation by year and T stage. AJCC, American Joint Committee on Cancer; ASCO, American Society of Clinical Oncology; ASCRS, American Society of Colon and Rectal Surgeons; CAP, College of American Pathologists; COC, Commission on Cancer; NCI, National Cancer Institute; NCCN, National Comprehensive Cancer Network; NQF, National Quality Forum; UICC, Union for International Cancer Control.

recommended evaluation in 2006 to 2009. Similarly, a majority of patients with high-grade (3 or 4) tumors were receiving guideline-recommended evaluation by 2000 to 2002, whereas patients with low-grade tumors were not evaluated at this level until 2003 to 2005 (Appendix Table A2).

Although lymph node evaluation was similar between sexes, patients experienced differential evaluation by age at diagnosis as well as race. Whereas the majority of patients diagnosed at age < 50 years experienced guideline-recommended evaluation within 1 year of the first published guideline, those age ≥ 80 years did not experience this level of guideline-recommended evaluation until 2003. However, even in 2006, older patients were experiencing lower levels of guideline-recommended lymph node evaluation (Appendix Table A2). Interestingly, trends by race did not reveal the typical white advantage. At the time the first guidelines were published, white patients received lower levels of guideline-recommended evaluation compared with blacks. By 2006 to 2009, however, this trend had reversed. Finally, patients with more-extensive resection were more likely to receive recommended evaluation. Overall, these patterns across demographic and clinical characteristics indicate that increases in lymph node evaluation were not linked to the release of a specific lymph node evaluation guideline published over the past 20 years (Appendix Table A1 lists dates of publication).

Association Between Patient Characteristics and Guideline-Recommended Lymph Node Evaluation

Appendix Table A3 (online only) summarizes the association between patient demographic and treatment characteristics and receipt of guideline-recommended evaluation (yes *v* no) in each

time period. Examining each individual multivariate analysis, we demonstrate that after adjusting for patient factors, younger age, higher T stage and grade, nonmetastatic disease, and more-extensive resection were all associated with earlier receipt of guideline-recommended lymph node evaluation (ie, these patients were more likely to have ≥ 12 nodes evaluated in the earliest time periods). Our analyses identified a significant interaction between year of diagnosis and both T stage and grade, indicating that those with higher T stage and grade—both signs of tumor aggressiveness—were more likely to have guideline-recommended staging earlier, yet remained more likely to receive this care at all points in time. As a result, we present patient demographic and tumor factors associated with guideline-recommended lymph node evaluation stratified by year of diagnosis (Appendix Table A3).

Across all years, increasing age at diagnosis was inversely associated with guideline-recommended lymph node evaluation. Additionally, patients diagnosed with distal tumors were significantly less likely to receive guideline-compliant care. This pattern remained consistent over time, suggesting no lessening of the relative pattern (distal *v* proximal colon: odds ratio [OR], 0.61; 95% CI, 0.55 to 0.68 in 1991 to 1993 and OR, 0.64; 95% CI, 0.58 to 0.69 in 2006 to 2009). However, the association between T stage and receipt of guideline-consistent lymph node evaluation increased in magnitude directly after the first published guideline. After this publication, patients with higher T-stage tumors, particularly T3 tumors, were more likely to receive guideline-recommended care. By 2006 to 2009, however, patients with T2, T3, and T4 tumors received similar levels of guideline-recommended care relative to those with T1 tumors. Additionally, although patients diagnosed with higher-grade tumors (3 or 4) were significantly more likely to have guideline-recommended lymph node evaluation by the end of the study period, this effect did not appear immediately after the first guideline was published; rather, it was observed beginning in 1997 to 1999 (grade 3 or 4 *v* 1 or 2: OR, 1.15; 95% CI, 1.06 to 1.27).

Discussion

Among surgically treated patients with colon cancer from 1988 to 2009 in the SEER program, we found significant increases in guideline-recommended lymph node evaluation during the past 20 years, particularly among patients with high risk (eg, high grade and T-stage 3 or 4 nonmetastatic disease) of being node positive. However, this improvement in guideline-recommended staging over the past two decades seemed to increase gradually over time, with adherence increasing in the later years of our study (Fig 1), potentially as a result of more-intense media and peer-reviewed coverage of this topic beginning in the late 1990s. In addition, despite the release of > nine different recommendations, the rate of guideline-compliant lymph node evaluation is still low, with 25% of patients not receiving guideline-compliant care. This is important when considered in light of our study inclusion criteria, requiring participants to undergo radical resection, necessarily falling under guideline recommendations for evaluation. By identifying those patients

who are least likely to receive guideline-recommended care, these findings present a starting point for promoting targeted improvements in cancer care and further understanding underlying contributors to these disparities.

Overall, our results are consistent with those of prior studies indicating that younger age,^{19,20} more-advanced tumor depth²⁰⁻²² and high tumor grade,²⁰ and surgical technique are important predictors of more-extensive lymph node evaluation. We additionally found that factors associated with guideline-recommended lymph node evaluation at each time point were also associated with earlier increases in lymph node evaluation over time. This points toward the possibility that providers may more carefully stage patients who they believe are at higher risk for node-positive disease than those believed to be at lower risk of having node-positive disease. Furthermore, our study identifies that surgical technique plays a role in the number of lymph nodes that are subsequently evaluated. Of note, however, whereas T3 and T4 nonmetastatic tumors were both more likely to undergo guideline-recommended evaluation over time, > 27% of patients with T4 metastatic tumors were still not receiving recommended evaluation in 2006 to 2009, potentially because the presence of metastatic disease would not change treatment or staging criteria regardless of nodal status. However, because 12 lymph nodes is not an onerous threshold for evaluation, and relatively little would be lost in adequately staging all patients, it is surprising that more patients did not receive guideline-compliant staging. Because the guideline applies equally to all patients with surgically resected colon cancer, this finding may provide better understanding of how guidelines are used and point toward opportunities to improve the quality of staging.

Clinical practice guidelines for lymph node evaluation were developed based on the findings of several single- and multi-institution studies identifying an association between increased lymph node evaluation and improved survival after surgical resection for colon cancer.^{1,23-25} However, these studies varied widely in the minimum number of nodes they concluded would accurately determine nodal status, ranging from $\geq$ six to > 20 nodes. As these studies were published, several multidisciplinary practice groups and consensus panels convened to publish clinical practice guidelines. The resulting recommendations varied in timing of publication and intended audience but were generally consistent in their threshold for adequate nodal evaluation. Because surgeons and pathologists vary in their roles for evaluating nodal status, the publication of these guidelines in different sets of literature presents important implications for how the information was disseminated and incorporated into practice. Although some guidelines were published in the surgical literature, the audience of which is responsible for removing tissue containing lymph nodes, others were published in pathology journals, the membership of which focuses on identifying and determining lymph node positivity. Holding the multidisciplinary team accountable for knowledge and use of these recommendations, while highlighting the interweaving roles between the pathologists and surgeons in achieving these guidelines, will be important as future updates are

considered. Specifically, future guidelines should capture the multidisciplinary approach to attaining this guideline, which can vary for a variety of factors ranging from surgical technique to the rigor of gross dissection of the specimen.

Previous research has acknowledged that guidelines are released into complex social systems.^{10,26} Clinicians are busy professionals who have social preferences and biases about what constitutes appropriate care. These individuals are often forced to balance multiple and often conflicting pressures from administrators, colleagues, and patients to provide specific services and care. Social and financial pressures may be coupled with incentives, monetary or otherwise, that may not be aligned with the recommended practices. Specifically, Medicare and other payers have discussed or implemented lymph node evaluation standards as a quality measure for pay-for-performance initiatives.^{27,28} Additionally, these clinicians work within unique practice settings, with varying levels of competition for patients and access to resources. In that context, one might expect that clinicians would first apply new guidelines to those patients perceived to be the highest-risk cases and, over time, apply them slowly and variably to others. For example, proximal tumors, advanced age, and more-extensive tumor penetration are all associated with worse prognosis, and such patients may be targeted by the multidisciplinary team for more-extensive evaluation. Additionally, the introduction of these practice guidelines over the past 20 years has been coupled with vast changes in how individuals access information, including the growth of the Internet and online resources for clinicians. In 1988, it would have been difficult for those not closely related to academic centers to have easy access to guideline information. However, online resources through the American Society for Clinical Oncology, the National Comprehensive Cancer Network, and other organizations make this information much more accessible. Additionally, today, many hospitals and cancer centers have colorectal cancer tumor boards, which serve as forums to implement and increase guideline adherence for all involved in the treatment of these patients.

Although our study provides insight into the adoption of clinical practice guidelines, we acknowledge several data-related limitations. First, SEER does not collect information on comorbidities that may limit a surgeon's ability to remove an adequate number of lymph nodes. However, these patients were seen as healthy enough to undergo surgical resection for treatment of their colon cancer. Additionally, we are unable to determine the reason behind the level of lymph node evaluation for an individual patient with cancer. Third, because our study population was predominately white, future studies should examine how the practice implications of guidelines vary in practice settings that include predominately nonwhite populations. Finally, we were unable to identify the surgeon, pathologist, or patient as the contributing factor associated with the level of lymph node evaluation. However, we do not believe that any of these limitations would challenge our population-based analysis, which underscores the role of both demographic and clinical factors associated with the adoption of clinical guidelines in patients with colon cancer in the United States.

In conclusion, our population-based analysis of surgically treated patients with colon cancer identified differential adoption of clinical practice guidelines across patient tumor and demographic characteristics. Although we do not know the reasons for adherence, differences in physician beliefs about what constitutes good quality staging may have influenced decisions about which patients would most benefit from comprehensive evaluation. Absent change in the guidelines, reminders that the guidelines are intended to apply equally to all patients regardless of their risk for node positivity will be important as strategies for effective guideline development and dissemination are considered. In addition, future work should explore whether the experience with guideline adherence in colon cancer is replicated in other malignancies. Finally, accounting for the different roles surgeons, pathologists, and hospitals play in attaining this clinical practice guideline is crucial for setting priorities and aligning goals in future quality guidelines. Overall, our findings identify those patients least likely to receive guideline-recommended care, promoting discussion about the further understanding of the underlying contributors to disparities in guideline-recommended care.

References

1. Chang GJ, Bigas MA, Skibber JM, et al: Lymph node evaluation and survival after curative resection of colon cancer: Systematic review. *J Natl Cancer Inst* 99:433-441, 2007
2. Wong SL, Ji H, Hollenbeck BK, et al: Hospital and lymph node examination rates and survival after resection for colon cancer. *JAMA* 298:2149-2154, 2007
3. Fielding LP, Arsenault PA, Chapuis PH, et al: Clinicopathological staging for colorectal cancer: An International Documentation System (IDS) and an International Comprehensive Anatomical Terminology (ICAT). *J Gastroenterol Hepatol* 6:325-344, 1991
4. Fleming ID, Cooper JS, Henson DE, et al (eds): *AJCC Cancer Staging Manual* (ed 5). Philadelphia, PA, Lippincott, 1997
5. Sobin LH, Wittekind C (eds): *TNM Classification of Malignant Tumors* (ed 5). New York, NY, Wiley, 1997
6. Compton CC, Fielding LP, Burgart LJ, et al: Prognostic factors in colorectal cancer: College of American Pathologists consensus statement. *Arch Pathol Lab Med* 124:979-994, 2000
7. Nelson H, Petrelli N, Carlin A, et al: Guidelines 2000 for colon and rectal cancer surgery. *J Natl Cancer Inst* 93:583-596, 2001
8. Otchy D, Hyman NH, Simmam C, et al: Practice parameters for colon cancer. *Dis Colon Rectum* 47:1269-1284, 2004
9. Rogers EM: *Diffusion of Innovations*. New York, NY, Free Press, 1983
10. Rogers EM: Lessons for guidelines from the Diffusion of Innovations Joint Commission. *J Qual Improvement* 21:324-328, 1995
11. Jerome-D'Emilia B, Begun JW: Diffusion of breast conserving surgery in medical communities. *Soc Sci Med* 60:143-151, 2005
12. Desch CE, McNiff KK, Schneider EC, et al: American Society of Clinical Oncology/National Comprehensive Cancer Network quality measures. *J Clin Oncol* 26:3631-3637, 2008
13. Mittman BS, Tonesk X, Jacobson PD: Implementing clinical practice guidelines: Social influence strategies and practitioner behavior change. *Qual Rev Bull* 18:413-422, 1992
14. Baxter NA: Is lymph node count an ideal quality indicator for cancer care? *J Surg Oncol* 99:265-268, 2009
15. Simunovic M, Baxter NB: Lymph node counts in colon cancer surgery: Lessons for users of quality indicators. *JAMA* 298:2194-2196, 2007

Authors' Disclosures of Potential Conflicts of Interest

The authors indicated no potential conflicts of interest.

Author Contributions

Conception and design: All authors

Financial support: Beth A. Virnig

Administrative support: Helen M. Parsons

Provision of study materials or patients: Helen M. Parsons, Beth Virnig

Collection and assembly of data: Helen M. Parsons

Data analysis and interpretation: Helen M. Parsons, James W. Begun, Karen M. Kuntz, Patricia M. McGovern, Beth A. Virnig

Manuscript writing: All authors

Final approval of manuscript: All authors

Corresponding author: Helen M. Parsons, PhD, MPH, Department of Epidemiology and Biostatistics, The University of Texas Health Science Center at San Antonio, 7703 Floyd Curl Dr, Mail Code 7933, San Antonio, TX 78229-3900; e-mail: parsonsh@uthscsa.edu.

DOI: 10.1200/JOP.2012.000812; published online ahead of print at jop.ascopubs.org on March 19, 2013.

16. Parsons HM, Tuttle TM, Kuntz KM, et al: Association between lymph node evaluation for colon cancer and node positivity over the past 20 years. *JAMA* 306:1089-1097, 2011
17. Baxter NN, Morris AM, Rothenberger DA, et al: Impact of preoperative radiation for rectal cancer on subsequent lymph node evaluation: A population-based analysis. *Int J Radiat Oncol Biol Phys* 61:426-431, 2005
18. Understanding the changes from the sixth to the seventh edition of the AJCC Cancer Staging Manual 2010. <http://www.cancerstaging.org/staging/changes2010.pdf>
19. Ostadi MA, Harnish JL, Steglenko S, et al: Factors affecting the number of lymph nodes retrieved in colorectal cancer specimens. *Surg Endosc* 21:2142-2146, 2007
20. Baxter NN, Virnig DJ, Rothenberger DA, et al: Lymph node evaluation in colorectal cancer patients: A population-based study. *J Natl Cancer Inst* 97:219-225, 2005
21. Cserni G: Lymph node harvest reporting in patients with carcinoma of the large bowel: A French population-based study. *Cancer* 85:243-245, 1999
22. Herrera-Ornelas L, Justiniano J, Castillo N, et al: Metastases in small lymph nodes from colon cancer. *Arch Surg* 122:1253-1256, 1987
23. Bui L, Rempel E, Reeson D, et al: Lymph node counts, rates of positive lymph nodes, and patient survival for colon cancer surgery in Ontario, Canada: A population-based study. *J Surg Oncol* 93:439-445, 2006
24. Chen SL, Bilchik AJ: More extensive nodal dissection improves survival for stages I to III of colon cancer: A population-based study. *Ann Surg* 244:602-610, 2006
25. Le Voyer TE, Sigurdson ER, Hanlon AL, et al: Colon cancer survival is associated with increasing number of lymph nodes analyzed: A secondary survey of intergroup trial INT-0089. *J Clin Oncol* 24:846-857, 2007
26. Hay MC, Weisner TS, Subramanian S, et al: Harnessing experience: Exploring the gap between evidence-based medicine and clinical practice. *J Eval Clin Pract* 14:707-713, 2008
27. Health Care Financing Administration: Medicare Coverage of Colorectal Cancer Screening: Program Memoranda to Intermediaries/Carriers. Baltimore, MD, Health Care Financing Administration, 1997
28. Bilimoria KY, Stewart AK, Edge SB: Lymph node evaluation as a colon cancer quality measure: A national hospital report card. *J Natl Cancer Inst* 100:1310-1317, 2008

Appendix

Table A1. Lymph Node Evaluation Guidelines for Colon Cancer

Year	Organization	Recommendation
1990	Working Party Report to the World Congresses of Gastroenterology	≥ 12 nodes
1997	American Joint Committee on Cancer	≥ 12 nodes
1997	Union for International Cancer Control	≥ 12 nodes
1999	College of American Pathologists	12-15 nodes
2000	National Cancer Institute Panel of Experts	≥ 12 nodes
2004	American College of Surgeons Commission on Cancer	≥ 12 nodes
2004	American Society of Colon and Rectal Surgeons	≥ 15 nodes
2007	National Comprehensive Cancer Network and the American Society of Clinical Oncology	≥ 12 nodes
2007	National Quality Forum	≥ 12 nodes

Table A2. Percentage of Patients With Guideline-Recommended Lymph Node Evaluation Over Time Across Demographic and Tumor Characteristics (N = 90,203)

Characteristic	Total No.	1988-1990		1991-1993		1994-1996		1997-1999		2000-2002		2003-2005		2006-2009		P
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
No. of patients	90,203	11,152		11,458		11,425		12,458		13,070		13,002		17,638		
Overall		3,854	34.6	4,165	36.4	4,332	37.9	5,225	41.9	6,107	46.7	7,199	55.4	13,358	75.7	< .001
Age at diagnosis, years																
< 50	7,392	339	48.0	419	50.1	426	50.4	571	54.9	646	58.2	816	67.6	1,349	82.4	< .001
50-59	13,226	489	37.9	528	39.9	601	41.1	717	43.1	932	48.6	1,326	58.6	2,586	78.3	< .001
60-69	21,032	981	33.8	993	35.6	1,038	38.7	1,148	41.6	1,372	47.5	1,518	53.6	3,132	75.0	< .001
70-79	26,933	1,227	33.9	1,327	35.4	1,334	36.5	1,569	40.0	1,755	44.6	1,904	53.2	3,324	74.4	< .001
≥ 80	21,620	818	31.0	898	32.7	933	33.6	1,220	39.8	1,402	43.6	1,635	52.4	2,967	73.2	< .001
Race																
White	73,344	3,247	33.9	3,418	35.5	3,544	37.3	4,200	41.1	4,849	46.4	5,663	55.3	10,455	76.2	< .001
Black	8,987	318	34.0	407	38.5	410	39.5	523	44.5	629	47.0	814	57.1	1,479	73.4	< .001
Other	7,872	289	44.3	340	43.9	378	43.0	502	47.5	629	49.0	722	54.3	1,424	75.2	< .001
Sex																
Male	42,351	1,775	33.5	1,878	35.4	1,930	36.8	2,372	40.6	2,853	46.4	3,313	54.0	6,228	74.4	< .001
Female	47,852	2,079	35.5	2,287	37.2	2,402	38.9	2,853	43.2	3,254	47.0	3,886	56.6	7,130	76.9	< .001
AJCC stage																
1	18,608	398	22.3	481	23.9	519	25.5	700	28.6	1,027	35.9	1,334	43.4	2,874	65.5	< .001
2	30,558	1,586	38.0	1,678	39.8	1,672	40.8	1,936	45.0	2,074	48.8	2,429	59.8	4,324	79.8	< .001
3	26,278	1,253	40.6	1,411	43.9	1,530	45.7	1,809	49.9	2,108	54.1	2,399	62.0	4,283	81.7	< .001
4	14,759	617	29.2	595	29.6	611	31.4	780	37.5	882	43.5	1,037	51.9	1,877	72.7	< .001
T stage																
1	10,289	165	17.2	176	16.9	179	17.7	282	22.4	441	27.8	693	38.4	1,505	57.5	< .001
2	11,345	312	29.3	383	30.5	443	33.5	552	35.4	769	44.1	922	50.8	1,963	75.9	< .001
3	46,959	2,237	40.3	2,408	42.4	2,527	43.7	3,034	48.3	3,380	52.2	4,349	61.1	8,047	80.0	< .001
4	21,610	1,140	32.0	1,198	34.4	1,183	35.8	1,357	40.5	1,517	46.5	1,235	54.5	1,840	77.5	< .001
Metastatic disease																
Yes (M1)	14,613	606	29.1	584	29.4	598	31.2	766	37.4	866	43.3	1,034	51.9	1,877	72.7	< .001
No (M0)	75,590	3,248	35.8	3,581	37.8	3,734	39.3	4,459	42.8	5,241	47.3	6,165	56.0	11,481	76.3	< .001
Tumor grade																
1 or 2	68,199	2,835	34.8	3,119	36.1	3,249	37.7	3,908	41.2	4,558	45.8	5,357	54.5	10,169	75.1	< .001
3 or 4	18,092	772	39.7	895	40.1	978	41.6	1,234	47.8	1,422	52.4	1,668	60.8	2,835	80.4	< .001
Unknown	3,912	247	23.3	151	25.4	105	22.8	83	21.8	127	31.3	174	40.5	354	61.1	< .001
Tumor location																
Proximal	53,484	2,541	41.2	2,809	43.1	2,996	45.0	3,557	48.4	4,186	52.9	4,819	61.3	8,837	80.5	< .001
Distal	35,460	1,267	26.1	1,299	27.2	1,280	27.8	1,580	32.3	1,812	36.5	2,265	45.8	4,329	67.6	< .001
Other	1,259	46	35.4	57	36.3	56	34.6	68	40.7	109	55.6	115	59.3	192	75.9	< .001
SEER type of surgical resection																
Partial colectomy	37,874	1,263	25.4	1,310	27.6	1,281	27.7	1,753	32.4	1,874	36.0	2,513	45.8	5,046	67.9	< .001
Subtotal colectomy/hemicolectomy	47,317	2,245	43.6	2,531	44.1	2,698	46.1	3,140	49.7	3,915	53.8	4,482	62.3	7,961	81.5	< .001
Colectomy/coloproctectomy with en bloc resection of other organs	3,364	267	33.1	251	33.0	265	36.8	225	42.5	195	53.3	52	55.3	65	74.7	< .001
Other (total colectomy, total proctocolectomy, colectomy, NOS)	1,648	79	35.3	73	36.5	88	38.3	107	54.3	123	58.0	152	66.1	286	80.6	< .001

Abbreviation: AJCC, American Joint Commission on Cancer; NOS, not otherwise specified; SEER, Surveillance, Epidemiology, and End Results.

Table A3. Multivariate Logistic Regression Assessing the Association Between Patient Demographic and Treatment Characteristics and Receipt of Guideline-Recommended Lymph Node Evaluation (≥ 12) by Year of Diagnosis (yes v no) (N = 90,203)

Characteristic	1988-1990 (n = 11,152)		1991-1993 (n = 11,458)		1994-1996 (n = 11,425)		1997-1999 (n = 12,458)		2000-2002 (n = 13,070)		2003-2005 (n = 13,002)		2006-2009 (n = 17,638)	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age at diagnosis, years														
< 50		Ref		Ref		Ref		Ref		Ref		Ref		Ref
50-59	0.71	0.56 to 0.86	0.70	0.58 to 0.84	0.67	0.56 to 0.80	0.63	0.53 to 0.74	0.67	0.58 to 0.79	0.70	0.60 to 0.81	0.81	0.69 to 0.95
60-69	0.56	0.47 to 0.67	0.54	0.46 to 0.64	0.59	0.50 to 0.69	0.56	0.48 to 0.65	0.61	0.53 to 0.71	0.53	0.46 to 0.62	0.60	0.52 to 0.70
70-79	0.52	0.44 to 0.61	0.50	0.43 to 0.59	0.49	0.42 to 0.57	0.48	0.42 to 0.56	0.50	0.43 to 0.58	0.47	0.41 to 0.55	0.51	0.44 to 0.60
≥ 80	0.40	0.33 to 0.48	0.40	0.34 to 0.48	0.39	0.33 to 0.46	0.43	0.37 to 0.50	0.43	0.37 to 0.50	0.40	0.35 to 0.47	0.41	0.35 to 0.48
Sex														
Male		Ref		Ref		Ref		Ref		Ref		Ref		Ref
Female	1.06	0.97 to 1.15	1.08	0.98 to 1.16	1.09	1.01 to 1.18	1.08	1.00 to 1.16	1.02	0.95 to 1.10	1.12	1.04 to 1.21	1.14	1.05 to 1.22
Race														
White		Ref		Ref		Ref		Ref		Ref		Ref		Ref
Black	1.00	0.86 to 1.17	1.08	0.94 to 1.25	1.02	0.88 to 1.17	1.01	0.88 to 1.16	0.90	0.79 to 1.02	1.03	0.90 to 1.17	0.75	0.66 to 0.85
Other	1.04	0.83 to 1.31	1.03	0.84 to 1.27	0.99	0.82 to 1.19	1.18	1.00 to 1.42	1.00	0.87 to 1.18	0.80	0.68 to 0.92	0.92	0.80 to 1.05
T stage														
1		Ref		Ref		Ref		Ref		Ref		Ref		Ref
2	1.71	1.37 to 2.14	1.86	1.51 to 2.29	1.99	1.62 to 2.45	1.59	1.34 to 1.90	1.87	1.61 to 2.19	1.61	1.40 to 1.86	2.29	2.03 to 2.60
3	2.59	2.16 to 3.11	3.02	2.53 to 3.61	3.02	2.53 to 3.61	2.63	2.27 to 3.06	2.57	2.27 to 2.92	2.47	2.19 to 2.77	3.07	2.78 to 3.39
4	2.22	1.79 to 2.73	2.94	2.40 to 3.59	2.72	2.22 to 3.33	2.31	1.93 to 2.77	2.32	1.97 to 2.74	1.99	1.72 to 2.31	2.76	2.40 to 3.17
Metastatic disease														
Yes (M1)		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.
No (M0)	1.45	1.25 to 1.68	1.77	1.53 to 2.05	1.61	1.39 to 1.87	1.41	1.22 to 1.63	1.38	1.19 to 1.59	1.43	1.28 to 1.60	1.69	1.51 to 1.87
Tumor grade														
1 or 2		Ref		Ref		Ref		Ref		Ref		Ref		Ref
3 or 4	1.09	0.99 to 1.22	1.08	0.97 to 1.19	1.04	0.94 to 1.14	1.15	1.06 to 1.27	1.13	1.03 to 1.24	1.18	1.08 to 1.30	1.14	1.03 to 1.26
Unknown	0.62	0.53 to 0.73	0.72	0.58 to 0.88	0.70	0.56 to 0.89	0.55	0.43 to 0.72	0.72	0.57 to 0.90	0.76	0.62 to 0.95	0.82	0.68 to 0.98
Tumor location														
Proximal		Ref		Ref		Ref		Ref		Ref		Ref		Ref
Distal	0.66	0.59 to 0.73	0.61	0.55 to 0.68	0.60	0.54 to 0.66	0.64	0.59 to 0.71	0.64	0.59 to 0.70	0.64	0.59 to 0.71	0.64	0.58 to 0.69
Other	0.90	0.62 to 1.32	0.76	0.55 to 1.08	0.61	0.43 to 0.85	0.76	0.54 to 1.05	1.05	0.78 to 1.41	0.98	0.72 to 1.32	0.79	0.59 to 1.08
SEER type of surgical resection														
Partial colectomy		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.
Subtotal colectomy/ hemicolectomy	1.73	1.56 to 1.92	1.54	1.39 to 1.71	1.63	1.47 to 1.80	1.64	1.49 to 1.79	1.60	1.47 to 1.76	1.58	1.45 to 1.73	1.70	1.56 to 1.85
Colectomy/coloproctectomy with en bloc resection of other organs	1.34	1.13 to 1.59	1.12	0.94 to 1.34	1.29	1.08 to 1.54	1.30	1.07 to 1.58	1.72	1.38 to 2.15	1.28	0.83 to 1.97	1.30	0.79 to 2.13
Other (total colectomy, total proctocolectomy, colectomy, NOS	1.48	1.10 to 1.98	1.33	0.98 to 1.80	1.42	1.07 to 1.89	2.25	1.67 to 3.03	2.38	1.78 to 3.18	2.13	1.60 to 2.85	1.88	1.43 to 2.48

NOTE. Each Individual model is also adjusted for Surveillance, Epidemiology, and End Results (SEER) registry. Bold indicates $P < .05$.
Abbreviations: NOS, not otherwise specified; OR, odds ratio.