Impact of Patient and Provider Characteristics on the Treatment and Outcomes of Colorectal Cancer

David C. Hodgson, Charles S. Fuchs, John Z. Ayanian

While the management and prognosis of colorectal cancer are largely dependent on clinical features such as tumor stage, there is considerable variation in treatment and outcome not explained by traditional prognostic factors. To guide efforts by researchers and health-care providers to improve quality of care, we review studies of variation in treatment and outcome by patient and provider characteristics. Surgeon expertise and case volume are associated with improved tumor control, although surgeon and hospital factors are not associated consistently with perioperative mortality or long-term survival. Some studies indicate that patients are less likely to undergo permanent colostomy if they are treated by high-volume surgeons and hospitals. Differences in treatment and outcome of patients managed by health maintenance organizations or fee-for-service providers have not generally been found. Older patients are less likely to receive adjuvant therapy after surgery, even after adjustment for comorbid illness. In the United States, black patients with colorectal cancer receive less aggressive therapy and are more likely to die of this disease than white patients, but cancer-specific survival differences are reduced or eliminated when black patients receive comparable treatment. Patients of low socioeconomic status (SES) have worse survival than those of higher SES, although the reasons for this discrepancy are not well understood. Variations in treatment may arise from inadequate physician knowledge of practice guidelines, treatment decisions based on unmeasured clinical factors, or patient preferences. To improve quality of care for colorectal cancer, a better understanding of mechanisms underlying associations between patient and provider characteristics and outcomes is required. [J Natl Cancer Inst 2001;93:501–15]

While there is continual progress in the development of new cancer therapies, there is considerable evidence that currently available treatments are not provided to all patients who would benefit from them. The importance of understanding the variability in cancer treatment and outcomes is gaining recognition (1). A large body of literature has documented variability in the quality of care provided to breast cancer patients (2), and there is similar evidence that clinically significant variability exists in the management of colorectal cancer. Three years after the National Institutes of Health recommended that patients with stage III colon cancer receive adjuvant chemotherapy, the combination of surgery and chemotherapy was used in only 43% of such patients registered in the National Cancer Data Base, suggesting that adjuvant chemotherapy is underutilized or not consistently documented in hospital tumor registries (3). Such inconsistencies in practice recently led the Institute of Medicine to conclude that, “for many Americans with cancer, there is a wide gulf between what could be construed as the ideal and the reality of their experience with cancer care” (4).

To improve treatment of colorectal cancer patients, it is necessary to understand the extent of variations in practice, how variations relate to the quality of cancer care, which patients may not be receiving optimal care, and which providers may not be delivering such care. Interventions designed to improve the quality of care can then be directed at those patients and providers most likely to benefit from them. To guide efforts by researchers and health-care providers to improve quality of care, we review the literature regarding the relationship between patient and provider characteristics and treatment and outcomes of colorectal cancer.

METHODS

The search strategy was designed to identify population-based or multi-institutional studies examining the impact of patient or provider factors on the treatment and outcome of colorectal cancer. A MEDLINE® search for English-language articles published in the years 1980–2000 was performed, linking the subject search headings “colorectal neoplasms,” “colonic neoplasms,” and “rectal neoplasms” with each of the following headings: health services research, quality of health care, physicians’ practice patterns, outcome assessment (health care), surgeon volume, hospital volume, insurance, health maintenance organizations, ethnic groups, blacks, whites, social class, socioeconomic factors, age, and sex factors. Studies that analyzed incidence or stage of disease only, evaluated the use of screening or diagnostic tests, or examined only follow-up care were excluded. We restricted the review of studies regarding race, socioeconomic, and insurance factors to those analyzing patients in the United States. This process yielded 46 relevant multi-institutional or population-based studies. Seven additional studies were identified by starting with a relevant study (1,5–10) and searching for “related articles.” Manual searching of the reference list within relevant articles identified an additional four studies. All relevant articles identified are in the reference list. The criteria for evaluating the quality of the studies were based on the guidelines of Naylor and Guyatt (11) and include sample size, the quality of the data source, and inclusiveness of important prognostic factors in multivariable analyses. Because of the diverse nature of the study designs, a quantitative synthesis was not possible, and a narrative review of individual studies is provided with assessments of their methodologic strengths and limitations.

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Provider Characteristics

Surgeon Case Load, Training, and Experience

Treatment. Few studies have examined the association between surgeon characteristics and processes of care for colorectal cancer patients (Table 1). Porter et al. (5) examined the treatment and outcomes of 683 patients undergoing potentially curative resection for rectal cancer in one of five hospitals in Edmonton, Canada. Patients were more likely to have a sphincter-sparing anterior resection when they were treated by a surgeon with a high case volume (61.1% versus 50.8% for low-volume surgeons) or with subspecialty colorectal training (72.5% versus 35.1% for non-colorectal-trained surgeons). A prospective Scottish study (12) that included 260 rectal cancer patients found that surgeons’ volume was not a statistically significant predictor of achieving an anastomosis (72.5% for high-volume surgeons versus 65.1% for low-volume surgeons), although the sample size was small and the absolute effect was comparable to that reported by Porter et al. (5). In a population-based study of 927 colorectal cancer patients in the U.K., Parry et al. (6) found no statistically significant effect of surgeon (or hospital) volume on the use of abdominoperineal resection. These results, however, were based on the physician responsible for the patient’s care rather than on the surgeon performing the operation, which may obscure the impact of technical expertise on the probability of sphincter preservation. Moreover, since rectal cancer surgery is more technically demanding than colon surgery, the inclusion of colon cancer cases may dilute the impact of surgical expertise on sphincter preservation compared with analyzing rectal surgery alone.

Outcomes. Most studies of surgeon characteristics have investigated their association with patient outcomes rather than with the treatment provided (Table 1). No consistent link has been demonstrated between surgeon characteristics and postoperative mortality. Kelly and Hellinger (13) found no statistically significant relationship between hospital mortality rates and surgeon case volume among 2612 patients, after adjustment for age, sex, disease severity, number of diagnoses, and several other patient and provider characteristics. A U.K. study (14) of 3520 colorectal cancer patients also found no surgeon-volume or specialty effect on 30-day postoperative mortality. Holm et al. (15) analyzed the outcome of 1399 rectal cancer patients treated in one of two randomized trials and found no association between postoperative mortality and surgeon case volume. In contrast, in a study of 9739 resections for colorectal cancer, Harmon et al. (7) reported that high-volume surgeons had lower in-hospital mortality than low-volume surgeons, after adjustment for patients’ comorbidity, age, sex, tumor stage, and other clinical characteristics (relative risk [RR] = 0.64; P<0.01). However, the absolute magnitude of the difference was small (1.9%) and was less than the statistically nonsignificant (2.3%) difference in the U.K. study (14), indicating the importance of statistical power in studies searching for small differences in rare outcomes.

While perioperative mortality is an important outcome, it is a weak indicator of the cancer control provided by the treating surgeon. Studies that have examined outcomes more directly related to tumor control have generally found better outcomes for patients treated by surgeons with more expertise in terms of training or time in practice and, in some studies, with greater case volume. Holm et al. (15) found that patients of surgeons who were certified for at least 10 years were less likely to have a local relapse (RR = 0.8; 95% confidence interval [CI] = 0.6 to 1.0) or death from rectal cancer (RR = 0.8; 95% CI = 0.7 to 1.0) than those operated on by less experienced surgeons. However, no effect of surgeon case volume on these outcomes was found. Porter et al. (5) found that rectal cancer patients operated on by non-specialty-trained or low-volume surgeons had worse 5-year local control and cancer-specific survival. A prospective multicenter study in Germany (16) analyzed the outcome of 1539 colorectal cancer patients treated in seven institutions. After adjustment for relevant factors, such as tumor stage and site, surgeon volume was a statistically significant predictor of local relapse of rectal cancer but not of cancer-specific survival (8,16). One limitation of this study was that a single high-volume surgeon with an elevated local relapse rate was excluded from the high-volume category in the analysis, thereby increasing the apparent statistical significance of surgeon volume on local control. Also, centers that registered fewer than 100 patients were excluded from the analysis, which may have reduced the number of surgeons with low case volume and, consequently, diminished the apparent volume effects on outcome. Furthermore, this study and other studies (5,15) included only patients who had microscopically complete resections, which may dilute the effect of surgical expertise if high-volume or more experienced surgeons are more likely to achieve complete resection than their less experienced colleagues.

Overall survival (OS) has not been associated with surgeon characteristics. Among 3135 patients registered in the Northern Ireland cancer registry, Kee et al. (17) found no association between surgeon volume or experience and 2-year OS, and a similar finding was reported in a population-based study in the U.K. (6), although neither study adjusted for comorbid illness.

Hospital Characteristics

Treatment. Not all hospitals are equally well equipped to treat cancer patients, but there are few studies documenting the institutional variability in colorectal cancer care and fewer still that link these variations to meaningful differences in outcomes. Some studies have found an association between hospital volume and the use of permanent colostomy (Table 1). In a population-based study of 2006 rectal cancer patients who underwent resection, Simons et al. (18) found that patients with localized disease who were treated in hospitals that performed more than an average of five rectal cancer surgeries per year were more likely to undergo sphincter-sparing procedures than those treated in hospitals that performed fewer rectal cancer surgeries per year (69% versus 63%; P = .049). The American College of Surgeons’ Commission on Cancer (19) analyzed survey data regarding the management and outcome of 39502 cases of colorectal cases registered by 943 oncology programs in 1983 and 1988. This study found sphincter-sparing surgery more likely to be performed in hospitals with large case loads (46.2% at hospitals with >1000 cancer cases/year versus 34.8% at hospitals with <150 cancer cases/year).

There is little information regarding how institutional characteristics influence the use of adjuvant therapy. Among all 44812 colon cancer patients registered in the National Cancer Data Base (3), chemotherapy was less likely to be given in hospitals with small cancer case loads, and institutions recognized by the National Cancer Institute were more likely to give chemotherapy with surgery. Neither of these findings definitive-
<table>
<thead>
<tr>
<th>Authors (reference No.), study period</th>
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</tr>
</thead>
</table>
| LBCP,* Fielding et al. (49,63), 1976–1980 | 2510 (colorectal) | Medical records (U.K.) | Univariate analysis† | Individual surgeon  
Not a prognostic factor for in-hospital or 3-y mortality.  
Hospital type (teaching/specialist versus district)  
No statistically significant effect on in-hospital surgical mortality. |
| Kelly and Hellinger (13), 1977 | 2612 (colorectal) | Administrative data (United States) | Age, sex, comorbidity, tumor stage, insurance status, surgeon board certification, and geographic location | Surgeon and hospital volume (continuous variables)  
No statistically significant effect on in-hospital mortality.  
Surgeon board certification  
No statistically significant effect on in-hospital mortality.  
Hospital type (member Council of Teaching Hospitals versus nonmember)  
Teaching hospitals had statistically significantly lower (3.9%) in-hospital mortality than nonteaching hospitals. |
| Holm et al. (15), 1980–1993 | 1399 (rectal) | Medical records (Sweden) | Age, sex, tumor stage (Dukes’), and radiotherapy | Hospital volume (cases/y: ≤5, 6–10, >10)  
Decrease in local recurrence with increasing hospital volume of borderline statistical significance (low volume = 20%; medium volume = 23%; high volume = 26%).  
No statistically significant effect on 30-day mortality or risk of rectal cancer death.  
Hospital type (university versus non-university)  
University hospitals produced statistically significantly lower rates of local recurrence (17% versus 23%) and death from rectal cancer (42% versus 49%).  
No statistically significant difference in 30-day mortality.  
Surgeon experience (<10 y versus >10 y)  
More experienced surgeons produced statistically significantly lower rate of local recurrence (20% versus 25%) and death from rectal cancer (44% versus 53%).  
No statistically significant effect on 30-day mortality.  
Surgeon volume (cases/y: 1–3, >3)  
No statistically significant effect on 30-day mortality, local recurrence, or risk of rectal cancer death. |
| Kingston et al. (23), 1981–1983 | 578 (colorectal) | Medical records (Northwest region, U.K.) | Univariate analyses | Hospital type (teaching versus nonteaching)  
No statistically significant effect on overall survival or cancer-specific survival. |
| Porter et al. (5), 1983–1990 | 683 (rectal, no residual disease after resection) | Medical records, cancer registry (Edmonton, Canada) | Age, tumor stage, tumor location, tumor grade, vascular/neural invasion, intraoperative tumor spillage or rectal perforation, perioperative transfusion, gastrointestinal obstruction by tumor, and adjuvant therapy | Surgeon training (after general surgery colorectal training)  
Colorectal surgeons statistically significantly more likely to perform sphincter-sparing surgery than other surgeons (61.0% versus 25.8%).  
Patients treated by surgeons with subspecialty training had statistically significantly lower 5-y local relapse (13.4%) and better cancer survival (60.8%) than those treated by non-specialty-trained surgeons (37.4% and 43.8%).  
No statistically significant effect on perioperative mortality.  
Surgeon volume (cases/8 y: ≥21, <21)  
High-volume surgeons statistically significantly more likely to perform sphincter-sparing procedure than low-volume surgeons (61.1% versus 50.8%).  
Patients of surgeons with greater volume had statistically significantly lower 5-y local relapse (26.0%) and better cancer survival (53.5%) than those of surgeons with low volume (42.2% and 38.8%, respectively).  
No statistically significant effect on perioperative mortality. |

(Table continues)
### Table 1 (continued). Studies of the effect of surgeon and hospital characteristics on the treatment and outcomes of colorectal cancer

<table>
<thead>
<tr>
<th>Authors (reference No.), study period</th>
<th>No. of patients (cancer site)</th>
<th>Source of data (location)</th>
<th>Variables in multivariable analyses</th>
<th>Major findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SGCRC† (8,16), 1984–1986</strong></td>
<td>1539 (colorectal)</td>
<td>Medical records (Germany)</td>
<td>Sex, age, carcinoembryonic antigen level, emergency surgery, tumor site, tumor stage, tumor histology, type of surgery, and intraoperative tumor spillage</td>
<td>Surgeon volume: Surgeons with high volume had statistically significantly lower locoregional recurrence (for rectal cancer ≤15 cases/2 y versus &gt;15 cases/2 y; odds ratio [OR] = 1.71; 95% confidence interval [CI] = 1.06 to 2.78). No statistically significant effect on 5-y cancer survival or overall survival. <strong>Individual hospitals</strong>: For rectal cancer patients, statistically significant differences in 5-y cancer survival among 3 participating institutions (63.7%–73.6%).</td>
</tr>
<tr>
<td><strong>Beart et al. (19), 1988</strong></td>
<td>16,527 (colon)</td>
<td>Medical records (United States)</td>
<td>Univariate analysis</td>
<td>Hospital volume (all cancers/y: ≤150, 150–499, 500–999, ≥999) Sphincter-sparing surgery more likely in high-volume hospitals (e.g., 46.2% highest volume category versus 34.8% in lowest volume).</td>
</tr>
<tr>
<td><strong>Simons et al. (18), 1988–1992</strong></td>
<td>2006 (rectal)</td>
<td>Cancer registry, administrative data (Los Angeles County, CA)</td>
<td>Stratified by tumor stage</td>
<td>Hospital volume (cases/5 y: ≤25, &gt;25) Patients with localized tumors treated in high-volume hospitals statistically significantly more likely to have sphincter-sparing procedure (69%) than those in low-volume hospitals (63%). 5-y overall survival in high-volume hospitals statistically significantly better than that in low-volume hospitals for both localized (69% versus 51%) and regional (41% versus 31%) disease.</td>
</tr>
<tr>
<td><strong>Kline et al. (20), 1989 and 1990</strong></td>
<td>408 (rectal, sigmoid)</td>
<td>Medical records (United States)</td>
<td>Univariate analysis</td>
<td>Radiation therapy (RT) center (academic, free-standing, hospital-based) Free-standing clinics statistically significantly less likely to use customized shielding (40%) than hospital-based (63%) or academic (55%) centers. Academic centers statistically significantly more likely to use suboptimal beam arrangement (22%) than hospital-based radiotherapy facilities (4%) and less likely to use rectal contrast during RT planning (27% versus 51%). For all types of facilities, many treatment factors do not meet Patterns of Care Study consensus guidelines.</td>
</tr>
<tr>
<td><strong>Consultant surgeons: Lothian and Borders Health Board (12), 1990–1992</strong></td>
<td>750 (colorectal)</td>
<td>Medical records (Scotland)</td>
<td>Univariate analysis</td>
<td>Surgeon volume (5 surgeons with 131 patients versus 23 surgeons with 129 patients) No statistically significant association with achieving anastomosis. Statistically significantly lower rate of anastomatic leakage (4.2%) for high-volume surgeons than for low-volume surgeons (14.3%).</td>
</tr>
<tr>
<td><strong>Kee et al. (17), 1990–1996</strong></td>
<td>3135 (colorectal)</td>
<td>Cancer registry (Northern Ireland)</td>
<td>Age, tumor stage, tumor grade, liver metastases, emergency status, and curative intent</td>
<td>Surgeon volume (cases/y: ≤9.7, 9.8–12.7, 12.8–16.1, 16.2–24.9, ≥25) No statistically significant effect on 2-y overall survival. <strong>Hospital volume (cases/y: ≤23, 24–32, 33–46, 47–54, ≥55)</strong> Medium-volume hospitals have worse 2-y survival than low-volume hospitals (33–46 versus ≤23 cases/y: OR = 1.48 [95% CI = 1.03 to 2.13]; 47–54 versus ≤23 cases/y: OR = 1.52 [95% CI = 1.08 to 2.13]).</td>
</tr>
<tr>
<td><strong>Schrag et al (22), 1991–1993</strong></td>
<td>13,989 (colon)</td>
<td>Cancer registry, administrative data (United States)</td>
<td>Age, race, tumor stage, and comorbid illness</td>
<td>Hospital volume Patients operated on at hospitals with higher procedure volumes had lower 30-day mortality and better 5-y survival.</td>
</tr>
<tr>
<td><strong>Mella et al. (14), 1992 and 1993</strong></td>
<td>3520 (colorectal)</td>
<td>Medical records (Trent, Wales, U.K.)</td>
<td>Univariate analysis</td>
<td>Surgeon volume (cases/y: ≤10, &gt;10) No statistically significant effect on 30-day mortality. Surgeon specialty (coloproctology, gastrointestinal surgery, general surgery, other) No statistically significant effect on 30-day mortality.</td>
</tr>
</tbody>
</table>

*(Table continues)*
Table 1 (continued). Studies of the effect of surgeon and hospital characteristics on the treatment and outcomes of colorectal cancer

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<th>Variables in multivariable analyses</th>
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</tr>
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<tbody>
<tr>
<td>Harmon et al. (7), 1992–1996</td>
<td>9739 (colorectal resections)</td>
<td>Cancer registry, administrative data (Maryland)</td>
<td>Age, sex, race, comorbidity, tumor stage, admission status, insurance, and procedure type</td>
<td>Surgeon volume (cases/y: &lt;=5, 5–10, &gt;10) In-hospital mortality statistically significantly lower for high-volume surgeons (2.6%) than for low-volume surgeons (4.5%).</td>
</tr>
<tr>
<td>Jessup et al (3), 1993</td>
<td>44,812 (colon)</td>
<td>Medical records (United States)</td>
<td>Univariate analysis</td>
<td>Hospital volume (casesy: &lt;=100, 100–499, 500–999, &gt;1000) Chemotherapy plus surgery less likely to be given in hospitals with smaller overall cancer case load (e.g., 17.5% in hospitals with &lt;10 casesy versus 22.6% in those with 150–499/yy).</td>
</tr>
<tr>
<td>Parry et al. (6), 1993</td>
<td>927 (colorectal)</td>
<td>Medical records (North Western Region, U.K.)</td>
<td>Age, tumor stage, tumor grade, and admission status</td>
<td>Surgeon volume (cases/6 mo: 1–6, 7–12, 13–18, &gt;19) No statistically significant effect on sphincter preservation or overall survival. Hospital volume (admissions/6 mo: 1–30, 31–44, 45–55, &gt;56) No statistically significant effect on sphincter preservation or overall survival.</td>
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*Large Bowel Cancer Project.
†Provider factors not statistically significant in univariate analyses; subsequent multivariate analyses performed.
‡German Study Group on Colo-Rectal Carcinoma.

ly indicates variation in the quality of care, however, because small hospitals may refer patients elsewhere for chemotherapy. The Patterns of Care Study (20) examined processes of radiation treatment planning in a random sample of U.S. radiotherapy facilities in 1989 and 1990. Free-standing radiotherapy clinics were less likely to use customized shielding than hospital-based or academic centers. Academic centers, however, were more likely to use suboptimal beam arrangements.

**Outcomes.** The impact of hospital characteristics on the outcomes of cancer care has been assessed in several studies. Greater hospital volume has been associated with lower 30-day mortality for complex cancer operations (21). Using Surveillance, Epidemiology, and End Results (SEER) data for 27,986 patients aged 65 years or more who were diagnosed during 1991 through 1996 in the United States, Schrag et al. (22) found lower 30-day mortality for colon cancer patients undergoing resection in high-volume facilities compared with those undergoing resection at low-volume facilities (3.5% versus 5.5%; P<.001). In contrast, the study by Harmon et al. (7) found no association between hospital volume and in-hospital mortality.

Tumor control may also vary according to hospital characteristics. Holm et al. (15) found that patients treated in university hospitals had a lower risk of local recurrence (RR = 0.7; 95% CI = 0.5 to 0.9) and death from rectal cancer (RR = 0.8; 95% CI = 0.7 to 1.0) than patients treated in community hospitals. In a German study (8), cancer-specific survival of rectal cancer patients varied by surgical center, although it was not clear what characteristics of the centers might account for this difference.

The evidence that hospital characteristics influence long-term OS for colorectal cancer patients is inconsistent. Simons et al. (18) found that, among 2006 rectal cancer patients, 5-year OS was statistically significantly better for patients undergoing surgery at hospitals with more than five cases per year among patients with localized disease (69% versus 51%) and regional disease (41% versus 31%). Schrag et al. (22) found a statistically significant increase in long-term OS rate with greater hospital volume, after adjusting for age, sex, race, comorbid illness, tumor stage, socioeconomic status, and emergent indications for surgery. Kee et al. (17) reported contradictory findings: Patients undergoing surgery in hospitals treating 33–54 cases per year had a higher risk of 2-year mortality than those treated in hospitals treating 23 or fewer cases per year. This study, however, did not adjust for comorbidity, and Kee et al. attributed this difference to unexplained confounding. A U.K. study (23) of 578 patients also found no statistically significant difference in cancer-specific survival or OS between patients undergoing surgery in community hospitals and those treated in teaching hospitals.

**Physician Payment and Practice Structure**

**Treatment.** In spite of concern that economic considerations may undermine quality of care, there is little evidence that physician payment and practice structure statistically significantly influence the treatment or outcome of patients with colorectal cancer in the United States (Table 2). Retchin and Brown (24) found no statistically significant delay in diagnosis among 150 Medicare recipients hospitalized for colorectal cancer who were enrolled in one of eight health maintenance organizations (HMOs), compared with 180 patients who were enrolled in fee-
for-service (FFS) care in the same geographic areas. In a similar study, Retchin et al. (25) compared the perioperative care of 412 colon cancer patients enrolled in 19 HMO plans with that of 401 colon cancer patients treated in FFS care in the same geographic areas. The length of the hospital stay was statistically significantly shorter for HMO patients (10.9 days versus 14.2 days), but there were no statistically significant differences between HMO and FFS patients in the number of lymph nodes dissected at surgery, the frequency of tumor involvement at the resection margins, the use of colostomy, or the readmission rates. Among 15352 Medicare patients with colorectal cancer registered in two SEER registries between 1985 and 1992, Merrill et al. (26) found that the proportion of HMO and FFS patients undergoing surgery was equivalent, although HMO patients with stage II/III rectal cancer were more likely to receive adjuvant radiotherapy following surgery than were similar FFS patients (44% versus 35%).

**Outcome.** No substantial differences in outcomes between HMO and FFS patients with colorectal cancer have been observed. Postoperative mortality was equivalent between HMO and FFS patients in the study by Retchin et al. (25). Merrill et al. (26) found that HMO and FFS patients had equivalent cancer-specific survival and that HMO patients had a statistically significantly better OS after adjustment for age, race, tumor stage, sex, and comorbidity. Equivalent outcomes between HMO and FFS patients have also been reported in a smaller study (27) and in a study of a single provider group (28).

### Table 2. Studies examining effect of health maintenance organization (HMO) and fee-for-service (FFS) coverage on treatment and outcomes of colorectal cancer*

<table>
<thead>
<tr>
<th>Authors (reference No.), study period</th>
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</tr>
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<tbody>
<tr>
<td>Francis et al. (27), 1975</td>
<td>189 (colorectal)</td>
<td>Patient interviews, cancer registry</td>
<td>Univariate analyses; survival time stratified by sex, tumor stage, and tumor site</td>
<td>HMO patients had statistically significantly longer time from first physician visit to surgery (47 days) than FFS patients (14 days). No statistically significant difference between HMO and FFS patients in the use of surgery, chemotherapy, or radiotherapy. No statistically significant difference in survival between HMO and FFS patients.</td>
</tr>
<tr>
<td>Retchin and Brown (24), 1983–1986</td>
<td>330 (colorectal)</td>
<td>Medical records</td>
<td>Univariate analysis</td>
<td>No statistically significant difference in the time from presenting symptoms to diagnosis for HMO (36.7 days) and FFS (26.7 days) patients. FFS patients more likely to have an imaging study performed before laparotomy (54%) than HMO patients (38.2%). No statistically significant difference in follow-up care between HMO and FFS patients.</td>
</tr>
<tr>
<td>Merrill et al. (26), 1985–1992</td>
<td>15 352 (colorectal)</td>
<td>Cancer registry, administrative data</td>
<td>Age, race, sex, geographic region, education, tumor stage, comorbidity, and tumor location</td>
<td>Patients reported from 2 HMOs had statistically significantly lower overall mortality (RR = 0.85; 95% CI = 0.79 to 0.91) but not rectal cancer mortality (RR = 0.94; 95% CI = 0.86 to 1.03) than FFS patients. No statistically significant difference in the proportion of patients undergoing surgical resection under HMO or FFS care. Statistically significantly more HMO patients with stage II/III rectal cancer received postoperative radiation therapy (44% versus 35% under FFS care).</td>
</tr>
<tr>
<td>Retchin et al. (25), 1989</td>
<td>813 (colon)</td>
<td>Medical records</td>
<td>Age, sex, race, comorbidity, functional status, and independent residence</td>
<td>HMO patients had statistically significantly shorter length of stay (10.9 days) than FFS patients (14.2 days). HMO patients less likely to be admitted to intensive care (36.4%) than FFS patients (44.4%). In-hospital death rate not statistically significantly different for HMO and FFS patients.</td>
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</tbody>
</table>

*RR = relative risk; CI = confidence interval.

### PATIENT CHARACTERISTICS

#### Age

**Treatment.** The management of elderly patients with cancer requires greater consideration of comorbid illness than is generally required for younger patients. Clinicians may believe that the relative gain of aggressive treatment is reduced by the presence of other illnesses and the physical toll that treatment takes on older patients.

Several studies that examine the management of colorectal cancer patients include age as a covariate, although the authors may emphasize other patient or provider characteristics (Table 3). Most studies (3,19,29–35) find that, except for the very elderly, advancing age is not associated with statistically significant reductions in the proportion of patients with colorectal cancer undergoing surgery. Samet et al. (29) described surgery rates among cancer patients registered in the New Mexico Tumor Registry from 1969 through 1982. Among the 1998 patients with colon cancer, there was a trend for older patients with regional disease to be less likely to undergo surgery than their younger counterparts. For the 949 patients with rectal cancer, a similar trend was evident among those with localized disease, with resection rates greater than 80% in all age categories except those aged 75 years or above. More recent population-based studies have found that the large majority of patients undergo surgical resection and that the use of surgery declines only after ages 75–90 years. For example, one study (35) analyzed the
outcome of 11,333 colorectal cancer patients registered in 15 European registries and found that 82%–86% of those under age 75 years underwent surgery, although this rate decreased to 70%–73% among those aged 75 years or older. Comparable findings have been reported in other studies (3,19,31,32,34,36), including those that adjust for comorbid illness (30,33). It appears that modern perioperative care has reduced the risks of surgery, and the dismal prognosis for patients not undergoing tumor resection likely motivates surgeons to withhold surgery only in the most futile cases (37).

In contrast to the use of surgery, adjuvant therapy is given much less frequently to elderly patients. Among all patients with colon cancer in the National Cancer Data Base (3), the use of surgery plus chemotherapy declined with age: 40% of those under age 50 years received both of these treatments, in contrast to 20% of those aged 70–79 years. Comparable results have been reported elsewhere (19,35). Even after adjustment for comorbidity, older patients are still less likely to receive chemotherapy (30,33,38). For example, among 3176 patients treated in Department of Veterans Affairs (VA) Medical Centers, Dominitz et al. (30) found that, after they adjusted for comorbid illness, tumor location, and the presence of metastatic disease, patients aged 50–64 years were less than half as likely to receive chemotherapy as those under age 50 years, and the rate of chemotherapy use continued to decrease with advancing age. And in a study of 9551 patients with colorectal cancer in the Florida state tumor registry, Roetzheim et al. (33) found that, after adjusting for tumor stage and comorbidity, each additional year of age decreased the likelihood of receiving chemotherapy (OR = 0.94; 95% CI = 0.94 to 0.95). Older age has also been associated with decreasing use of radiotherapy in several descriptive analyses (3,19,35), as well as in studies that adjust for relevant clinical factors (30,31,33,39).

Some, but not all, studies suggest that older patients are more likely to experience chemotherapy-related toxicity (40–43), and this observation may, in part, explain why older patients are less likely to receive adjuvant therapy. Furthermore, the number of elderly patients enrolled in the trials that define the standard use of adjuvant therapy is small (44,45), so that the benefit of such therapy in older patients is less certain. However, there is evidence (43,46) suggesting that failure to provide full treatment in the elderly may have adverse effects. Research on the delivery of breast cancer treatment (47) has shown that physicians may inappropriately limit adjuvant therapy to older patients, and the studies cited above indicate that a similar phenomenon may be occurring for older patients with colorectal cancer.

Outcomes. Several studies (7,13,32,34,48–51) indicate that, among patients undergoing surgery for colorectal cancer, postoperative mortality increases with advancing age. Postoperative mortality is generally less than 3% among patients younger than 70 years, but it increases to approximately 5%–15% for older patients (32,34,50). For example, among 6457 patients registered in the Rotterdam cancer registry, Damhuis et al. (32) found that the postoperative mortality was 0.6% for those under age 50 years and increased with each decade of age, reaching 12.9% for those older than 89 years. Other population-based studies (34,50) have reported similar results. Adjustment for comorbid illness does not negate the adverse effect of age on postoperative mortality. A German study (51) examined factors associated with postoperative mortality, adjusting for comorbidity that was

Table 3. Summary of studies examining age effects in colorectal cancer

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>No. of studies (reference Nos.)</th>
<th>No. of studies with medical records as data source (reference Nos.)</th>
<th>No. of studies adjusting for other prognostic factors (reference Nos.)</th>
<th>Major findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provision of surgery</td>
<td>9 (3,19,29–35)</td>
<td>4 (3,19,31,35)</td>
<td>3 (30,31,33)</td>
<td>Small or no statistically significant association between age and the provision of surgery for colorectal cancer patients, except for the very elderly.</td>
</tr>
<tr>
<td>Provision of chemotherapy</td>
<td>6 (3,19,30,33,35,38)</td>
<td>3 (3,19,38)</td>
<td>3 (30,33,38)</td>
<td>Older patients less likely to receive chemotherapy in all studies reviewed, including those adjusting for extent of disease or comorbidity.</td>
</tr>
<tr>
<td>Provision of radiotherapy</td>
<td>7 (3,19,30,33,35,39)</td>
<td>3 (3,19,31)</td>
<td>4 (30,31,33,39)</td>
<td>Older patients less likely to receive radiotherapy in all studies, including those adjusting for tumor stage and site of disease.</td>
</tr>
<tr>
<td>Postoperative mortality</td>
<td>8 (7,13,32,34,48–51)</td>
<td>2 (49,51)</td>
<td>4 (7,13,32,51)</td>
<td>Older patients more likely to die postoperatively in all studies, including studies adjusting for comorbidity.</td>
</tr>
<tr>
<td>Cancer-specific survival (CSS)</td>
<td>6 (5,8,52–55)</td>
<td>4 (5,8,53,55)</td>
<td>5 (5,8,52–54)</td>
<td>Three studies (5,8,52) found no association between age and CSS; older patients had worse CSS in 3 studies (53–55).</td>
</tr>
<tr>
<td>Relative survival (RS)</td>
<td>8 (3,19,48,50,56–59)</td>
<td>2 (3,19)</td>
<td>5 (3,19)</td>
<td>Five studies (3,19,57–59) found that older patients had worse RS.</td>
</tr>
<tr>
<td>Overall survival (OS)</td>
<td>14 (6,17,26,30,33,34,37,53,60–64,67)</td>
<td>6 (6,53,62–64,67)</td>
<td>10 (6,26,30,33,53,60–63,67)</td>
<td>Older patients had worse OS in 12 studies (6,17,26,30,33,34,53,60–63,67); two other studies (37,64) found clinically significant decrease in OS with older age but were underpowered to meet statistical significance.</td>
</tr>
</tbody>
</table>
assessed prospectively. Older age continued to be associated with an increased risk of postoperative death (OR = 2.65 [95% CI = 1.30 to 5.39] for those older than 65 years versus those 65 years old or younger).

The impact of age on tumor control is less certain, and it is difficult to study because age may be related to several confounding factors, such as tumor stage and the provision of adjuvant treatment. Some studies (5,8,52) report no statistically significant association between age and cancer-specific survival, although in some cases using only two age categories (8) or a small sample size (52) may conceal statistically significant variations in cancer-specific survival that might exist between finer age strata. In contrast, other authors (53–55) have reported a decrease in cancer-specific survival with advancing age. Kune et al. (53) analyzed the outcome of a population-based cohort of 1140 colorectal cancer patients in Australia. After stratification by tumor stage and adjustment for several histologic features, age was one of the statistically significant factors affecting cancer-specific survival, although the magnitude of this effect in multivariate analysis was not reported. After adjusting for tumor stage and other demographic variables, Wegner et al. (54) found an increased cancer-specific “survival ratio” among those under age 65 years versus those aged 65 years or older. In summary, studies differ in their conclusions regarding the association between age and cancer-specific survival. These differences likely arise from differences in the categorization of age, the accuracy of data regarding confounding prognostic variables, and statistical power.

Estimation of relative survival provides an adjustment for non-cancer-related deaths, and for most forms of cancer, relative survival is comparable to cancer-specific survival. Similar to studies analyzing cancer-specific survival described above, there is no clear association between age and relative survival. Wingo et al. (56) examined the relative survival of 167,400 colorectal cancer patients registered in the SEER database during 1974–1991. Age had little effect on the relative survival of white patients, although older black men had worse relative survival (56). Other studies (48,50) have also found no statistically significant association between age and relative survival, although, in some cases, only patients undergoing surgery were analyzed, which could inflate relative survival rates and dilute a possible association between age and relative survival.

Decreasing relative survival with advancing age has also been reported (3,19,57–59). For example, among 250,445 colorectal cancer cases registered in the European study during 1978–1989, 5-year relative survival declined steadily with age. Among colon cancer patients diagnosed from 1985 to 1989, those aged 15–44 years had a relative survival of 57%, in contrast to 42% for those aged 75–99 years, with a similar decrease among rectal cancer patients (57,58).

OS declines with age in the general population, so it is not surprising that most studies (6,17,30,33,34,53,60–63) find this trend among patients with colorectal cancer. Studies that report no statistically significant association between age and OS are apt to be too small to allow adjustment for all important prognostic variables (64).

**Sex**

**Treatment.** Several population-based studies (3,32,34,35) have reported equivalent rates of surgery between men and women, although Roetzheim et al. (33) found that women were more likely than men to undergo definitive surgery (OR = 1.18; 95% CI = 1.02 to 1.37) (Table 4). The Commission on Cancer study (19) found that women were less likely than men to undergo abdominoperineal resection (i.e., sphincter loss) (20.1% versus 29.2%), and this finding has also been reported elsewhere (39). This result is almost certainly due to differences in pelvic anatomy that facilitate low anterior resection in women.

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>No. of studies (reference Nos.)</th>
<th>No. of studies with medical records as data source (reference Nos.)</th>
<th>No. of studies adjusting for other statistically significant variables (reference Nos.)</th>
<th>Major findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provision of surgery</td>
<td>7 (3,19,32–35,39)</td>
<td>2 (3,19)</td>
<td>2 (33,39)</td>
<td>No difference in the rate of surgical resection in 4 studies (3,32,34,35). Women more likely to undergo definitive surgery in 1 study (33). Men more likely to undergo sphincter resection in 2 studies (19,39).</td>
</tr>
<tr>
<td>Provision of chemotherapy</td>
<td>5 (3,19,33,35,38)</td>
<td>3 (3,19,38)</td>
<td>2 (3,38)</td>
<td>No difference in the use of chemotherapy.</td>
</tr>
<tr>
<td>Provision of radiotherapy</td>
<td>5 (3,19,33,35,39)</td>
<td>2 (3,19)</td>
<td>2 (33,39)</td>
<td>No difference in the use of radiotherapy in 4 studies (3,19,33,35). Men with rectal cancer and no colostomy more likely to get radiotherapy in 1 study (39).</td>
</tr>
<tr>
<td>Postoperative mortality</td>
<td>5 (7,13,32,34,49)</td>
<td>1 (49)</td>
<td>5 (7,13,32,34,49)*</td>
<td>Three studies (13,34,49) found no association; 2 studies (7,32) found lower risk of postoperative death among women.</td>
</tr>
<tr>
<td>Cancer-specific survival (CSS)</td>
<td>5 (8,26,53–55)</td>
<td>3 (8,53,55)</td>
<td>3 (8,53,54)</td>
<td>No association with CSS in 4 studies (8,26,53,54) including those that adjust for other prognostic variables.</td>
</tr>
<tr>
<td>Relative survival (RS)</td>
<td>5 (3,19,48,50,56,58)</td>
<td>Stratification: tumor stage, age, race, and sex (56)</td>
<td>No clear association with RS.</td>
<td></td>
</tr>
<tr>
<td>Overall survival (OS)</td>
<td>13 (6,26,33,34,37,39,53,60–64,67)</td>
<td>6 (6,37,53,62,63,67)</td>
<td>11 (6,26,33,34,37,53,60–63,67)*</td>
<td>No association in 9 studies (6,33,34,37,53,60,61,63,67); men had worse OS in 3 studies (26,39,62) and better OS in 1 study (64).</td>
</tr>
</tbody>
</table>

*For references (34,49), association between sex and outcome reported only in univariate analyses.
As with age, sex is also associated with side effects of adjuvant chemotherapy, with several studies (40–42, 65) finding that women are more likely to experience severe 5-fluorouracil toxicity than men. Although this finding could lead to less use of chemotherapy for female patients, few studies have assessed this issue. The National Cancer Data Base report on colon cancer (3) found that, for all stages of disease, 23% of the men in the sample had received surgery and chemotherapy and 21% of the women received both of these treatments. The Commission on Cancer study (19) also found no major difference in the proportion of males and females receiving chemotherapy, radiotherapy, or both, and large population-based studies (33, 35, 38) have reported similar findings.

**Outcomes.** Data have been equivocal as to whether mortality following colorectal cancer surgery is related to sex. Harmon et al. (7) found that women had a statistically significantly lower risk of postoperative death than men (RR = 0.75; P < 0.01) after adjusting for important variables, such as age and comorbidity. Damhuis et al. (32) also found an increased risk of postoperative death among males with colorectal cancer in the Rotterdam cancer registry (OR = 1.53; 95% CI = 1.08 to 2.17). However, other studies (13, 34, 49, 63) have reported no sex-related differences in postoperative mortality.

Most of the studies reviewed here indicate that cancer-specific survival is not related to sex. Although an early Commission on Cancer study (55) of patients treated before 1973 found better cancer-specific survival for women, several other large studies (8, 26, 53, 54) found no difference in cancer-specific survival between men and women. Furthermore, in prospective multi-institutional phase III trials (44, 45, 66), sex has not been a statistically significant predictor of recurrence or survival, and results are mixed regarding whether men or women benefit more from adjuvant chemotherapy.

The relationship between sex and OS is weak, with some studies indicating that women with colorectal cancer have a better OS than men. In a study of 5145 colorectal cancer patients treated in 11 Comprehensive Cancer Centers, Dayal et al. (60) found that men with colon cancer had a statistically significantly worse OS than women, although this result was not seen among rectal cancer patients. Among men treated in the National Surgical Adjuvant Breast and Bowel Project (NSABP) colon cancer trials (62), men had worse OS than women, and similar findings have been reported in population-based studies (26, 33, 67). However, other studies (6, 34, 53, 61, 63) with adequate statistical power have found no association between sex and OS. Since women in the general population have better OS than men, it is possible that the better OS of women with colorectal cancer in some studies reflects the same general phenomenon. Differences in the precision of case-mix adjustment also may account for the varying results between studies.

**Race and Ethnicity**

**Treatment.** In the United States, race is linked to differences in the treatment and outcomes of colorectal cancer (Table 5). Ball and Elixhauser (68) examined the outcome of 20,634 hospitalizations for patients with colorectal cancer. Black patients without metastatic disease were 41% less likely to undergo a major colorectal therapeutic procedure than white patients (OR = 0.59; P < 0.001) and were almost twice as likely to die while hospitalized. Tropman et al. (38) found that race was the most statistically significant predictor of whether patients with stage III colon cancer in rural North Carolina and South Carolina received adjuvant chemotherapy, with whites having almost five times higher odds of receiving it than blacks. Cooper et al. (34) noted that, among Medicare beneficiaries, blacks were less likely than whites to undergo surgical resection (68% versus 78%), even after age, comorbidity, and tumor location and extent were considered.

Possible explanations for these results include racial discrimination, as well as differences in severity of disease, comorbid illness, access to care, or patient attitudes toward medical interventions. Dominitz et al. (30) examined the processes and outcomes of care for 3176 colorectal cancer patients treated at VA Medical Centers. Treatment in the VA system is not dependent on the patient’s ability to pay, so racial differences in access to care should be minimized. Essentially no difference was found in the proportion of white and black patients undergoing surgical resection (73% versus 70%), chemotherapy (23% for both), or radiation therapy (16% versus 17%) (30). These results suggest that economic barriers may contribute to racial disparities in treatment documented in other studies.

Not all studies have found statistically significant undertreatment of black patients, however. In a study of 975 colon cancer patients identified in U.S. population-based tumor registries during 1985 and 1986, Mayberry et al. (69) found no statistically significant difference in the use of adjuvant treatment between black patients and white patients. For example, among those with stage III disease, 12.3% of blacks and 17.0% of whites received chemotherapy. Lee et al. (70) found no difference between black and white patients in the frequency of Medicare billings for radiotherapy or several diagnostic procedures for colon cancer in nine states and the District of Columbia. Radiotherapy plays a minor role in the management of colon cancer, however, so examining variation in its use is not an ideal method for demonstrating meaningful inequities in treatment.

**Outcomes.** Black patients in the United States have worse tumor control and OS than white patients. Using SEER data, Wingo et al. (56) found that 10-year relative survival rates were 52% for white colorectal cancer patients and 42% for black colorectal cancer patients. In 11 U.S. Comprehensive Cancer Centers, Dayal et al. (60) found that, after adjusting for other prognostic variables, blacks had a statistically significantly higher death rate than whites (RR = 1.28 for colon cancer; RR = 1.44 for rectal cancer; P < 0.001 for both comparisons), and other studies (19, 34, 69, 71) have reported similar findings. Racial differences in outcome appear to be reduced when equivalent treatment is given to patients with the same stage of disease. In the VA study by Dominitz et al. (30), racial disparities in survival were reduced compared with other studies, although blacks still had worse overall 5-year survival after adjustment for other prognostic factors. And in an analysis of 6632 colon cancer patients treated in five randomized trials of the NSABP (62), the 5-year relapse-free survival rate was 70% for whites and 67% for blacks, while the 5-year OS rates were 72% and 65%, respectively. These results suggest that, when black patients receive the same treatment as white patients, they have similar cancer control rates, although greater comorbid illness may contribute to worse OS rates in the black population.
Table 5. Studies of the effect of race and ethnicity on treatment and outcomes of colorectal cancer in the United States

<table>
<thead>
<tr>
<th>Authors (reference Nos., study period)</th>
<th>No. of patients (cancer site)</th>
<th>Source of data</th>
<th>Variables in multivariable analyses</th>
<th>Major findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wegner et al. (54), 1960–1974</td>
<td>2327 (colorectal)</td>
<td>Cancer registry</td>
<td>Age, sex, tumor stage, and SES</td>
<td>Compared with Japanese patients, Hawaiian and Filipino patients had a lower rate of survival (RR = 0.64 [95% CI = 0.48 to 0.85] and RR = 0.68 [95% CI = 0.50 to 0.90], respectively).</td>
</tr>
<tr>
<td>Samet et al. (10), 1969–1982</td>
<td>4583 (colorectal)</td>
<td>Cancer registry</td>
<td>Age, sex, treatment, and tumor stage</td>
<td>Native Americans with local/regional stage rectal cancer more likely to have no documented treatment compared with whites (11.9% versus 3.1%). 5-y survival worse for Native Americans (33%) and Hispanics (31%) with rectal cancer than for white patients (41%). No statistically significant racial variation in 5-y survival among colon cancer patients.</td>
</tr>
<tr>
<td>Gilliland et al. (72), 1969–1994</td>
<td>9852 (colorectal)</td>
<td>Cancer registry</td>
<td>Age, sex, era of diagnosis, tumor stage, tumor grade, and primary treatment</td>
<td>From 1983 through 1994, 5-y relative survival worse for American Indians (45%) and Hispanics (50%) with rectal cancer than for whites (63%). From 1983 through 1994, 5-y relative survival for American Indians with colon cancer worse (48%) than for whites (64%). Relative survival improved for all ethnic groups from 1969 through 1994.</td>
</tr>
<tr>
<td>Metlin et al. (55), before 1973</td>
<td>20 193 (rectal)</td>
<td>Medical records</td>
<td>Stratified by tumor stage</td>
<td>Black patients had worse 5-y survival than white patients for all stages of disease.</td>
</tr>
<tr>
<td>Sugarman et al. (74), 1974–1989</td>
<td>24 134 (colorectal)</td>
<td>Cancer registry</td>
<td>Age, sex, tumor stage, urban residence, and receipt of cancer treatment</td>
<td>No difference in the proportion of Native Americans receiving treatment compared with whites. Native American patients had worse 5-y survival (39.7%) than white patients (47.3%).</td>
</tr>
<tr>
<td>Wingo et al. (56), 1974–1991</td>
<td>167 400 (colorectal)</td>
<td>Cancer registry</td>
<td>Age and sex</td>
<td>Black patients had worse 10-y relative survival than white patients (42% versus 52%).</td>
</tr>
<tr>
<td>Dayal et al (60), 1977–1982</td>
<td>5145 (colorectal)</td>
<td>Cancer registry,† census data</td>
<td>Age, sex, tumor stage, and SES</td>
<td>Blacks had worse OS than whites for both colon (RR = 1.28; P&lt;.001) and rectal (RR = 1.44; P&lt;.001) cancers.</td>
</tr>
<tr>
<td>Dignam et al. (62), 1977–1994</td>
<td>6632 (colon)</td>
<td>Medical records (5 randomized trials)</td>
<td>Stratified by trial. Age, sex, tumor stage, and tumor location.</td>
<td>5-y relapse-free survival comparable for black and white patients treated on trials (67% versus 70%). Blacks had worse OS (65%) than whites (72%).</td>
</tr>
<tr>
<td>Ball and Elixhauser (68), 1980–1987</td>
<td>20 634 hospitalizations (colorectal)</td>
<td>Administrative data</td>
<td>Age, sex, comorbidity, complications, metastases, hospital characteristics, and community SES indicators</td>
<td>Black patients less likely to receive major therapeutic procedures (ORs = 0.59–0.76) than white patients. Inpatient mortality higher for blacks than for whites.</td>
</tr>
<tr>
<td>Bleed et al. (73), 1982–1987</td>
<td>83 (colorectal)</td>
<td>Cancer registry</td>
<td>Age and sex</td>
<td>Native Americans in Montana, New Mexico, and Arizona had worse 3-y relative survival (48%–50%) than U.S. whites (64%).</td>
</tr>
<tr>
<td>Beart et al. (19), 1983 and 1989</td>
<td>39 502 (colorectal)</td>
<td>Medical records</td>
<td>Univariate analysis</td>
<td>Black patients less likely to have sphincter-sparing resection (33.1%) than white patients (42.7%). Black patients had worse 5-y relative survival than white patients for both colon cancer (45% versus 51%) and rectal cancer (38% versus 49%).</td>
</tr>
<tr>
<td>Dominitz et al. (30), 1984–1994</td>
<td>3176 (colorectal)</td>
<td>Administrative data</td>
<td>Age, tumor location, metastases, comorbidity, VA eligibility, marital status, and geographic region</td>
<td>In the VA system, black and white patients had similar rates of surgery (70% versus 73%), chemotherapy (23% versus 23%), and radiation therapy (17% versus 16%). Compared with white patients, black patients had higher risk of mortality (RR = 1.13; 95% CI = 1.01 to 1.28) but similar relative survival (42% versus 39%).</td>
</tr>
<tr>
<td>Mayberry et al. (69), 1985 and 1986</td>
<td>975 (colon)</td>
<td>Patient interviews, medical records</td>
<td>Age, sex, tumor stage, histology, anatomic location, treatment, comorbidity, health behaviors, symptoms, geographic location, and SES</td>
<td>No statistically significant difference between black and white patients in the use of adjuvant therapy. Black patients had worse cancer-specific survival than white patients (RR = 1.3; 95% CI = 1.0 to 1.8).</td>
</tr>
</tbody>
</table>

(Table continues)
There is less information on the treatment and outcomes of colorectal cancer among other ethnic groups in the United States. Gilliland et al. (72) examined data collected by the New Mexico Tumor Registry during 1969–1994 including 6776 patients with colon cancer and 3076 patients with rectal cancer. During 1983–1994, the adjusted relative mortality rate for Hispanic rectal cancer patients compared with white patients was 1.28 (95% CI = 1.11 to 1.47). In Florida, Roetzheim et al. (33) found that, among 211 elderly patients with colorectal cancer, those with a family income lower than $10,000 had a higher risk of death than those with a family income greater than $20,000 (RR = 2.5; 95% CI = 1.4 to 4.6). In the National Cancer Data Base report on colon cancer (3), patients with low income (estimated using residential ZIP code) had 5%–7% worse 5-year relative survival than middle-income or high-income patients, and a smaller study (52) reported a similar finding. However, in their study of colorectal cancer patients treated in Comprehensive Cancer Centers, Dayal et al. (60) found that, after adjusting for race, tumor stage, sex, and age, SES (measured by the percentage of high school graduates in a given ZIP code) was not statistically significantly associated with OS. It is unclear, however, whether the range of SES among patients treated in such centers reflects the diversity of SES in the wider population. Roetzheim et al. (33) examined the impact of insurance status (a proxy measure of SES) in the non-Medicare population in 9551 patients with colorectal cancer registered in the state of Florida cancer registry in 1994. Among non-Medicare patients, those with no health insurance were less likely to undergo surgery than patients with indemnity insurance, after adjustment for stage. Uninsured patients and patients enrolled in HMO plans had higher mor-

<table>
<thead>
<tr>
<th>Authors (reference Nos.), study period</th>
<th>No. of patients (cancer site)</th>
<th>Source of data</th>
<th>Variables in multivariable analyses</th>
<th>Major findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooper et al. (34), 1987</td>
<td>81,579 hospitalizations (colorectal)</td>
<td>Administrative data</td>
<td>Age, sex, comorbidity, tumor location and extent, and hospital type</td>
<td>Compared with white patients, black patients less likely to undergo surgical resection (68% versus 78%) and had higher 2-y mortality (40.0% versus 33.5%).</td>
</tr>
<tr>
<td>Cooper et al. (71), 1989–1991</td>
<td>148,947 (colorectal)</td>
<td>Administrative data</td>
<td>Age and sex</td>
<td>2-y case fatality higher among blacks (42.1%–47.9%) than among whites (37.8%–39.4%).</td>
</tr>
<tr>
<td>Lee et al. (70), 1989</td>
<td>790 (colon)</td>
<td>Administrative data</td>
<td>Age, sex, comorbid illness, hospital characteristics, county characteristics, distance to hospital, and Medicaid eligibility</td>
<td>No statistically significant difference between blacks and whites in the odds of undergoing colectomy or receiving radiation therapy within 90 days of hospital admission.</td>
</tr>
<tr>
<td>Tropman et al. (38), 1991 and 1996</td>
<td>230 (colon)</td>
<td>Medical records</td>
<td>Age, sex, tumor size, state, and year of diagnosis</td>
<td>White patients with stage III cancer more likely to receive adjuvant chemotherapy than nonwhite patients (OR = 4.9; 95% CI = 1.49 to 16.39)</td>
</tr>
<tr>
<td>Roetzheim et al. (33), 1994</td>
<td>9551 (colorectal), Florida</td>
<td>Cancer registry, administrative data</td>
<td>Age, sex, tumor stage, tumor location, comorbidity, marital status, smoking status, and SES</td>
<td>No statistically significant racial differences in definitive surgery. Black patients had higher mortality rate than white patients (RR = 1.18; 95% CI = 1.01 to 1.37).</td>
</tr>
</tbody>
</table>

*SES = socioeconomic status; RR = relative risk; CI = confidence interval; OS = overall survival; VA = Department of Veterans Affairs.
†Comprehensive Cancer Centers centralized data system.

There is less information on the treatment and outcomes of colorectal cancer among other ethnic groups in the United States. Gilliland et al. (72) examined data collected by the New Mexico Tumor Registry during 1969–1994 including 6776 patients with colon cancer and 3076 patients with rectal cancer. During 1983–1994, the adjusted relative mortality rate for Hispanic rectal cancer patients compared with white patients was 1.28 (95% CI = 1.11 to 1.47). In Florida, Roetzheim et al. (33) found that, after adjusting for race, tumor stage, sex, and age, blacks had a statistically significantly higher mortality rate than whites after adjustment for age and tumor stage (RR = 1.2; 95% CI = 1.0 to 1.6). Wegner et al. (54) analyzed the outcome of 2327 colorectal cancer patients registered in the Hawaii tumor registry during 1960 through 1974. Japanese patients were found to have the best cancer-specific survival for both colon and rectal cancers, statistically significantly better than for Filipino or Hawaiian patients.

### Socioeconomic Status

A wealth of data indicates an inverse relationship between cancer survival and socioeconomic status (SES) (9). However, remarkably few studies have examined the impact of SES on the treatment or outcomes of patients with colorectal cancer in the United States (Table 6). In a study of patients identified through the New Mexico tumor registry, Goodwin et al. (37) found that, among 211 elderly patients with colorectal cancer, those with a family income lower than $10,000 had a higher risk of death than those with a family income greater than $20,000 (RR = 2.5; 95% CI = 1.4 to 4.6). In the National Cancer Data Base report on colon cancer (3), patients with low income (estimated using residential ZIP code) had 5%–7% worse 5-year relative survival than middle-income or high-income patients, and a smaller study (52) reported a similar finding. However, in their study of colorectal cancer patients treated in Comprehensive Cancer Centers, Dayal et al. (60) found that, after adjusting for race, tumor stage, sex, and age, SES (measured by the percentage of high school graduates in a given ZIP code) was not statistically significantly associated with OS. It is unclear, however, whether the range of SES among patients treated in such centers reflects the diversity of SES in the wider population. Roetzheim et al. (33) examined the impact of insurance status (a proxy measure of SES) in the non-Medicare population in 9551 patients with colorectal cancer registered in the state of Florida cancer registry in 1994. Among non-Medicare patients, those with no health insurance were less likely to undergo surgery than patients with indemnity insurance, after adjustment for stage. Uninsured patients and patients enrolled in HMO plans had higher mor-

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tality rates than patients enrolled in FFS plans. In Hawaii, Wegner et al. (54) found that colorectal cancer patients with a high SES had better cancer-specific survival than low- or middle-SES patients, although the difference was not statistically significant.

Other studies have compared the impact of SES on cancer outcomes in the United States and Canada. Boyd et al. (75) used data from the SEER Program and the Ontario Cancer Registry to analyze the association between community income and cancer-specific survival for several forms of cancer. For most cancer sites, including colorectal cancer, those living in more affluent communities had better 5-year cancer-specific survival and relative survival than those living in less affluent communities in both the United States and Canada, although the association between SES and outcome was stronger in the United States. However, U.S. colorectal cancer patients had better 5-year cancer-specific survival than their Canadian counterparts in all equivalent SES quintiles. In a similar study, Gory et al. (76) performed a population-based comparison of cancer survival between Toronto, ON, Canada, and Detroit, MI. In Detroit, colon cancer patients in the lowest SES tertile had worse 5-year cancer-specific survival than those in the highest tertile, while this association was not found for patients in Toronto. Recently, a quality-of-life survey of 173 colorectal cancer patients sampled from the Washington State Cancer Surveillance System (77) found that, of several demographic and tumor variables, only low income was associated with worse ambulation, pain, and social and emotional well-being.

### CONCLUSION

This review indicates that surgeon experience has been related most consistently to outcomes that measure tumor control, such as better local control or cancer-specific survival. In some reports, surgeon or hospital volume has been associated with a greater chance of sphincter preservation. While some studies have reported an association between provider characteristics and postoperative mortality or OS, these findings were not consistent. There is no evidence that patients treated by HMO providers receive substantially different treatment or have different outcomes than those receiving care under FFS plans.

Older patients are less likely to be given chemotherapy than younger patients. This situation may be due in part to increased toxicity among older patients, but it is possible that older patients with regional disease are not receiving potentially beneficial adjuvant therapy. Some studies, however, did not control for tumor stage and comorbidity, making it difficult to determine what proportion of eligible patients were not receiving adjuvant therapy and the extent to which reasonable clinical judgments about patient performance status contributed to this apparent discrepancy. In studies that controlled for these factors, however, tumor stage and comorbidity did not fully account for the less intensive treatment provided to older patients. To achieve greater insight into the quality of care received by older patients, it would be useful to study the impact of patient preferences, comorbidity, and functional status on the treatment provided.

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Table 6. Studies of the effect of socioeconomic status on treatment and outcomes of colorectal cancer*

<table>
<thead>
<tr>
<th>Authors (reference Nos.), study period</th>
<th>No. of patients (cancer site)</th>
<th>Source of data (location)</th>
<th>Variables in multivariable analyses</th>
<th>Major findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wegner et al. (54), 1960–1974</td>
<td>2327 (colorectal)</td>
<td>Cancer registry, census (Hawaii)</td>
<td>Age, sex, and tumor stage</td>
<td>SES (based on education and income) not statistically significantly associated with CSS.</td>
</tr>
<tr>
<td>Chirikos and Horner (52), 1977–1981</td>
<td>84 (colorectal)</td>
<td>Cancer registry, census (Ohio)</td>
<td>Age, tumor stage, surgery, and tumor site</td>
<td>High-income patients had better survival.</td>
</tr>
<tr>
<td>Dayal et al. (60), 1977–1982</td>
<td>5145 (colorectal)</td>
<td>Cancer registry, census (United States)</td>
<td>Age, sex, tumor stage, and race</td>
<td>Stepwise increase in OS with increasing SES (proportion of high school graduates among adults in patient’s ZIP code).</td>
</tr>
<tr>
<td>Goodwin et al. (37), 1984–1986</td>
<td>211 (colorectal)</td>
<td>Cancer registry, patient interviews (New Mexico)</td>
<td>Age, sex, tumor stage, treatment, social support, ethnicity, comorbidity, functional status, and educational level</td>
<td>Survival decreased with decreasing family income.</td>
</tr>
<tr>
<td>Boyd et al. (75), 1987–1992</td>
<td>Not stated (included all incident colon and rectal cancer cases in SEER and Ontario during study period)</td>
<td>Cancer registry (United States; Ontario, Canada)</td>
<td>Age, sex, and year of diagnosis</td>
<td>Stepwise decrease in CSS with decreasing SES quintile in the United States (median income in patient’s ZIP code).</td>
</tr>
<tr>
<td>Gory et al. (76), 1990–1991</td>
<td>21 851 (colorectal)</td>
<td>Cancer registry, census (Toronto, Canada; Detroit, MI)</td>
<td>Age</td>
<td>Stepwise decrease in CSS with decreasing SES tertile in the United States (median household income in census tract).</td>
</tr>
<tr>
<td>Roetzheim et al. (33), 1994</td>
<td>9551 (colorectal)</td>
<td>Cancer registry, census, administrative data (Florida)</td>
<td>Age, sex, tumor stage, tumor location, comorbidity, marital status, race, educational level, and smoking status</td>
<td>Uninsured patients are less likely to undergo surgery and have higher mortality than patients with private insurance. Median income level not associated with surgery rates or survival.</td>
</tr>
</tbody>
</table>

*SEER = Surveillance, Epidemiology, and End Results; SES = socioeconomic status; CSS = cancer-specific survival; OS = overall survival.
No sex-related differences in the use of chemotherapy for colorectal cancer are apparent, although few studies have examined this issue. Furthermore, the sex of the patient does not appear to be a major determinant of the outcomes of colorectal cancer.

Black and Native American patients with colorectal cancer receive less intensive therapy and have worse outcomes than white patients. Few studies, however, have assessed treatment and outcomes of Hispanic or Asian-American patients, and more research will be required to assess the care that these groups receive. When black and white patients have received comparable care, these two groups have had similar relative and cancer-specific survival, indicating that racial disparities in treatment may, in part, account for the disparities in outcome.

While these studies generate useful hypotheses about how patient and provider characteristics influence treatment and outcomes, they leave many important issues unresolved. First, the reproducibility of the results has not been established. Unlike biologic risk factors such as tumor stage, provider characteristics have been assessed in relatively few studies, and some of these studies have produced conflicting results. Secondly, there has been no uniform definition regarding what constitutes provider "expertise" and how many cases are sufficient to achieve "high volume." Different studies (5,8,15) have applied different definitions of surgical expertise, which may, in part, account for their contradictory findings. Also, many studies have not had clear a priori hypotheses about expected findings or mechanisms to account for them. Thirdly, many studies considered colon and rectal cancers together. The technical demands of rectal surgery and the demonstrated relationship between surgical technique and local control in rectal cancer (78,79) suggest that surgical expertise may have a greater impact on the outcome of rectal cancer than of colon cancer. Finally, there is little information on the mechanisms by which provider characteristics influence outcome. High-volume surgeons may perform more skillful procedures, have access to better medical equipment, and may refer their patients more appropriately to adjuvant therapy.

To provide optimal treatment equitably to patients with colorectal cancer, a better understanding of factors that produce variations in treatment will be required. Although cancer registries and administrative data can provide insight into the treatment and outcomes of patients in a large population, these sources often lack important variables that are used to make clinical decisions. To understand how variations in care relate to the quality of care, further research is needed to characterize in more detail the treatment that patients receive as well as broader cancer-related outcomes, such as quality of life. Variations in practice may represent inequitable access to care, poor-quality care, or sound clinical judgment reflecting the variability of disease. Physicians may have differing degrees of familiarity with standards of care (80), and practice may vary when clear standards do not exist, as with follow-up after surgical resection (81–85).

Because the existing literature indicates areas of concern for suboptimal care, future studies will need to collect more detailed data on physicians’ decision-making and patients’ preferences and quality of life to shed light on the quality of care provided. Understanding the causes of variations in clinical practice and outcomes will provide the basis for improving quality of care by applying the best available treatment to all eligible patients with colorectal cancer.

References

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(68) Ball JK, Elixhauser A. Treatment differences between blacks and whites with colorectal cancer. Med Care 1996;34:970–84.


NOTES

Editor’s note: SEER is a set of geographically defined, population-based, central cancer registries in the United States, operated by local nonprofit organizations under contract to the National Cancer Institute (NCI). Registry data are submitted electronically without personal identifiers to the NCI on a biannual basis, and the NCI makes the data available to the public for scientific research.

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