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Variation in treatment and outcome of patients with rectal cancer by region, hospital type and volume in the Netherlands ☆

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Abstract

Background: Aim of this study was to describe treatment patterns and outcome according to region and hospital type and volume among patients with rectal cancer in the Netherlands.
Methods: All patients with rectal 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 receiving preoperative radiotherapy and on the odds of postoperative mortality. Relative survival analysis was used to estimate relative excess risk of dying according to hospital type and volume.
Results: In total, 16 039 patients were selected. Patients diagnosed in a teaching or university hospital had a lower odds (OR 0.85; 95% CI 0.73–0.99 and OR 0.70; 95% CI 0.52–0.92) and patients diagnosed in a hospital performing >50 resections per year had a higher odds (OR 1.95; 95% CI 1.09–1.76) of receiving preoperative radiotherapy. A large variation between individual hospitals in rates of preoperative radiotherapy and between Comprehensive Cancer Centre-regions in the administration of preoperative chemoradiation was revealed. Postoperative mortality was not correlated to hospital type or volume. Patients with T1-M0 tumours diagnosed in a hospital with >50 resections per year had a better survival compared to patients diagnosed in a hospital with <25 resections per year (RER 0.11; 95% CI 0.02–0.78).
Conclusion: This study demonstrated variation in treatment and outcome of patients with rectal cancer in the Netherlands, with differences related to hospital volume and hospitals teaching or academic status. However, variation in treatment patterns between individual hospitals proved to be much larger than could be explained by the investigated characteristics. Future studies should focus on the reasons behind these differences, which could lead to a higher proportion of patients receiving optimal treatment for their stage of the disease.

Keywords: Rectal cancer; Guidelines; Hospital characteristics; Treatment; Survival

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Introduction

Worldwide, there is an increasing interest in variations in quality of cancer care. Many authors reported on differences in quality of care between hospitals analyzing the effects of differences in volume and specialization on patient outcome.[1–3] Only a few studies revealed differences regarding other aspects of the care process, such as compliance to (national) guidelines.

In the Netherlands, colorectal cancer is the second most common type of cancer. In 2007, almost 12 000 patients were diagnosed with colorectal cancer of which approximately 3300 included patients with rectal cancer.[4] In the same year, about 1000 patients died of rectal cancer.[5]

In the Netherlands, an improvement in survival of patients with rectal cancer has been demonstrated due to changes in treatment strategies,[6,7] including the wide clinical implementation of total mesorectal excision (TME) together with a shift from postoperative to preoperative radiotherapy. According to the current Dutch treatment guidelines, preoperative radiotherapy is recommended for patients with clinical T2–T3 tumours, while in case of locally advanced tumours preoperative chemoradiation is preferred.[8] However, large interhospital variation in the use of radiotherapy was reported in a regional population-based study.[9]

Limited data exist on differences in treatment patterns of patients with rectal cancer and to what extent these differences could be explained by differences in hospital characteristics. Several studies revealed an association between high volume and better outcome after surgery for several cancers, such as cancer of the pancreas, esophagus and lung.[1,2,10–12] However, the association between volume and outcome for rectal cancer surgery is not that clear: some reported lower postoperative mortality or better overall survival in patients who were operated in a high-volume hospital, while others did not find such relationship.[13–16] Studies examining the relation between type of hospital and outcome also published contrasting results for rectal cancer.[14,17–19]

The aim of this study was to describe variation in treatment patterns and outcome according to region and characteristics of individual hospitals among patients with rectal 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.[20] Data are collected from the medical records by specially trained registrars and are coded according to a national 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.[21] Cancers are staged according to the TNM classification.[22] Quality of the data is high[23] and completeness is estimated to be at least 95%.[24]

Patients

All patients with invasive rectal carcinoma, diagnosed between 2001 and 2006 were selected from the NCR ($N = 16\,039$). Patients with diagnoses without histological confirmation, with diagnoses based only on autopsy findings, patients living abroad and patients with incomplete records were excluded from the analyses.

As the main interest was the first choice of treatment, clinical stage was used, except for those cases where clinical stage was unknown. In these cases, the pathological stage was applied. In cases where clinical T-stage was unknown and in whom preoperative chemoradiation was applied, the tumour was assumed to be cT4, because according to the guidelines preoperative chemoradiation should, among others, be administered to patients with cT4-tumours.

Regions and hospitals

The Netherlands are divided into 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 cancer registry. Each CCC serves an area covered by 5–20 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.

Hospital characteristics, such as type of hospital, were retrieved from Prismant, an organisation which collects objective data about hospitals such as quality of care assessment.[25] Hospitals with several locations, but organized as one hospital in 2003 were considered as one hospital.

Patients of all 97 hospitals in the Netherlands were included in the analyses. Hospitals were categorized into general, teaching and university hospitals, based on data from Prismant for the period between 2003 and 2005. A teaching hospital was defined as a hospital which provides medical training to surgical residents and/or to residents of internal medicine. University hospitals were teaching hospitals affiliated to a medical university. The one specialized oncology centre in the Netherlands was also classified as university hospital.

For the analyses concerning treatment and overall 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 be considered as a good standard of care. For the analyses on postoperative

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mortality, type of hospital was based on the hospital where the surgery was performed.

Hospital volume was categorized into <25, 25–50 and >50 resections per year, including the resections of rectosigmoid tumours since rectosigmoid tumours are frequently resected by the same surgical technique as rectal tumours.

Statistical analyses

Treatment according to guidelines

Treatment was described as percentages per stage and age group (<75 years and ≥75 years). The influence of age at diagnosis, gender, year of diagnosis, depth of invasion, nodal involvement, type of hospital of diagnosis, hospital volume and CCC-region on the odds of receiving preoperative radiotherapy (including preoperative chemoradiation) in patients with T2/T3-M0 was examined using logistic regression analysis. For this analysis, patients diagnosed in the period 2003–2006 were used, because preoperative radiotherapy was not introduced nationwide until 2003. One hospital was excluded from this analysis due to a deviating treatment policy. To compare the performance of the individual hospitals for this outcome measure, a funnel plot was made using 95% control limits calculated around the mean of the 20% best performing hospitals.[26,27] In the funnel plot, each hospital was displayed as a scatter point presenting the hospital volume and type and the adjusted rate for proportion of patients receiving preoperative radiotherapy. The proportion was adjusted for gender, age at diagnosis, depth of invasion and nodal involvement in order to account for differences in case-mix between the hospitals. Furthermore, the proportion of patients with T4-M0 tumours receiving preoperative chemoradiation was analyzed according to CCC-region and year of diagnosis.

Postoperative mortality

Logistic regression analysis was used to investigate the odds of postoperative mortality by age at diagnosis, gender, type of resection, type of hospital of surgery, hospital volume and CCC-region. Postoperative mortality was defined as death within 30 days after surgery. Patients with distant metastasis (M1) were excluded from this analysis. Postoperative mortality was determined for tumours diagnosed in 2005 and 2006, because date of surgery was not registered in the NCR before 2005.

Survival

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.[28] Follow-up was calculated as the time from diagnosis to death or to 1st January 2008. Multivariate relative survival analyses were used to estimate relative excess risk (RER) of death by hospital type and volume. Only first tumours were included in the multivariate survival analyses.

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

Results

In the Netherlands 16 039 patients with rectal carcinoma were diagnosed in the period from 2001 to 2006. During this period, the number of annual diagnoses increased from 2325 in 2001 to 2918 in 2006. Of these patients 59% were male and 30% were aged 75 years or older. In total, 59% had T2/T3-M0 tumours, 10% had T4-M0 tumours and 17% had tumours with distant metastasis (M1). More than 50% of the patients were diagnosed in a teaching hospital for surgery and 6% were diagnosed in a university hospital. Almost half of the patients (46%) were diagnosed in hospitals with 25–50 resections annually. The share of each CCC varied between 8 and 17% (Table 1).

Treatment by stage and age

Fig. 1 shows treatment by stage and age group. Among patients with T1-M0 tumours, 34% of the patients younger than 75 years underwent polypectomy or Transanal Endoscopic Microsurgery (TEM), compared to 43% among patients of 75 years or older. Almost all other patients with T1-M0 tumours underwent a surgical resection with or without preoperative radiotherapy.

Most patients with T2/T3-M0 tumours underwent a resection, mainly combined with preoperative radiotherapy. Among the patients younger than 75 years, 70% underwent resection with preoperative radiotherapy compared to 57% among patients 75 years or older. Around 84% of the patients younger than 75 years with a T4-M0 tumour underwent a surgical resection, 37% in combination with preoperative radiotherapy and 40% in combination with neoadjuvant chemoradiation. Of the patients of 75 years or older with a T4-M0 tumour, 57% underwent a surgical resection; including 31% in combination with preoperative radiotherapy and 11% in combination with neoadjuvant chemoradiation.

The proportion of patients younger than 75 years with an M1 tumour who underwent surgical resection of the primary tumour was 44%, compared to 31% for patients of 75 years or older. Around 16% of the younger patients with an M1 tumour and 42% of the older patients with an M1 tumour did not receive any treatment.

Preoperative radiotherapy and chemoradiation

Female patients were less likely to receive preoperative radiotherapy (Table 2). The odds ratio decreased with increasing age, down to 0.40 (95% CI 0.33–0.47) in patients aged 75 years and older compared to those younger than 60

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Table 1
Description of study population ($N = 16{,}039$).

	N	%
Gender		
Male	9384	58.5
Female	6655	41.5
Age at diagnosis		
<60	4209	26.2
60–74	6966	43.4
75+	4864	30.3
Year of diagnosis		
2001	2325	14.5
2002	2586	16.1
2003	2611	16.3
2004	2798	17.4
2005	2801	17.5
2006	2918	18.2
Clinical stage		
T0/IS-M0	51	0.3
T1-M0	1384	8.6
T2/T3-M0	9393	58.6
T4-M0	1655	10.3
Tany-Nany-M1	2794	17.4
Unknown	762	4.8
Hospital of diagnosis		
General hospital	6721	41.9
Teaching hospital for surgery	8326	51.9
University hospital	992	6.2
Annual volume of hospital of diagnosis		
<25 resections	5099	31.8
25–50 resections	7337	45.7
>50 resections	3603	22.5
Comprehensive Cancer Centre region		
1	2663	16.6
2	1422	8.9
3	1094	6.8
4	2323	14.5
5	1468	9.2
6	2130	13.3
7	2405	15.0
8	1299	8.1
9	1235	7.7

years. Patients with a higher T-stage (T3) and with positive lymph nodes (N1) were more likely to receive preoperative radiotherapy. Patients diagnosed in a teaching hospital for surgery and in a university hospital had a lower odds of receiving preoperative radiotherapy compared to patients diagnosed in a general hospital (OR 0.84, 95% CI 0.72–0.99 and OR 0.70, 95% CI 0.52–0.93, respectively). Patient diagnosed in a hospital with more than 50 resections per year were more likely to receive preoperative radiotherapy (OR 1.39, 95% CI 1.09–1.76). There was variation between CCC-regions in the odds of receiving preoperative radiotherapy. In the funnel plot, the adjusted proportion of patients younger than 75 years who received preoperative radiotherapy is depicted for each hospital by hospital type and mean number of resections per year, showing a large variation between the individual hospitals (Fig. 2). The proportion of patients who received preoperative radiotherapy ranged from 100% to less than 50%.

Fig. 3, showing the proportion of patients receiving preoperative chemoradiation aged <75 years with T4-M0 tumours according to year of diagnosis and CCC-region, demonstrates large variation in the administering of chemoradiation between CCC-regions.

Postoperative mortality

Overall, 3.2% of the patients undergoing a resection died within 30 days after surgery. Male patients had a higher risk of dying within 30 days after surgery. The OR increased with increasing age, up to 21.33 (95% CI 8.57–53.08) for patients 75 years or older. The odds of dying was lower in patients who underwent an abdomino-perineal resection compared to patients who underwent a low anterior resection (OR 0.50, 95% CI 0.33–0.76). No differences in postoperative mortality were found between types of hospitals. Patients operated in hospitals with 50 or more resections per year had a lower odds of dying within 30 days compared to patients operated in hospitals with less than 25 resections per year. The odds of postoperative mortality also differed between CCC-regions (Table 3).

Survival

Among all patients with rectal cancer as well as for the stages seperately, differences in overall survival between hospitals of different types and volumes were only found among patients with a T1-M0 tumour. Patients diagnosed in hospitals with more than 50 resections per year had a lower risk of dying compared to patients diagnosed in hospitals with less than 25 resections per year (RER 0.11, 95% CI 0.02–0.78) (Table 4).

Discussion

In this nationwide population-based study, examining cancer registry data of 16,039 patients with rectal carcinoma diagnosed in the period 2001–2006 in the Netherlands, we revealed marked variation in treatment patterns and outcome. Even after correction for differences in case-mix, there were substantial differences between individual hospitals in the proportion of patients receiving preoperative radiotherapy. In addition, we found variation between CCC-regions in the proportion of patients receiving chemoradiation. Furthermore, hospital type and volume had an effect on the odds of receiving preoperative radiotherapy. Hospital volume was also associated with postoperative mortality.

Preoperative radiotherapy

According to the Dutch evidence-based guidelines for the treatment of rectal cancer, patients with T2–T3

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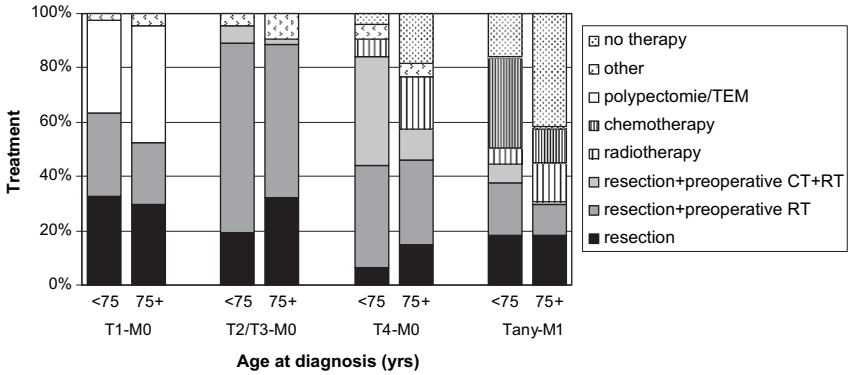

Figure 1. Treatment by stage and age group at diagnosis.

tumours without distant metastasis should receive 5 × 5 Gy radiotherapy preceding resection to reduce the risk of local recurrence.[8] A French study, which combined the use of preoperative and postoperative radiotherapy, reported a higher odds of receiving radiotherapy in patients who were operated in university hospitals, suggesting a more rapid spread of improvements in emerging treatment strategies in university hospitals.[29] A questionnaire completed by Korean surgeons also demonstrated a higher use of preoperative radiotherapy in university hospitals.[30] However, our results showed that patients diagnosed in a teaching hospital or university hospital were less likely to receive preoperative radiotherapy. Regretfully, our study was hampered by the lack of data on comorbidities of patients. Therefore, the differences between these groups of hospitals might actually be explained by selective referral of patients with more comorbidities,[31] who are likely to receive preoperative radiotherapy less often.

A nationwide survey in Australia reported no relation between hospital volume and the proportion of patients receiving radiotherapy preoperatively, whereas our results show higher odds for patients diagnosed in a high-volume hospital.[32] A study with data from the California Cancer Registry reported patients diagnosed in the lowest-volume hospitals were less likely to receive adjuvant radiotherapy compared to the highest-volume hospitals. They suggested more accurate staging, closer affiliation with radiation facilities and a broader range of specialists and technologic resources in the high-volume hospitals as explanations for this result.[33] The explanation of a closer affiliation of high-volume hospitals with radiation facilities does not apply to the situation in the Netherlands, because radiotherapy institutions easily accessible in our country. On the other hand, there could be differences in local expertise between hospitals with and without radiotherapy facilities. Nevertheless, in our study a high-volume proved no guarantee for a high percentage of patients receiving preoperative radiotherapy, as our funnel plot showed considerable variation between individual hospitals regardless of hospital volume.

Table 2
Odds ratio of receiving preoperative radiotherapy in patients with T2/T3-M0 in the period 2003–2006 (multivariate logistic regression analysis).

	OR	95% CI
Gender		
Male	1.00	Reference
Female	0.84*	0.74–0.96
Age at diagnosis		
<60 years	1.00	Reference
60–74 years	0.84*	0.71–0.99
≥75 years	0.40*	0.33–0.47
Year of diagnosis		
2003	1.00	Reference
2004	1.01	0.85–1.21
2005	1.25*	1.04–1.50
2006	1.06	0.89–1.27
Depth of invasion		
cT2	1.00	Reference
cT3	1.34*	1.18–1.52
Nodal involvement		
cN0/X	1.00	Reference
cN+	2.30*	1.78–2.97
Hospital of diagnosis		
General hospital	1.00	Reference
Teaching hospital for surgery	0.84*	0.72–0.99
University hospital	0.70*	0.52–0.93
Annual volume of hospital of diagnosis		
<25 resections	1.00	Reference
25–50 resections	0.93	0.78–1.10
>50 resections	1.39*	1.09–1.76
Comprehensive Cancer Centre region		
1	1.00	Reference
2	1.42*	1.10–1.82
3	1.04	0.79–1.37
4	0.70*	0.53–0.92
5	1.04	0.80–1.35
6	0.68*	0.54–0.85
7	1.27	0.98–1.64
8	0.70*	0.53–0.92
9	0.60*	0.45–0.80

*$p < 0.05$.

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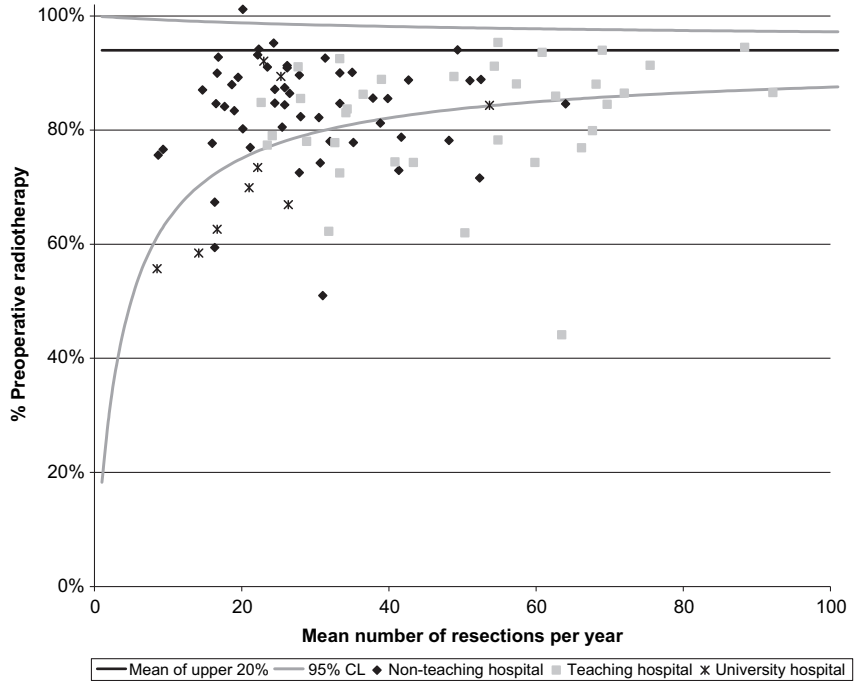

Figure 2. Funnel plot of proportion of patients receiving preoperative radiotherapy aged <75 years with clinical stage T2/T3-M0 in the period 2003–2006 by hospital type and mean number of resections per year. The proportion for each hospital was adjusted for gender, age at diagnosis, depth of invasion and nodal involvement to account for differences in case-mix between the hospitals.

Chemoradiation

In 2004, several studies revealed improved local control with preoperative chemoradiation.[34,35] In the Netherlands, preoperative chemoradiation was recommended for T4 tumours and tumours with an expected positive CRM since the summer of 2005. Unfortunately, detailed information about the preoperative assessment of (circumferential) margins is not available in the NCR. Therefore, we could not include these tumours in our analyses concerning preoperative chemoradiation. Indeed, T2–T3 tumours with an expected positive CRM were included in the analyses of preoperative radiotherapy, which is the minimum therapy they should receive.

This study demonstrated large differences in the pace and extent in which preoperative chemoradiation was introduced for patients with T4 rectal tumours in separate regions in the Netherlands, identifying slow and fast adaptors in the introduction of a relatively new treatment strategy among the hospitals within these CCC-regions. These differences could reflect different results of the debates in regionally organized multidisciplinary meetings (facilitated by the CCCs). To our knowledge no other research has been done on differences between hospitals in administering chemoradiation.

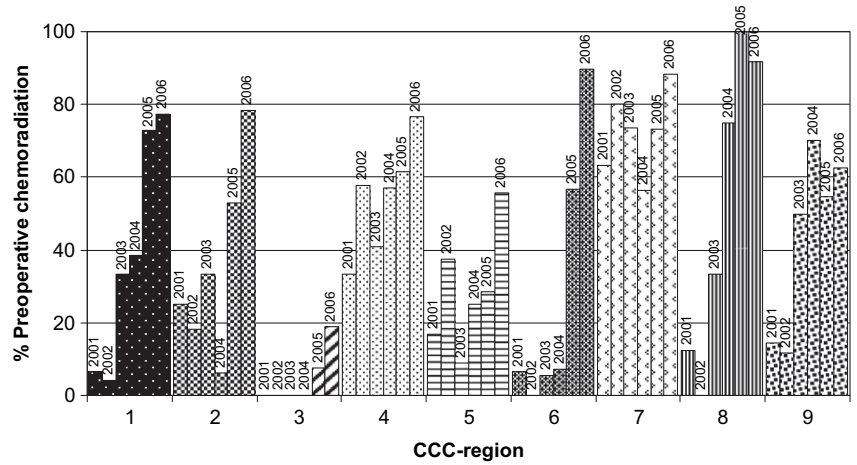

Figure 3. Proportion of patients receiving preoperative chemoradiation aged <75 years with T4-M0 tumours according to CCC-region and year of diagnosis.

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Table 3
Odds ratio of death within 30 days after elective resection in patients without distant metastasis in the period 2005–2006 (multivariate logistic regression analysis).

	OR	95% CI
Gender		
Male	1.00	Reference
Female	0.38*	0.25–0.59
Age at diagnosis		
<60 years	1.00	Reference
60–74 years	4.39*	1.71–11.27
≥75 years	21.32*	8.57–53.08
Depth of invasion		
pT1	1.00	Reference
pT2	0.68	0.35–1.31
pT3	0.83	0.45–1.55
pT4	0.83	0.28–2.49
Nodal involvement		
pN0	1.00	Reference
pN+	1.11	0.74–1.66
Type of resection		
Low anterior resection	1.00	Reference
Abdomino-perineal resection	0.50*	0.33–0.76
Other/unknown	0.74	0.37–1.47
Hospital of surgery		
General hospital	1.00	Reference
Teaching hospital for surgery	0.98	0.60–1.61
University hospital	0.47	0.20–1.10
Annual volume of hospital of surgery		
<25 resections	1.00	Reference
25–50 resections	0.70	0.44–1.14
>50 resections	0.40*	0.19–0.84
Comprehensive Cancer Centre region		
1	1.00	Reference
2	1.19	0.61–2.31
3	2.25*	1.08–4.72
4	1.11	0.47–2.66
5	0.41	0.15–1.14
6	0.87	0.41–1.83
7	1.34	0.65–2.77
8	3.20*	1.56–6.57
9	0.84	0.31–2.25

*$p < 0.05$.

Postoperative mortality

The risk of death within 30 days after resection was most affected by age. Patients over 75 years of age had a substantially increased mortality risk. A study from the south of the Netherlands demonstrated a higher risk of developing treatment-related complications for older patients and patients with co-morbidity leading to a worse survival.[36] Another Dutch study revealed that elderly patients have more complications leading to higher mortality. Furthermore, the complications that occur just as frequently in younger patients as in elderly patients were associated with a higher mortality in the elderly.[37] Unfortunately, no data about co-morbidities, complications and performance status are available in the NCR.

The higher risk of postoperative mortality in patients who underwent a low anterior resection could reflect the high risk of anastomotic leakage after sphincter preserving surgery which is a major cause of postoperative death.[38,39] Furthermore, we found a lower risk of postoperative mortality in patients operated in hospitals with 50 or more rectal cancer resections per year. This could be explained by the specialized and more experienced surgeons and by the technically more advanced equipment leading to a higher standard of perioperative care in these hospitals.[31] Another explanation may be the lower rates of intraoperative and postoperative complications in high-volume hospitals.[40]

Survival

In our study, we found a positive association between a large hospital volume and survival only for patients with T1-M0 tumours. Furthermore, no differences between hospital types and volumes for relative survival were revealed. Notably, for patients with T2/3-M0 tumours, for whom preoperative radiotherapy in our study depended on hospital characteristics, no effect of hospital type and volume on survival was found. This is in agreement with the long-term results of the TME-trial, which showed an effect of preoperative radiotherapy in addition to TME-surgery on the incidence of local recurrence but no effect on survival.[41] Other studies have shown an association between hospital characteristics and survival. Two Scandinavian nationwide studies demonstrated an improved survival for university hospitals compared to local hospitals,[16,18] whereas a Canadian study found no effect of teaching status of the hospital on overall survival.[14] A nested cohort study from the US showed no significant relation between hospital volume and overall survival.[42] Another American study demonstrated better survival rates among patients who underwent surgery at high-volume hospitals compared to patients treated in low-volume hospitals.[15]

Measuring quality of care based on differences in characteristics of individual hospitals, like volume and teaching status, has some essential shortcomings. Our study demonstrated a large influence of local treatment patterns in individual hospitals. Beside differences in treatment between hospitals with different patient volumes, our results showed a large variation in providing preoperative radiotherapy within each volume category. This indicates a limitation of volume as a measure of quality of care: individual, low-volume, hospitals could provide good care whereas high-volume hospitals could provide suboptimal care.[43] Since 2005, the Netherlands has a nationwide guideline for the treatment of patients with rectal cancer. Differences in local practices between hospitals are expected to decrease due to general adaption of these guidelines, though without adequate monitoring of the actual compliance, the beneficial effects are unsure.

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Table 4
Relative excess risks (RERs) of dying for patients with rectal cancer diagnosed in the period 2001–2006, by clinical stage (multivariate relative survival analyses).

	Total[a]		T1-M0[b]		T2/T3-M0[b]		T4-M0[c]		M1[d]	
	RER	95% CI	RER	95% CI	RER	95% CI	RER	95% CI	RER	95% CI
Hospital of diagnosis										
General hospital	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
Teaching hospital for surgery	1.02	0.94–1.10	0.98	0.44–2.16	0.97	0.83–1.13	1.03	0.83–1.29	0.99	0.88–1.11
University hospital	0.94	0.81–1.08	2.59	0.78–8.58	0.90	0.68–1.18	1.12	0.78–1.61	0.83	0.68–1.01
Annual volume of hospital of diagnosis										
<25 resections	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference	1.00	Reference
25–50 resections	0.95	0.88–1.04	0.53	0.20–1.41	0.98	0.83–1.14	1.10	0.88–1.39	0.90	0.80–1.02
>50 resections	1.02	0.91–1.14	0.11*	0.02–0.78	1.05	0.84–1.31	1.06	0.78–1.44	1.01	0.85–1.19

*$p < 0.05$.
[a] Adjusted for gender, age at diagnosis, grade, year of diagnosis, clinical stage, surgery, chemotherapy, radiotherapy and CCC-region.
[b] Adjusted for gender, age at diagnosis, grade, year of diagnosis, clinical N stage, surgery, radiotherapy and CCC-region.
[c] Adjusted for gender, age at diagnosis, grade, year of diagnosis, clinical N stage, surgery, chemotherapy, radiotherapy and CCC-region.
[d] Adjusted for gender, age at diagnosis, grade, year of diagnosis, surgery, chemotherapy, radiotherapy and CCC-region.

In conclusion, there is a considerable variation in treatment and outcome of patients with rectal cancer in the Netherlands. Although this variation could be partly explained by differences in hospital type and volume, differences in local treatment patterns between individual hospitals seem to have a large influence. Further research is needed to identify factors causing this variation between individual hospitals, in which the identification of differences in case-mix and patients preferences are essential. By this, we could reveal the reasons behind differences in treatment patterns and outcome, potentially leading to more patients receiving optimal treatment for their rectal cancer.

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Conflict of interest

None declared.

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