Variation in diagnosis, treatment and outcome in colon and rectal cancer

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Disparities in quality of care for colon cancer between hospitals in the Netherlands

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Abstract

Background

Aim of this study was to describe treatment patterns and outcome according to region, and according to hospital types and volumes among patients with colon cancer in the Netherlands.

Methods

All patients with invasive colon carcinoma diagnosed in the period 2001-2006 were selected from the Netherlands Cancer Registry. Logistic regression analyses were performed to examine the influence of relevant factors on the odds of having adequate lymph node evaluation, receiving adjuvant chemotherapy and postoperative mortality. Relative survival analysis was used to estimate relative excess risk of dying according to hospital type and volume.

Results

In total, 39,907 patients were selected. Patients diagnosed in a university hospital had a higher odds (OR 2.47; 95% CI 2.19-2.78) and patients diagnosed in a hospital with >100 colon carcinoma diagnoses annually had a lower odds (OR 0.70; 95% CI 0.64-0.77) of having ≥10 lymph nodes evaluated. The odds of receiving adjuvant chemotherapy was lower in patients diagnosed in teaching hospitals (OR 0.85; 95% CI 0.73-0.98) and university hospitals (OR 0.56; 95% CI 0.45-0.70) compared to patients diagnosed in non-teaching hospitals. Funnel plots showed large variation in these two outcome measures between individual hospitals. No differences in postoperative mortality were found between hospital types or volumes. Patients diagnosed in university hospitals and patients diagnosed in hospitals with >50 diagnoses of colon carcinoma per year had a better survival.

Conclusions

Variation in treatment and outcome of patients with colon cancer in the Netherlands was revealed, with differences between hospital types and volumes. However, variation seemed mainly based on the level of the individual hospital.

Introduction

Ever since the Institute of Medicine reviewed variations in the quality of cancer care in their 1999 report,[1] there is an ongoing debate on this issue, not only in the United States, but also in European countries. Especially, the differences in surgical outcome of patients treated in high- and low-volume hospitals and between specialised and non-specialised providers, have been studied extensively.[2-4] Most of these studies focus on adverse outcomes like complications and postoperative mortality; few describe differences in the proportion of patients getting optimal treatment for their cancer.

In the Netherlands, colon cancer is one of the most frequent cancers with more than 7,500 new diagnoses in 2007.[5] It is also one of the most frequent causes of cancer death with more than 3,800 deaths in 2007.[6] According to the current Dutch guidelines, the primary treatment for colon cancer is surgery, while adjuvant chemotherapy should be considered for patients with lymph node metastasis. Therefore, adequate lymph node evaluation is important in patients with colon cancer;[7-9] 10 or more lymph nodes should be evaluated for accepting N0 status.[10] However, regional population-based studies in the Netherlands showed large variation on the level of lymph nodes evaluated by pathologists and in the proportion of patients receiving adjuvant chemotherapy.[11;12]

Currently, colon cancer patients are treated in every hospital in the Netherlands. These patients are treated in different settings: university, teaching and non-teaching hospitals; high- and low-volume hospitals, situated in urbanised or more rural regions. It is unknown, to what extent these structural differences between hospitals lead to differences in patterns of care and outcome. A number of studies demonstrated better patient outcomes in teaching versus non-teaching hospitals.[13-15] Others found lower mortality with increasing hospital or surgeon volume.[16;17] However, studies on mortality among patients with colon cancer showed conflicting results: some demonstrated an association between mortality and hospital volume or teaching status, while others did not.[18-24]

Aim of this study was to describe variation in staging, treatment patterns and outcome according to region and, according to type and volume of individual hospitals among patients with colon cancer in the Netherlands.

Methods

Netherlands Cancer Registry

In the Netherlands, all newly diagnosed malignancies are registered in the nationwide population-based Netherlands Cancer Registry (NCR). The automated pathological archive (PALGA) and the haematology departments are the main sources of notification. The National Registry of Hospital Discharge Diagnosis is an additional source, which accounts for up to 8% of new cases.[25] Data are collected from the medical records by specially trained registrars and are coded according to a nationally used manual. Information on patient characteristics, tumour characteristics, treatment, hospital of diagnosis, hospital of treatment and follow-up is recorded. For coding tumour site and morphology the International Classification of Diseases for Oncology (ICD-O) is used.[26] Cancers are staged according to TNM classification.[27] Quality of the data is high[28] and completeness is estimated to be at least 95%.[29]

Patients

All patients with an invasive colon carcinoma, diagnosed in the period 2001-2006 were selected from the NCR. Diagnoses without histological confirmation, diagnoses based only on autopsy findings, patients living abroad and incomplete records were excluded from analyses. Tumour site was classified as ascendens (C18.0-C18.2), transversum and descendens (C18.3-C18.6), sigmoid (C18.7) and overlapping/unknown (C18.8-C18.9). Pathological stage was used to classify the extent of the disease. In cases where pathological stage was unknown, clinical stage was used.

CCC-regions and hospitals

The Netherlands is divided in 9 regions, each served by a Comprehensive Cancer Centre (CCC). Activities of CCCs are facilitation of consultancy services, development and implementation of guidelines, improving organisation of cancer care, coordinating palliative care and the population-based cancer registry. Each CCC serves an area covering five to twenty hospitals. All hospitals are affiliated to one centre. Within each CCC-region, treatment policies are discussed within multidisciplinary meetings which may lead to differences in oncologic care between the regions. Patients of all 97 hospitals in the Netherlands were included in the analyses.

A teaching hospital was defined as a hospital which provides medical training to residents. A distinction was made between a teaching hospital for surgery and a teaching hospital for internal medicine. All teaching hospitals for surgery were also teaching hospitals for internal medicine. University hospitals were teaching hospitals affiliated to a medical university. The one specialised oncology centre in the Netherlands was also classified as a university hospital.

Hospital volume was based on the mean number of diagnoses of colon carcinoma per year or on the mean number of colon resections for cancer per year. In the Netherlands, resections for colon cancer are in general performed in the hospital of diagnosis. Hospital volume was categorised into <50 , 50-100 and >100 diagnoses/resections per year.

For the analyses of treatment and relative survival, type of hospital was based on the hospital where the tumour was diagnosed reasoning that referral of patients for treatment in another hospital can also be considered as a good standard of care. For the analyses of postoperative mortality, type of hospital was based on the hospital where the surgery was performed.

Statistical analyses

Treatment was described as percentages per stage and age group (<75 years and ≥75 years).

Variation in lymph node evaluation and adjuvant chemotherapy

Logistic regression analysis was performed to examine the influence of age at diagnosis, gender, depth of invasion, nodal involvement, type of hospital of diagnosis, hospital volume, CCC-region and year of diagnosis on the odds of having an adequate lymph node evaluation (defined as 10 or more evaluated lymph nodes). Patients whose tumour was removed by polypectomy and patients with distant metastasis (M1) were excluded from this analysis.

Moreover, the influence of age at diagnosis, gender, type of hospital of diagnosis, hospital volume, CCC-region and year of diagnosis on the odds of receiving adjuvant chemotherapy among patients with stage III disease was analysed using logistic regression analysis. To compare the performance of the individual hospitals for these two outcome measures, funnel plots were made using 95% control limits calculated around the mean of the 20% best performing hospitals.[30;31] The proportion of resections involving 10 or more evaluated lymph nodes was adjusted for age, gender, depth of invasion (pT) and nodal involvement (pN). The proportion of resected patients receiving adjuvant chemotherapy was adjusted for age and gender. Each hospital was displayed as a scatter point presenting the adjusted rate for the outcome and the hospital type and volume.

Variation in postoperative mortality

Logistic regression analysis was used to investigate the odds of postoperative mortality by age at diagnosis, gender, depth of invasion, type of hospital of surgery, resection volume of hospital of surgery and CCC-region. Postoperative mortality was defined as death within 30 days after surgery. Patients with distant metastasis (M1) and acute surgery

(date of surgery = date of first pathological examination) were excluded from this analysis. Postoperative mortality was analysed for tumours diagnosed in 2005 and 2006, because date of surgery was not registered in the NCR until 2005.

Variation in survival

Relative excess risks (RER) of dying according to hospital type and volume were estimated by means of multivariate relative survival analyses. Relative survival, an estimation of disease-specific survival, was calculated as the ratio of the observed rates in cancer patients to the expected rates in the general population using the Ederer method.[32] Results of the multivariate relative survival analyses were stratified by pathological stage of the tumour, because interaction was found between stage and hospital type. Length of follow-up was calculated as the time from diagnosis to death or to 1st January 2008. Only first tumours were included in the multivariate relative survival analyses.

STATA (version 10.0) was used for the analyses. A p-value below 0.05 was considered statistically significant.

Results

In the period 2001-2006, 39,907 patients were newly diagnosed with colon carcinoma in the Netherlands, with an annual increase from 6,016 in 2001 to 7,360 in 2006. The male/female ratio was 1:1 and 40% of the patients were aged 75 years or older. Most frequent were stage II tumours (35%). Stage was unknown for 3% of the patients. Six percent of the patients were diagnosed in a university hospital and half of the patients were diagnosed in a hospital with 50-100 diagnoses per year (Table 1).

Treatment

Almost all patients with stages I-III disease underwent surgical resection. Around 10% of the stage I tumours were removed by endoscopic polypectomy. Of the patients younger than 75 years with stage III disease 76% received adjuvant chemotherapy. Among patients 75 years and older this proportion was 17%. Around 60% of patients with stage IV disease underwent surgical resection of the primary tumour. The surgery of the primary tumour was combined with chemotherapy in 39% of the patients younger than 75 years and in 10% of the patients 75 years and older. The proportion of patients with stage IV disease who did not receive any treatment was 15% among patients younger than 75 years and 37% among patients 75 years and older (Figure 1).

Table 1 Description of study population (N=39,907)

	N	%
Gender		
Male	19,882	49.8
Female	20,025	50.2
Age at diagnosis (yrs)		
<60	7,269	18.2
60-74	16,553	41.5
≥75	16,085	40.3
Year of diagnosis		
2001	6,016	15.1
2002	6,127	15.4
2003	6,487	16.3
2004	6,840	17.1
2005	7,077	17.7
2006	7,360	18.4
Tumour location		
Ascendens	14,434	36.2
Transversum and descendens	9,318	23.4
Sigmoid	15,091	37.8
Overlapping/unknown	1,064	2.7
Pathological stage		
I	6,209	15.6
II	13,812	34.6
III	10,024	25.1
IV	8,662	21.7
Unknown	1,200	3.0
Teaching hospital surgery		
No	16,808	42.1
Yes	20,651	51.8
University hospital	2,448	6.1
Teaching hospital internal medicine		
No	12,231	30.7
Yes	25,228	63.2
University hospital	2,448	6.1
Annual volume of hospital of diagnosis		
<50 diagnoses of colon carcinoma	7,484	18.8
50-100 diagnoses of colon carcinoma	19,816	49.7
>100 diagnoses of colon carcinoma	12,607	31.6
Comprehensive Cancer Centre region		
1	6,900	17.3
2	5,496	13.8
3	3,529	8.8
4	2,930	7.3
5	4,044	10.1
6	5,632	14.1
7	5,651	14.2
8	2,485	6.2
9	3,240	8.1

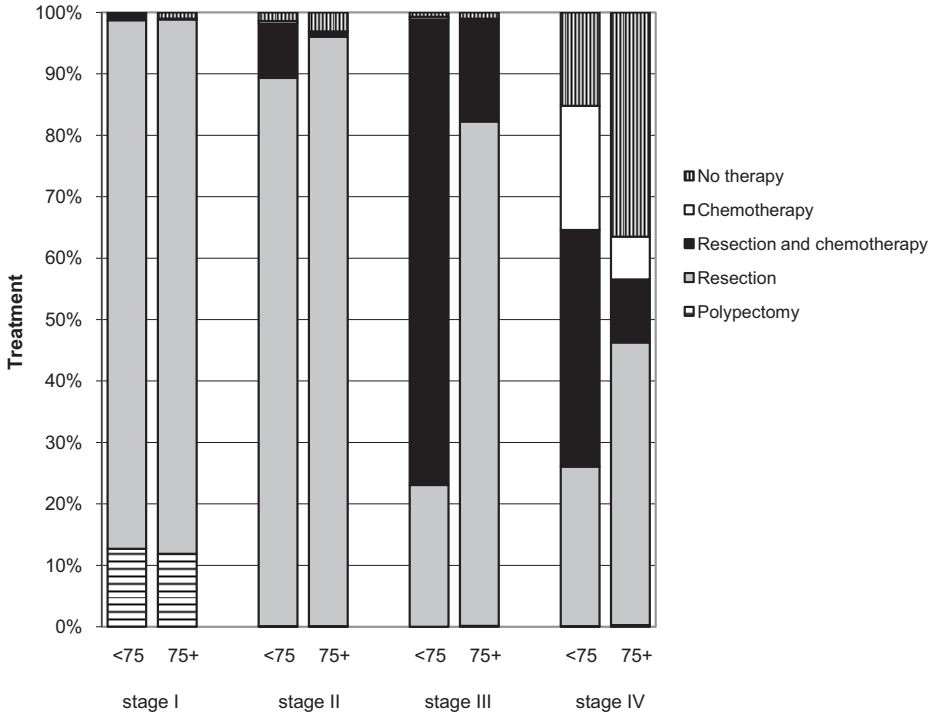

Figure 1 Treatment according to stage and age at diagnosis

Lymph node evaluation

The proportion of patients with 10 or more evaluated lymph nodes after resection increased from 31% in 2001 to 58% in 2006, with an odds ratio of 3.29 (95% CI 3.00-3.60) in 2006 compared to 2001. Female patients were more likely to have had 10 or more lymph nodes evaluated after resection. The odds ratio decreased with older age at diagnosis. The odds of having an adequate lymph node evaluation increased by year of diagnosis, up to 3.29 (95% CI 3.00-3.60) in 2006 compared to 2001. Patients with a larger depth of invasion and with nodal involvement were more likely to have had 10 or more lymph nodes evaluated. Patients diagnosed in a university hospital were more likely to have an adequate lymph node evaluation (OR 2.47; 95% CI 2.19-2.78). Patients diagnosed in a hospital with more than 100 resections per year were less likely to have an adequate lymph node evaluation (OR 0.70; 95% CI 0.64-0.77). There was variation between CCC-regions in the odds of having 10 or more lymph nodes evaluated (Table 2). In the funnel plot, the adjusted proportion of patients with 10 or more evaluated lymph nodes is depicted for each hospital by hospital type and the mean number of colon resections per year, showing a large variation between the individual

Table 2 Odds ratio of having 10 or more lymph nodes evaluated in patients with stage I-III (multivariate logistic regression analysis)

	OR	95% CI
Gender		
Male	1.00	Reference
Female	1.14*	1.08-1.20
Age at diagnosis (yrs)		
<60	1.00	Reference
60-74	0.74*	0.69-0.79
≥75	0.54*	0.50-0.58
Year of diagnosis		
2001	1.00	Reference
2002	1.16*	1.06-1.28
2003	1.30*	1.18-1.43
2004	1.61*	1.47-1.77
2005	2.57*	2.34-2.81
2006	3.29*	3.00-3.60
Depth of invasion		
pT1	1.00	Reference
pT2	3.06*	2.64-3.55
pT3	5.02*	4.38-5.76
pT4	4.62*	3.97-5.38
Nodal involvement		
pN0	1.00	Reference
pN+	1.27*	1.20-1.34
Hospital of diagnosis		
Non-teaching hospital	1.00	Reference
Teaching hospital for surgery	1.04	0.97-1.11
University hospital	2.47*	2.19-2.78
Annual volume of hospital of diagnosis		
<50 resections of colon carcinoma	1.00	Reference
50-100 resections of colon carcinoma	0.97	0.91-1.04
>100 resections of colon carcinoma	0.70*	0.64-0.77
Comprehensive Cancer Centre region		
1	1.00	Reference
2	1.22*	1.11-1.34
3	1.32*	1.19-1.47
4	1.38*	1.24-1.55
5	1.19*	1.08-1.32
6	0.92	0.84-1.01
7	0.70*	0.64-0.78
8	0.85*	0.75-0.97
9	1.28*	1.15-1.42

* P<0.05
OR, odds ratio; 95% CI, 95% confidence interval

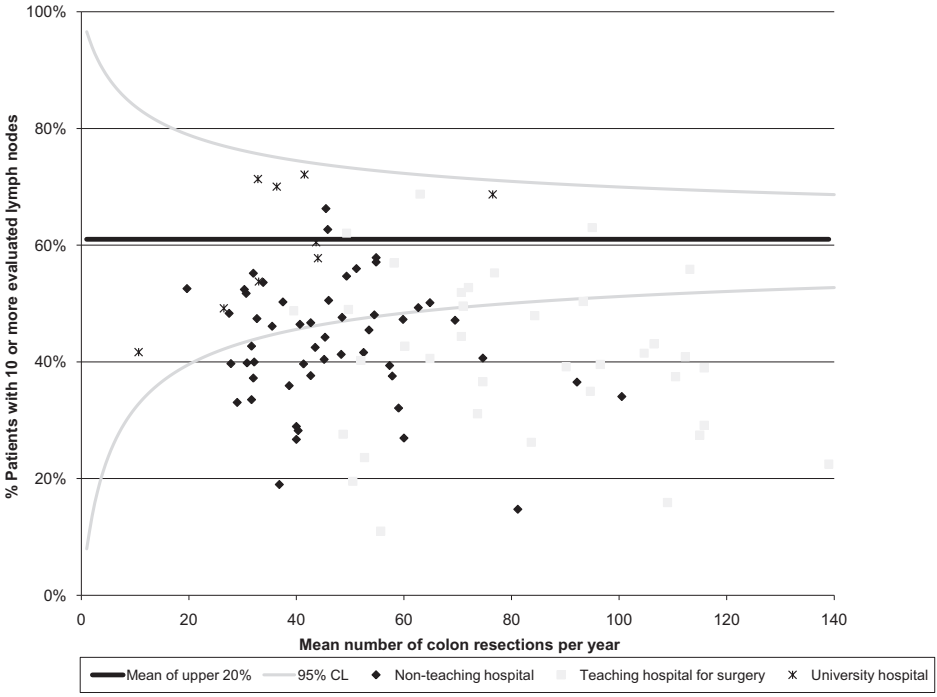

Figure 2 Funnel plot of proportion of patients of whom 10 or more lymph nodes were evaluated after resection in the period 2001-2006 according to hospital type and the mean number of colon resections per year. The proportion for each hospital was adjusted for gender, age at diagnosis, depth of invasion and nodal involvement to account for differences in case-mix between the hospitals.

hospitals (Figure 2). The proportion of patients with an adequate lymph node evaluation ranged from more than 70% to less than 20% per hospital.

Adjuvant chemotherapy

In Table 3 the odds of receiving adjuvant chemotherapy in patients with stage III tumours is shown. The use of adjuvant chemotherapy in patients with stage III tumours increased from 49% in 2001 to 58% in 2006, with an odds ratio of 1.66 (95% CI 1.40-1.97) in 2006 compared to 2001. Female patients had a lower odds of receiving adjuvant chemotherapy (OR 0.88; 95% CI 0.80-0.98). The odds of receiving adjuvant chemotherapy decreased with increasing age, with an odds ratio of 0.03 (95% CI 0.03-0.04) in patients 75 years and older compared to those younger than 60 years. Patients diagnosed in a teaching hospital for internal medicine or in a university hospital had a lower odds of receiving adjuvant chemotherapy, compared to patients diagnosed in a non-teaching hospital. No significant difference in adjuvant chemotherapy administration between hospitals with different volumes was found. The administration of adjuvant

chemotherapy differed between CCC-regions. However, there was also a wide variation between hospitals within the regions (data not shown). The funnel plot shows, for each hospital, the adjusted proportion of patients younger than 75 years with stage III disease receiving adjuvant chemotherapy by hospital type and the mean number of diagnoses per year, demonstrating some variation between the hospitals (Figure 3). The proportion of patients who received adjuvant chemotherapy varied from less than 50% to more than 90% for individual hospitals.

Table 3 Odds ratio of receiving adjuvant chemotherapy in patients with stage III disease (multivariate logistic regression analysis)

	OR	95% CI
Gender		
Male	1.00	Reference
Female	0.88*	0.80-0.98
Age at diagnosis (yrs)		
<60	1.00	Reference
60-74	0.40*	0.34-0.46
≥75	0.03*	0.03-0.04
Year of diagnosis		
2001	1.00	Reference
2002	1.05	0.88-1.25
2003	1.22*	1.02-1.46
2004	1.34*	1.13-1.59
2005	1.44*	1.21-1.71
2006	1.66*	1.40-1.97
Hospital of diagnosis		
Non-teaching hospital	1.00	Reference
Teaching hospital for internal medicine	0.85*	0.73-0.98
University hospital	0.56*	0.45-0.70
Annual volume of hospital of diagnosis		
<50 diagnoses of colon carcinoma	1.00	Reference
50-100 diagnoses of colon carcinoma	1.04	0.89-1.22
>100 diagnoses of colon carcinoma	0.91	0.74-1.11
Comprehensive Cancer Centre region		
1	1.00	Reference
2	0.84	0.70-1.02
3	0.73*	0.59-0.90
4	0.86	0.69-1.07
5	0.76*	0.63-0.93
6	0.98	0.82-1.18
7	0.88	0.73-1.06
8	1.66*	1.29-2.12
9	0.84	0.68-1.05

* P<0.05
OR, odds ratio; 95% CI, 95% confidence interval

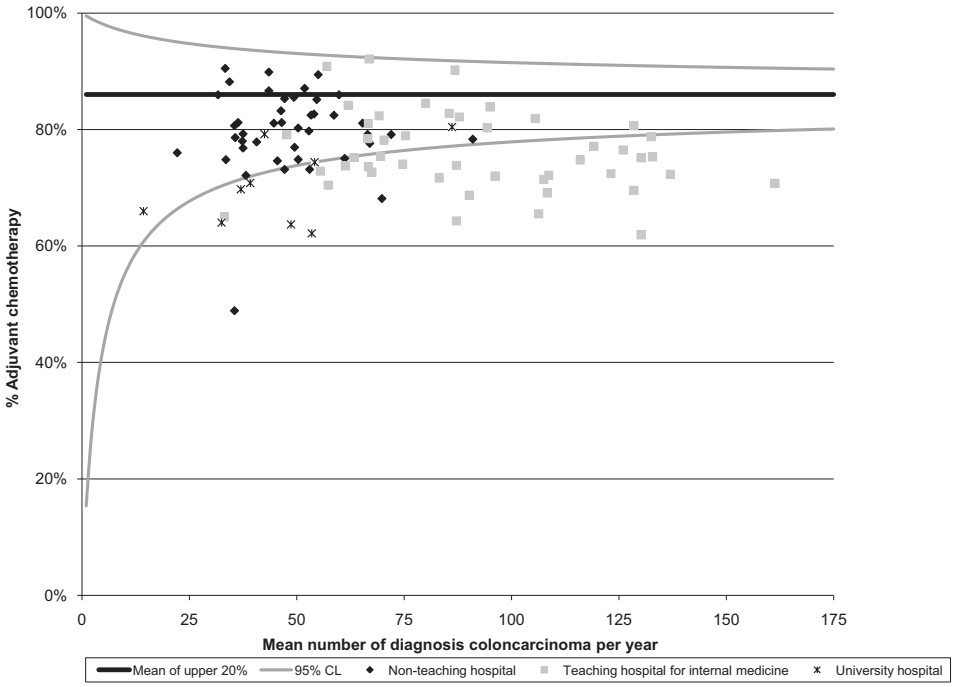

Figure 3 Funnel plot of proportion of patients <75 years with stage III disease receiving adjuvant chemotherapy in the period 2001-2006 according to hospital type and the mean number of diagnoses per year. The proportion for each hospital was adjusted for age and gender to account for differences in case-mix between the hospitals.

Postoperative mortality

Overall, 4.2% of the patients without distant metastasis at diagnosis undergoing an elective resection died within 30 days after surgery. Female patients had a lower odds of dying within 30 days after resection (OR 0.74; 95% CI 0.58-0.93). The odds of dying within 30 days increased with increasing age, up to 11.61 (95% CI 6.13-21.98) for patients aged 75 years and older compared to those younger than 60 years. The odds was higher for T4 tumours compared with T1-T3 tumours (OR 1.87; 95% CI 1.37-2.56). No differences in postoperative mortality were found between hospital types, hospital volumes and CCC-regions (Table 4).

Multivariate relative excess risks (RER) of dying

In the multivariate model for all patients with colon cancer, patients diagnosed in a university hospital had a lower risk of dying compared to patients diagnosed in a non-teaching hospital (RER 0.76; 95% CI 0.69-0.83). Patients diagnosed in hospitals with 50-100 diagnoses of colon carcinoma and with more than 100 diagnoses of colon carcinoma yearly had a lower risk of dying compared to patients diagnosed in a hospital with

Table 4 Odds ratio of death within 30 days after resection in patients without distant metastasis (multivariate logistic regression analysis)

	OR	95% CI
Gender		
Male	1.00	Reference
Female	0.74*	0.58-0.93
Age at diagnosis (yrs)		
<60	1.00	Reference
60-74	2.55*	1.30-5.00
≥75	11.61*	6.13-21.98
Depth of invasion		
T1-T2-T3	1.00	Reference
T4	1.87*	1.37-2.56
Unknown	1.58	0.37-6.81
Hospital of surgery		
Non-teaching hospital	1.00	Reference
Teaching hospital for surgery	0.95	0.71-1.28
University hospital	1.06	0.63-1.80
Annual volume of hospital of surgery		
<50 resections of colon carcinoma	1.00	Reference
50-100 resections of colon carcinoma	1.33	0.93-1.88
>100 resections of colon carcinoma	1.23	0.77-1.98
Comprehensive Cancer Centre region		
1	1.00	Reference
2	0.69	0.44-1.08
3	0.84	0.51-1.38
4	0.95	0.58-1.57
5	0.95	0.61-1.47
6	0.83	0.54-1.27
7	1.07	0.71-1.63
8	0.61	0.32-1.16
9	0.83	0.50-1.38

* P<0.05
OR, odds ratio; 95% CI, 95% confidence interval

less than 50 diagnoses of colon carcinoma yearly (RER 0.90; 95% CI 0.85-0.95 and RER 0.86; 95% CI 0.80-0.93, respectively).

For stage I, survival was worse in patients diagnosed in a university hospital (RER 1.87; 95% CI 1.02-3.42). No differences in survival of patients with stage II disease were found between hospital types or between hospital volumes. Both among patients with stage III disease and among patients with stage IV disease, patients diagnosed in a university hospital had a lower risk of dying compared to patients diagnosed in a non-teaching hospital (RER 0.70; 95% CI 0.57-0.87 and RER 0.77; 95% CI 0.69-0.86, respectively). For stage IV, patients diagnosed in hospitals with 50-100 diagnoses of colon carcinoma yearly and more than 100 diagnoses of colon carcinoma yearly had a better survival (RER 0.88; 95% CI 0.82-0.95 and RER 0.85; 95% CI 0.77-0.94, respectively) (Table 5).

Table 4 Relative excess risks of dying for patients with colon cancer diagnosed in the period 2001-2006, according to stage (multivariate relative survival analyses)

	Total[1]		Stage I[2]		Stage II[2]		Stage III[3]		Stage IV[4]	
	RER	95 % CI	RER	95% CI	RER	95% CI	RER	95% CI	RER	95% CI
Type of hospital of diagnosis										
Non-teaching hospital	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Teaching hospital surgery	1.03	0.98-1.09	1.11	0.70-1.76	1.14	0.99-1.31	0.96	0.86-1.07	1.05	0.98-1.12
University hospital	0.76*	0.69-0.83	1.87*	1.02-3.42	0.74	0.54-1.00	0.70*	0.57-0.87	0.77*	0.69-0.86
Annual volume of hospital of diagnosis										
<50 diagnoses of colon carcinoma	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
50-100 diagnoses of colon carcinoma	0.90*	0.85-0.95	0.92	0.56-1.51	0.98	0.83-1.16	0.90	0.80-1.02	0.88*	0.82-0.95
>100 diagnoses of colon carcinoma	0.86*	0.80-0.93	0.84	0.44-1.61	0.87	0.70-1.07	0.88	0.75-1.03	0.85*	0.77-0.94

[1] Adjusted for gender, age at diagnosis, grade, year of diagnosis, tumour location, stage, surgery, chemotherapy and CCC-region
[2] Adjusted for gender, age at diagnosis, grade, year of diagnosis, tumour location, depth of invasion, surgery and CCC-region
[3] Adjusted for gender, age at diagnosis, grade, year of diagnosis, tumour location, depth of invasion, surgery, chemotherapy, number of positive nodes and CCC-region
[4] Adjusted for gender, age at diagnosis, grade, year of diagnosis, tumour location, depth of invasion, surgery, chemotherapy and CCC-region
* P<0.05
RER, relative excess risk; 95% CI, 95% confidence interval

Discussion

In this nationwide population-based study, analysing Netherlands Cancer Registry data of 39,907 patients with colon carcinoma diagnosed in the period 2001-2006, considerable variation in treatment patterns and outcome was identified. The proportion of patients receiving optimal postoperative staging with adequate lymph node evaluation and accurate treatment for their cancer increased considerably over time, but differed widely between individual hospitals.
Being diagnosed in a hospital with a large patient volume or in a university hospital was positively related with the odds of having an adequate lymph node evaluation, and being diagnosed in a teaching hospital or in a university hospital had a negative relation with the odds of receiving adjuvant chemotherapy. Differences in relative survival were found between the various types and volumes of hospitals. In total, patients diagnosed in a university hospital or patients diagnosed in a hospital with a large volume had a better survival.

In literature, the number of studies evaluating differences in quality of care between various types of providers is overwhelming. Most studies show an inverse relationship between hospital volume and mortality, especially for high-risk surgical procedures.[2;16;17] However, few studies have focused on other dimensions of quality of care besides differences in morbidity and mortality after surgery. In our study two important aspects of high leverage colon cancer treatment were investigated, lymph node evaluation and the administration of adjuvant chemotherapy. The choice for these specific process measures is supported by evidence from the literature.[9;33]

Lymph node evaluation
Lymph node evaluation is crucial for staging and planning treatment in patients with colon cancer. Since adjuvant chemotherapy should be considered for patients with positive lymph nodes, inadequate lymph node examination might lead to understaging and undertreatment.[7;8] On the other hand, according to Dutch treatment guidelines, adjuvant chemotherapy should be considered for patients with stage II disease who had less than 10 evaluated lymph nodes, which could lead to overtreatment.[10] In our study we found that patients diagnosed in a university hospital were more likely to have more lymph nodes examined. This confirms the results of earlier studies from Canada and France.[34;35] The available resources in university hospitals to provide high quality multidisciplinary cancer care could be an explanation for this result. Other studies found a positive correlation between hospital volume and number of evaluated lymph nodes.[36;37] The current study, however, found an inverse relationship and showed that patients diagnosed in high-volume hospitals were less likely to have 10 or more lymph

nodes examined. This suggests that an increased workload for pathology staff might lead to a less extensive lymph node evaluation, although a high-volume hospital not always was served by a high-volume pathology laboratory. Furthermore, the workload per pathologist depends on the number of pathologists in the staff. Unfortunately, data on individual pathologists was not available in the NCR. However, the differences found between individual hospitals are remarkable.

Adjuvant chemotherapy

Ever since a randomised trial in the early nineties showed that patients with stage III colon carcinoma treated with adjuvant chemotherapy had a significant survival benefit,[33] chemotherapy after surgery has been the standard of care for stage III patients with an adequate performance status.[10] However, not all patients with stage III disease receive adjuvant chemotherapy.[12] There are several explanations why elderly patients receive adjuvant chemotherapy less often than younger patients, such as the presence of comorbidities, unfavourable performance status or patient refusal.[38-40] Our study is hampered by the lack of information about comorbidities and performance status of the patient at the time of diagnoses. Nevertheless marked differences in the performance status of patients between hospitals in the Netherlands have not been reported.

University hospitals and teaching hospitals proved more restraint in the use of adjuvant chemotherapy compared to general hospitals. A French regional study showed the opposite: a lower relative risk for receiving adjuvant chemotherapy in patients treated in non-teaching hospitals compared to a single university centre.[34] An American study demonstrated that patients treated by surgeons practicing in a teaching hospital were more likely to see a medical oncologist.[41] Our contrasting findings suggest a more severe selection of patients for administering adjuvant chemotherapy in university hospitals.

Postoperative mortality

In our study, age was an important predictor for postoperative mortality. According to a review of the Colorectal Cancer Collaborative Group, the increased proportion of elderly patients undergoing emergency surgery, together with multiple comorbidities, could contribute to this increased risk of postoperative mortality.[42] However, in our study only elective procedures were included, with a very high risk of postoperative mortality in the elderly patient group compared to the younger patient group. Elderly patients undergoing major surgery can have similar outcomes as younger patients if carefully selected.[42;43] However, the risk of obstruction or even perforation in colon cancer patients forces surgeons to perform surgery in elderly patients with an unfavourable physical status. Apparently, colon resections in elderly people are high-risk procedures, in which specific experience and expertise are needed.

Nevertheless, no association between postoperative mortality and the volume or teaching status of hospitals was found in our study. This confirms the results of earlier Dutch and Canadian studies, in which no association between type or volume of hospitals and postoperative mortality was found.[18;44] For other high-risk operations, like pancreatic or esophageal resections, clear differences between low- and high-volume hospitals were demonstrated, also in the Netherlands.[2;3;45] Due to the high incidence of colon carcinoma, hospital volumes are substantially higher than the hospital volume of, for example, pancreas or esophageal cancer, which might explain our results. Nevertheless, despite the lack of an inverse relationship between hospital volume and postoperative mortality, our study identified important differences in quality of care between hospitals in the Netherlands, as shown above.

Survival

Some consider survival as the most important performance indicator for cancer treatments. Process measures, like the number of lymph nodes evaluated and the use of adjuvant chemotherapy investigated in the current study, are futile, when a relationship with direct outcome measures, like survival, is lacking. Survival was analysed in the present study and significant differences between hospital types and volumes were found. Survival of patients diagnosed in university hospitals was better than in other hospitals, especially those with a high volume of colon cancer diagnoses. This finding does not parallel the restrained use of adjuvant chemotherapy in stage III patients diagnosed in these university hospitals, although it could be related to a better patient selection for adjuvant chemotherapy. Furthermore, one might speculate about a more aggressive and multidisciplinary approach in case of recurrence. Unfortunately, information on incidence and treatment of recurrences is lacking in the Netherlands Cancer Registry. The relatively low survival of patients diagnosed in low-volume hospitals was reported before by a nested cohort study from the US.[46] Another American population-based study found an association between both surgeon and hospital volume and outcome, but hospital volume had a stronger effect.[47]

Comparing quality of care between hospitals on the basis of structural characteristics like volume and teaching status might have important disadvantages. Investigating acknowledged measures of quality of care, our study shows that variation was largest on the level of the individual hospital. Characterisations of hospitals by, for instance, volume, do not necessarily correspond with quality of care and do not reveal the differences in patterns of care that lead to poor or better outcomes. The advantage of direct measurement of the care process and its outcome is the possibility to feed this information back to individual hospitals. Several studies have stressed the beneficial effects of quality assurance and outcome analysis in the evaluation of the quality of cancer care.

In conclusion, we found variation in treatment and outcome of patients diagnosed with colon cancer in the Netherlands, with differences based on hospital types and volumes. However, variation in quality of care seemed mainly determined on the level of the individual hospital.

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