No difference in overall survival between hospital volumes for patients with colorectal cancer in The Netherlands.

Short title: CRC hospital volumes in The Netherlands

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ABSTRACT

Background: High-volume hospitals have been associated with improved patient outcomes for tumors with a relatively low incidence that require complex surgeries, such as esophageal and pancreatic cancer. The volume-outcome association for colorectal cancer is under debate.

Objective: This study investigated whether hospital volume for colorectal cancer is associated with surgical care characteristics and 5-year overall survival.

Design: This is a population-based study.

Setting: Data were gathered from the Netherlands Cancer Registry. Hospitals were grouped by volume for colon (less than 50; 50-74; 75-99 and 100 or more resections per year) and rectum (less than 20; 20-39 and 40 or more resections per year).

Patients: All of the patients with primary nonmetastatic colorectal cancer who underwent resection between 2005 and 2012 were included.

Main outcome measures: Differences in surgical approach, anastomotic leakage, and postoperative 30-day mortality between hospital volumes were analysed using χ^2 tests and multivariable logistic regression analyses. Cox proportional hazard models were used to investigate the effect of hospital volume on overall survival.

Results: This study included 61,394 patients with colorectal cancer. In 2012, 31 of the 91 hospitals performed less than 50 colon cancer resections per year and 21 of the 90 hospitals performed less than 20 rectal cancer resections per year. No differences in anastomotic leakage between hospital volumes were observed. Only small differences between hospital volumes were revealed for conversion of laparoscopic to open resection (OR of less than 50 versus 100 or more resections per year = 1.25 (95% CI, 1.06-1.46) and postoperative 30-day mortality (colon: OR of less than 50 versus 100 or more resections per year = 1.17 (95% CI, 1.02-1.35); rectum: OR of less than 20 versus 40 or more resections per year = 1.42 (95% CI, 1.09-1.84)). No differences in overall survival were found between hospital volumes.

Limitations: Although we adjusted for several patient and tumor characteristics, data regarding comorbidity, surgeon volume, local recurrences, and specific postoperative complications other than anastomotic leakage were not available.

Conclusion: In the Netherlands, no differences in 5-year survival rates were revealed between hospital volumes for patients with nonmetastatic colorectal cancer.

Keywords: Colorectal cancer; Hospital volume; Surgical outcome; Anastomotic leakage; Survival

INTRODUCTION

In the last decade, there has been an increasing interest in improving quality of cancer care and the need for reliable parameters thereof. Differences in hospital volume and its relation with patient outcomes have been studied extensively in the ongoing debate of centralization of surgical care.[1-3] In tumors with a relatively low incidence that require complex surgeries, such as oesophageal and pancreatic cancer, patients have better short- and long-term outcomes when operated in high-volume hospitals.[4-9]

In 2011 the Dutch Society for Surgery established a minimum volume norm of 50 colorectal cancer (CRC) resections per year per hospital. Additionally, for rectal cancer a minimum volume norm of 20 resections per year per hospital is required.[10] For patients with CRC, the volume-outcome association is under debate.

A Cochrane review from 2012 showed that 5-year overall survival (OS) was higher for patients with CRC who were treated in high-volume hospitals. For only patients with patients with rectal cancer, 5-year OS rate but not postoperative mortality was higher in high-volume hospitals. The quality of the evidence was regarded as low in this review, and evidence was based on studies with a large heterogeneity in volume definitions.[11]

Because it is still not clear to what extent hospital volume differences between hospitals lead to differences in short- and long-term patient outcomes, we aimed to investigate whether hospital volume determines surgical care characteristics, postoperative 30-day mortality rates, and long-term survival in patients with CRC in the Netherlands. On the basis of previous literature, we hypothesized that high-volume hospitals are not associated with better OS rates. Furthermore, we hypothesize that there was no association between surgical care characteristics (eg,. presence of anastomotic leakage and postoperative 30-day mortality) and hospital volumes.

METHODS

Data source

Data from the nationwide population-based Netherlands Cancer Registry were used, managed by the Netherlands Comprehensive Cancer Organisation. Information on patient and tumor characteristics, diagnosis, and treatment is routinely extracted from the medical charts. The quality of the data is high because of thorough training of the registration team and computerized consistency checks at regional and national levels. Anatomical site of the tumor is registered according to the *International Classification of Disease–Oncology*.[12] The TNM classification is used for stage notification of the primary tumor, according to the edition valid at time of cancer diagnosis.[13]

Study population

All patients who underwent surgical resection for primary stage I to III CRC (C18-20) between 2005 and 2012 were included. Data for the evaluation of surgical care (eg, surgical approach, emergency resection, and anastomotic leakage) were available in the Netherland Cancer Registry since 2008; therefore, we limited our selection for these analyses to patients who underwent surgical resection in 2009-2012. Patients who underwent surgical resection without primary anastomosis were excluded from the analyses regarding anastomotic leakage (n=2981).

Disease stage was based on the pathological TNM classification. Patients were stratified by tumor localization: colon (C18) and rectum (rectosigmoid and rectum, C19-20). Tumor localization was categorized into anatomical subsites: proximal colon (C18.0-18.3), transverse colon and splenic flexure (C18.4-18.5), distal colon (C18.6-1.87), unknown or overlapping subsites of the colon (C18.8-18.9); rectosigmoid (C19.9), and rectum (C20.9).

Surgical care characteristics were recorded for the following categories: surgical approach (laparoscopic resection versus intent for laparoscopic but conversion to open resection versus open resection); presence of an anastomotic leakage, and postoperative 30-day mortality. Anastomotic leakage was only recorded as such if a surgical intervention or readmission was necessary within two months after primary anastomosis.

Patient vital status was obtained by linking the Netherlands Cancer Registry to the Municipal Personal Records Database. Follow-up was completed until January 1, 2015.

Hospital volumes

After stratification by tumor localization, the number of resections per year per hospital over the period 2005-2012 were calculated. Hospitals were divided per year into separate categories for colon and rectal cancer based on their annual hospital volume. Hospital volume for colon cancer was divided into 4 categories: less than 50; 50-74; 75-99 and 100 or more resections per year. Hospital volume for rectal cancer was divided into 3 categories: less than 20; 20-39 and 40 or more resections per year. The lowest category for colon cancer was based on the Dutch minimum volume norm for CRC because there were no minimum requirements available for colon cancer separately. The lowest category for rectal cancer was based on the Dutch minimum volume norm for rectal cancer. The higher categories for both colon and rectal cancer were chosen to create an equal distribution of patients between hospital volume categories.

All of the hospitals in the Netherlands were included. Hospitals that merged in the period 2005-2012 were counted as separate until the date of the merge and as 1 after the merge or the subsequent year if this was during the year.

Statistical analyses

Differences in patient and tumor characteristics, observed proportions of anastomotic leakage, and postoperative 30-day mortality between hospital volumes were calculated using χ^2 tests after stratification by tumor localization. In addition, for patients with a tumor located in the colon, differences in surgical approach between hospital volumes were analyzed using the same methods. Multivariable logistic regression models were used to determine adjusted ORs for surgical approach, presence of anastomotic leakage, and postoperative 30-day mortality adjusting for sex, age, T stage, N stage, differentiation grade, tumor location, and neoadjuvant treatment (the latter for rectal cancer only).

Crude 1-, 3- and 5-year OS were calculated using the Kaplan-Meier method, and differences in OS outcomes were assessed with the log-rank test. OS was also determined using Cox proportional hazard models. Patients who survived the first 30 days after the date of resection were included in the survival analyses. *Follow-up time* was defined as the time between 30 days after resection and either date of death or last follow-up date for patients who were still alive. Patient and tumor characteristics influencing survival were included as covariates in the model to discriminate independent risk factors for death.

P values <0.05 were considered statistically significant. SAS/STAT® statistical software (SAS system 9.4, SAS Institute, Cary, NC) was used for all analyses.

RESULTS

Over the period 2005-2012, 61,496 patients underwent surgical resection for primary nonmetastatic CRC: 41,015 patients with colon cancer and 20,481 patients with rectal cancer. Table 1 presents the number of hospitals per hospital volume per year, showing a decreasing trend in low-volume hospitals. Fig. 1 shows the annual average hospital volume, per hospital, in the period 2005-2012, combined with the annual minimum and maximum (range) hospital volume, per hospital, for colon and rectal cancer.

Table 2 shows the distribution of patient and tumor characteristics of the patients who underwent surgical resection for CRC by hospital volume and tumor localization. Statistically significant differences were found between hospital volumes for colon and rectal cancers with regard to age, period of resection, T stage, N stage, and differentiation grade.

Surgical approach in patients with colon cancer

Table 3 presents observed proportions and adjusted ORs of laparoscopic resection by hospital volume. The distribution of surgical approaches differed between hospital volumes ($p<0.0001$). Moreover, among patients initially treated laparoscopically, a higher proportion of patients underwent conversion from laparoscopic to open resection in low-volume hospitals compared with high-volume hospitals ($p=0.011$; Table 3).

Anastomotic leakage

Table 3 presents observed proportions and adjusted ORs of anastomotic leakage by hospital volume and tumor localization. For patients with either colon or rectal cancer, no differences were found between hospital volumes (colon $p=0.81$; rectum $p=0.97$).

Postoperative mortality

Table 3 presents observed proportions and adjusted ORs for postoperative 30-day mortality by hospital volume and tumor localization. For both colon and rectal cancers, postoperative mortality was marginally higher in low-volume hospitals (colon $p=0.029$; rectum $p=0.007$).

Survival

Median follow-up time for patients included was 60 months. For patients with colon cancer, crude 1-, 3-, and 5-year observed survival rates were similar between hospital volumes, at 94%, 81% and 71% ($p=0.49$; Fig. 2a).

For patients with rectal cancer, crude 1-, 3-, and 5-year observed survival rates were also similar between hospital volumes, at 96%, 84% and 74% (p=0.71; Fig. 2b).

Table 4 shows adjusted HRs for death by hospital volume. The risk of death was not correlated with hospital volume for patients with either colon or rectal cancer.

When the analyses were repeated with the hospitals that performed less than 50 colon resections per year or less than 20 rectum resections per year versus hospitals that performed 50 or more colon resections per year or 20 or more rectum resections per year, similar results were found for OS (data not shown).

Subgroup analyses excluding patients who underwent emergency resection

As a sensitivity analysis, all analyses were repeated for the period 2009-2012 excluding patients who underwent emergency resection. Similar results were found for surgical approach, presence of anastomotic leakage, postoperative 30-day mortality rate, and OS (data not shown).

DISCUSSION

In this population-based study covering the Netherlands in the period 2005-2012, we analyzed to what extent hospital volumes lead to differences in short- and long-term patient outcomes. We found no differences in OS between hospitals that did and did not meet the Dutch minimum volume norms for CRC. However, marginal differences were found between hospital volumes in surgical approach and postoperative 30-day mortality rates.

Our data were based on all consecutive nonmetastatic CRC patients who underwent resection in the Netherlands between 2005 and 2012. Conflicting evidence exists as to whether hospital volume is associated with differences in postoperative mortality and OS in CRC. The variation in results between studies may be caused by the hospital volume categories that are differently defined in the literature. The cutoff for low volume ranged from 25 or less to 90 or less CRC resections, and the number of CRC resections considered as high volume ranged from 25 or more to 110 or more.[11] Furthermore, the low-volume thresholds used in this study would place Dutch hospitals in high-volume categories in most studies originating from the United States.[1, 14, 15] Other studies categorized hospitals based on the CRC hospital volume[16, 17], whereas we intentionally separated colon and rectal cancers because of differences in surgical procedures. A subgroup analysis in a meta-analysis of the Cochrane collaboration, where studies were grouped according to continent of origin, showed that studies originating from other countries than the United States had no significant hospital volume effect on 5-year survival, whereas US data suggested a potential benefit for high-volume hospitals.[11] Similar to the results found in non-US studies, we demonstrated no better survival in high-volume hospitals. Moreover, patient selection varied between studies, some only included patients aged >65 years with CRC.[18, 19] Furthermore, we excluded patients with metastatic disease while others have included these.[19-23]

For patients with colon cancer who were initially treated laparoscopically, we found a slightly higher proportion of patients (4%) converted from laparoscopic to open resection in hospitals with less than 50 resections per year compared with hospitals with 100 or more resections per year. van Erning et al[24] showed a similar trend in a population-based study in the southern part of the Netherlands. Laparoscopic resection is proven to be safe, with comparable disease-free and OS compared with open resection.[25, 26] However, conversion to open resection is associated with increased morbidity, longer length of hospital stay, and shorter disease-free survival.[27-29] The technique of laparoscopic resection is still in progress, hence it is likely that variance in proportions of laparoscopic resection between hospitals will decrease.

Interestingly, marginal differences in postoperative mortality rates were present between hospital volumes for patients with colon or rectal cancer. For patients with rectal cancer, this was in line with a previous Dutch study of Elferink et al.[30] In this study, patients who were operated in hospitals with 50 or more resections per year had lower odds of dying within 30 days compared with patients who were operated in hospitals with less than 25 resections per year. When these results are compared with our results, it seems that the postoperative mortality rates have not been changed over time. More studies found an association between postoperative mortality and hospital volumes.[1, 14, 21-23, 31, 32] A possible explanation could be that a higher standard of care is provided in high-volume hospitals by more specialized and experienced surgeons and by more technically advanced equipment. Another possible explanation could be that low-volume hospitals with higher postoperative mortality rates are less skilled to recognize and manage serious complications once they occur, a phenomenon known as failure to rescue.[33] Nevertheless, Henneman et al[34] showed recently that annual average hospital volume was not significantly associated with failure to rescue in the Netherlands. We found no associations between hospital volumes and the presence of anastomotic leakage, even though lower rates of postoperative complications in high-volume hospitals were expected. Data on other specific postoperative complications were not available. Finally, elderly patients and patients with comorbidities were reported to be associated with higher risk of postoperative mortality, but this was not associated with hospital volume.[24]

The main strengths of this study are the use of a large dataset including more than 60,000 CRC patients and the inclusion of all hospitals in the Netherlands. Furthermore, the lowest-volume categories in our study were based on the Dutch minimum volume norms. We calculated the annual hospital volume according to tumor location, instead of calculating an average over the included years.

Due to the increasing incidence of CRC,[35] hospital volumes became substantially higher through the years. Moreover, during the study period some hospitals have merged, thereby increasing their annual hospital volume. In anticipation of the mergers, hospitals may have collaborated and made agreements about referral of patients who needed complex surgeries. This could have led to a higher number of complex patients treated in certain hospitals, which may have led to a worse outcome in these hospitals. Although the number of referred patients may be small and one might expect to see a minor effect, we have adjusted for several patient and tumor characteristics in our analyses.

However, some shortcomings of our study should be noted. We could not adjust for hospital volume of local recurrences (mainly for rectal cancer), which are mostly treated in a limited number of hospitals, thereby underestimating the volume of these hospitals. Moreover, a recent Dutch study by Homan et al[36] suggested a trend toward a higher involved circumferential resection margin of 13% in patients with rectal cancer at low-volume hospitals (less than 20 per year) versus 6% in high-volume hospitals (more than 40 per year) in a small area of The Netherlands. However, data on completeness of the surgical resection, as well as data regarding local recurrence, were not routinely available in the nationwide cancer registry. Furthermore, we cannot exclude that other factors, such as variation in comorbidities between patients treated in different hospitals, may have influenced our results as well. Moreover, we studied the number of resections on the hospital level and not on the surgeon level. Several studies showed that postoperative mortality was lower for surgeons with a higher caseload of patients with colon cancer, regardless of the hospital volume of the hospital in which the surgeons practiced.[15, 22, 31, 37-39] This suggests that an association between hospital volumes and postoperative mortality could be mediated by surgeon volume. Unfortunately, data on surgeon volume were not available.

Because of the large data set, one might dispute whether the statistically significant differences that were present between hospital volumes are clinically relevant. For example, the difference in postoperative mortality rates between lowest- and highest-volume hospitals was ≈1%. Future studies should focus on the identification of processes associated with good outcomes and factors causing variation between individual hospitals. However, identification of these processes and their effect on quality of care remains challenging.

No differences in 5-year OS rates were revealed between hospital volumes for patients with nonmetastatic CRC. However, marginal differences in surgical approach and postoperative 30-day mortality rates were present between hospital volumes. Exploring factors causing variation between hospitals will provide more insight in the quality-of-care debate on whether undergoing a resection in a low-volume hospital is a risk factor for unfavorable patient outcomes.

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Table 1 Total number of hospitals per annual hospital volume of colon and rectal cancers in 2005-2012 n=(61,496).

Hospital volume per year	**2005** n (%)	**2006** n (%)	**2007** n (%)	**2008** n (%)	**2009** n (%)	**2010** n (%)	**2011** n (%)	**2012** n (%)
Colon cancer								
<50	65 (68)	54 (57)	54 (57)	47 (50)	46 (50)	37 (41)	35 (38)	31 (34)
50-74	18 (19)	29 (31)	25 (27)	31 (33)	22 (24)	27 (30)	22 (24)	26 (29)
75-99	10 (11)	10 (11)	13 (14)	12 (13)	18 (20)	14 (15)	17 (19)	15 (16)
≥100	2 (2)	1 (1)	2 (2)	4 (4)	6 (6)	13 (14)	17 (19)	19 (21)
Total hospitals performing colon cancer resections, n	95	94	94	94	92	91	91	91
Rectal cancer								
<20	43 (45)	38 (40)	32 (34)	35 (38)	29 (32)	28 (31)	24 (27)	21 (23)
20-39	37 (39)	38 (40)	44 (47)	43 (47)	47 (51)	45 (49)	44 (49)	46 (51)
≥40	15 (16)	18 (20)	18 (19)	14 (15)	16 (17)	18 (20)	22 (24)	23 (26)
Total hospitals performing rectal cancer resections, n	95	94	94	92	92	91	90	90

Table 2 Patient and tumour characteristics of patients who underwent surgical resection for colon or rectal cancer (n=61496).

	Hospital volume								
	Colon					Rectum			
Variable	**<50 per y**	**50-74 per y**	**75-99 per y**	**≥100 per y**	***p***	**<20 per y**	**20-39 per y**	**≥40 per y**	***p***
	n (%)	n (%)	n (%)	n (%)		n (%)	n (%)	n (%)	
Total	8279 (20)	11645 (29)	8663 (21)	12428 (30)		2545 (13)	8830 (43)	9106 (44)	
Sex					0.59				0.73
Men	4269 (51)	5908 (51)	4403 (51)	6296 (51)		1525 (60)	5366 (61)	5503 (60)	
Women	4010 (49)	5737 (49)	4260 (49)	6132 (49)		1020 (40)	3464 (39)	3603 (40)	
Age, y					0.001*				0.027*
<60	1425 (17)	1937 (17)	1399 (16)	1895 (15)		627 (24)	2148 (14)	2174 (24)	
60-69	2213 (27)	3076 (26)	2215 (26)	3283 (26)		781 (31)	2764 (32)	2991 (32)	
70-79	2750 (33)	4029 (35)	2975 (34)	4416 (36)		757 (30)	2734 (31)	2788 (31)	
≥80	1891 (23)	2603 (22)	2074 (24)	2834 (23)		380 (15)	1184 (13)	1153 (13)	
Period of resection					<0.0001*				<0.0001*
2005-2006	2674 (33)	2723 (23)	1934 (23)	1248 (10)		782 (31)	2072 (23)	1772 (20)	
2007-2008	2204 (26)	3171 (27)	1993 (23)	2133 (17)		626 (25)	2245 (25)	2176 (24)	
2009-2010	1942 (23)	2835 (25)	2340 (26)	3656 (30)		611 (24)	2295 (27)	2252 (24)	
2011-2012	1459 (18)	2916 (25)	2396 (28)	5391 (43)		526 (20)	2218 (25)	2906 (32)	
T stage					0.010*				0.0001*
1	598 (7)	873 (8)	601 (7)	903 (7)		241 (9)	886 (10)	1067 (12)	
2	1329 (16)	1864 (16)	1377 (16)	1907 (15)		872 (34)	2939 (34)	2935 (32)	
3	5192 (63)	7257 (62)	5604 (65)	7929 (64)		1332 (52)	4553 (51)	4623 (51)	
4	1160 (14)	1651 (16)	1081 (12)	1689 (14)		100 (4)	452 (5)	481 (5)	
N stage					0.018*				0.045*
0	5206 (63)	7471 (64)	5681 (65)	7896 (64)		1649 (65)	5896 (67)	6184 (68)	
1	2012 (24)	2789 (24)	2018 (23)	3093 (25)		603 (24)	1955 (22)	1972 (22)	
2	1061 (13)	1385 (12)	1027 (12)	1439 (11)		293 (11)	979 (11)	950 (10)	
Differentiation grade					<0.0001*				
Well/moderated	6218 (75)	8699 (75)	6574 (76)	9310 (75)					
Poor/undifferentiated	1235 (15)	1932 (16)	1376 (16)	1902 (15)					
Unknown	826 (10)	1014 (9)	713 (8)	1216 (10)					

Table 2 continued

Variable	Hospital volume: Colon <50/yr n (%)	50-74/yr n (%)	75-99/yr n (%)	≥100/yr n (%)	*p*-value	Rectum <20/yr n (%)	20-39/yr n (%)	≥40/yr n (%)	*p*-value
Tumor location					0.79				<0.0001*
Colon ascendens	3187 (38)	4401 (38)	3284 (38)	4819 (39)					
Colon transversum	1513 (18)	2162 (18)	1599 (18)	2200 (17)					
Colon descendens	3446 (42)	4878 (42)	3633 (42)	5197 (42)					
Colon NOS/other	133 (2)	204 (2)	147 (2)	212 (2)					
Rectosigmoid						405 (16)	1270 (14)	1101 (12)	
Rectum						2140 (84)	7560 (86)	8005 (88)	

NOS = not otherwise specified.

***** *p*<0.05 between hospital volume categories.

Table 3 Crude percentages and adjusted ORs for laparoscopic resection and conversion from laparoscopic to open resection among patients with colon cancer, as well as anastomotic leakage and postoperative 30-day mortality among patients with colon or rectal cancer.

			Multivariable analysis	
Variable	**Crude %**	***p***	**OR**	**95% CI**
Laparoscopic resection [b]				
Colon cancer, per y		<0.001[a]		
<50	42.2		1.04	0.96-1.13
50-74	43.4		1.10	1.03-1.18
75-99	38.2		0.88	0.82-0.95
≥100	40.8		reference	
Conversion from laparoscopic to open resection [c]				
Colon cancer, per y		0.020[a]		
<50	20.2		1.25	1.06-1.46
50-74	19.4		1.20	1.05-1.37
75-99	18.5		1.14	0.98-1.33
≥100	16.9		reference	
Anastomotic leakage [d]				
Colon cancer, per y		0.81		
<50	8.2		0.95	0.81-1.10
50-74	8.4		0.99	0.88-1.13
75-99	8.4		0.97	0.85-1.11
≥100	8.6		reference	
Rectal cancer, per y		0.97		
<20	13.2		1.03	0.79-1.34
20-39	13.2		0.97	0.83-1.15
≥40	13.4		reference	
Postoperative mortality [e]				
Colon cancer, per y		0.029 [a]		
<50	4.4		1.17	1.02-1.35
50-74	4.7		1.24	1.09-1.41
75-99	4.3		1.10	0.96-1.27
≥100	3.9		reference	
Rectal cancer, per y		0.007 [a]		
<20	3.4		1.42	1.09-1.84
20-39	2.6		1.12	0.92-1.36
≥40	2.3		reference	

ORs were adjusted for sex, age, year of surgical resection, T stage, N stage, differentiation grade, tumor location, and neoadjuvant treatment (the latter for rectal cancer only).

[a]*p*<0.05.

[b]Data include patients diagnosed between 2009 and 2012 (N=20,589).

[c]Data include patients diagnosed between 2009 and 2012 who underwent laparoscopic resection (N=9162).

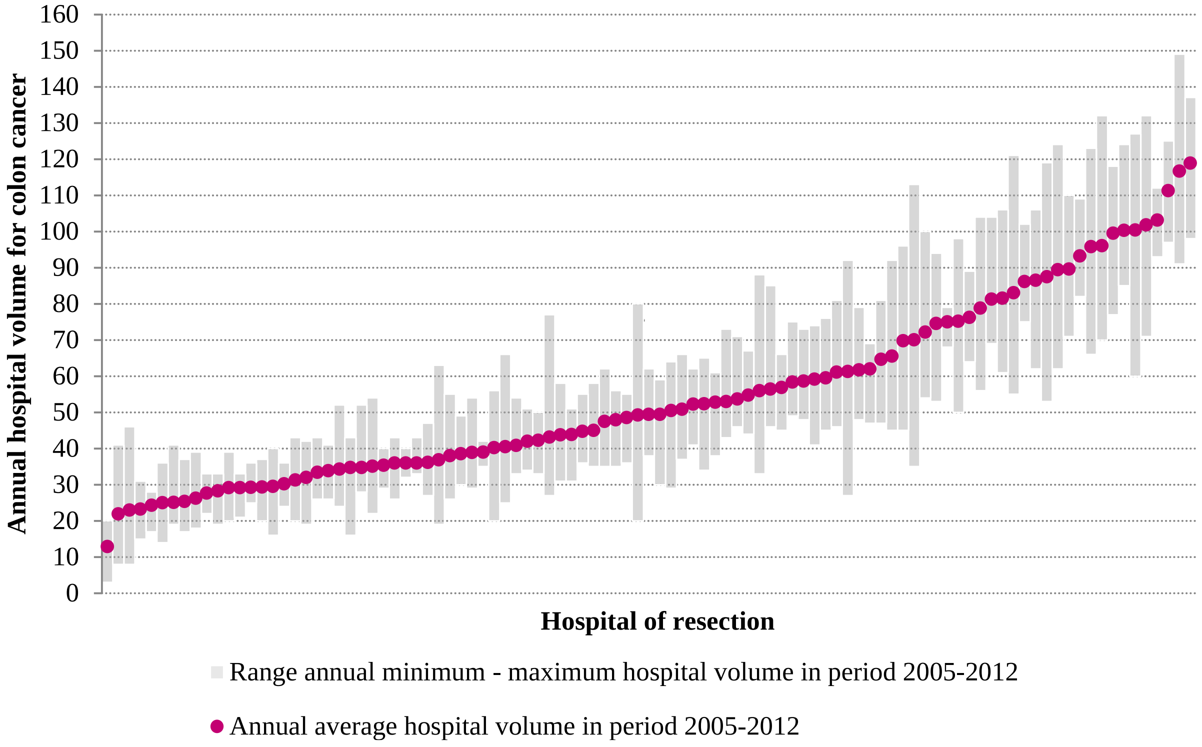
[d]Data include patients diagnosed between 2009 and 2012 who underwent surgical resection with primary anastomosis (N=26,871).

[e]Data include patients diagnosed between 2005 and 2012 (N=61,496).

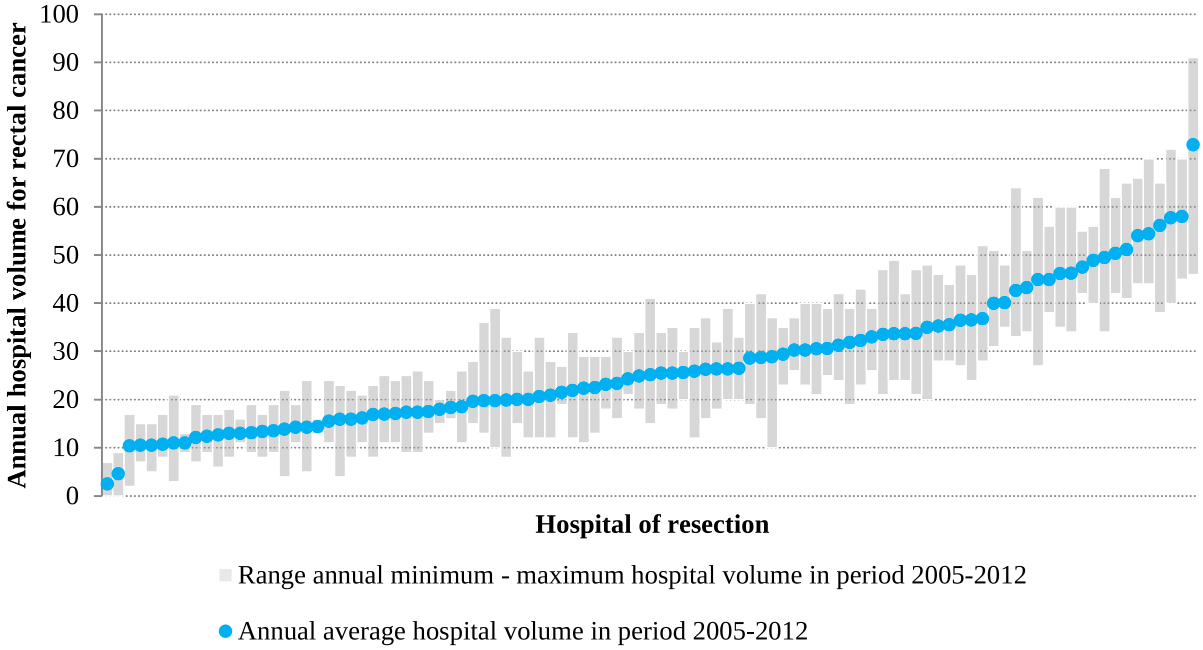
Table 4 Cox regression analysis for the relation of the number of patients who underwent surgical resection for colon or rectal cancer per hospital per year and the risk of death of patients with colon and rectal cancer in the Netherlands, 2005-2012 (n=58,218).

Hospital volume	Adjusted HR[a]	95% CI
Colon cancer, per y		
<50	1.03	0.97-1.08
50-74	1.02	0.97-1.06
75-99	0.99	0.94-1.04
≥100	reference	
Rectal cancer, per y		
<20	0.98	0.91-1.07
20-39	1.00	0.95-1.06
≥40	reference	

[a] HR was adjusted for sex, age, year of surgical resection, T stage, N stage, differentiation grade, and tumour location.

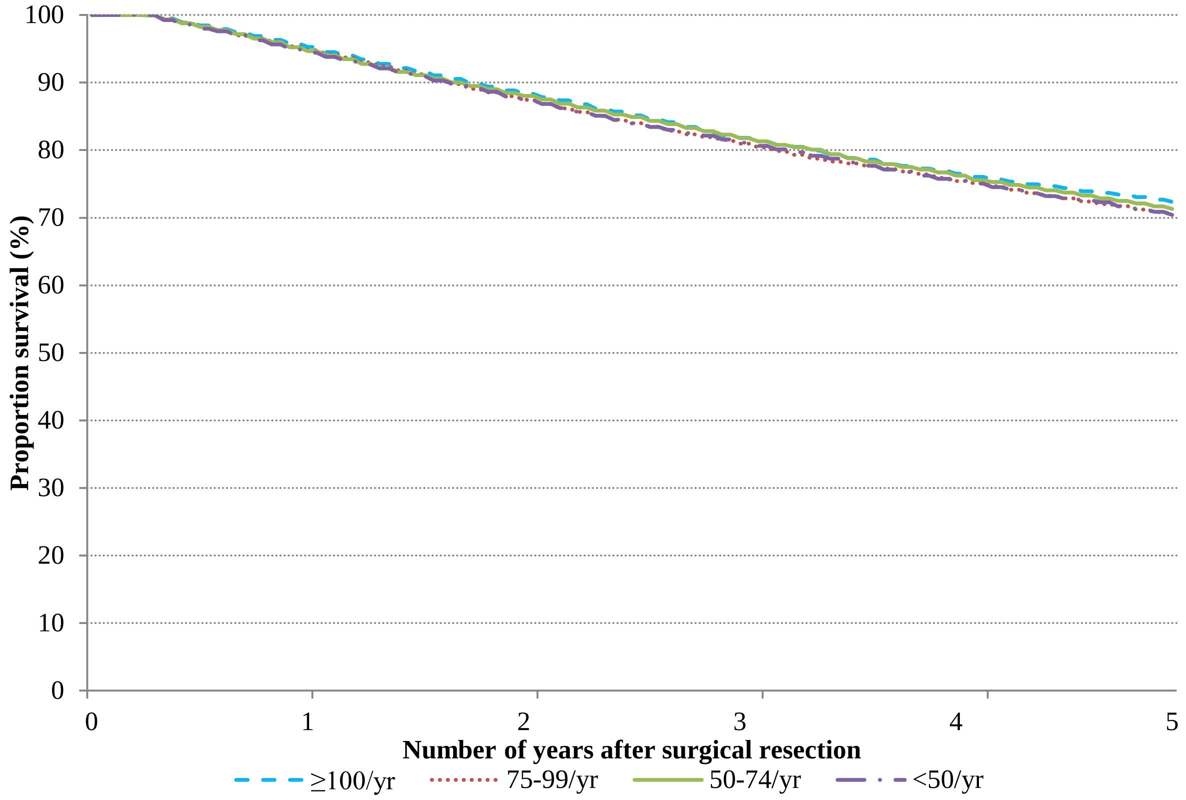


a.

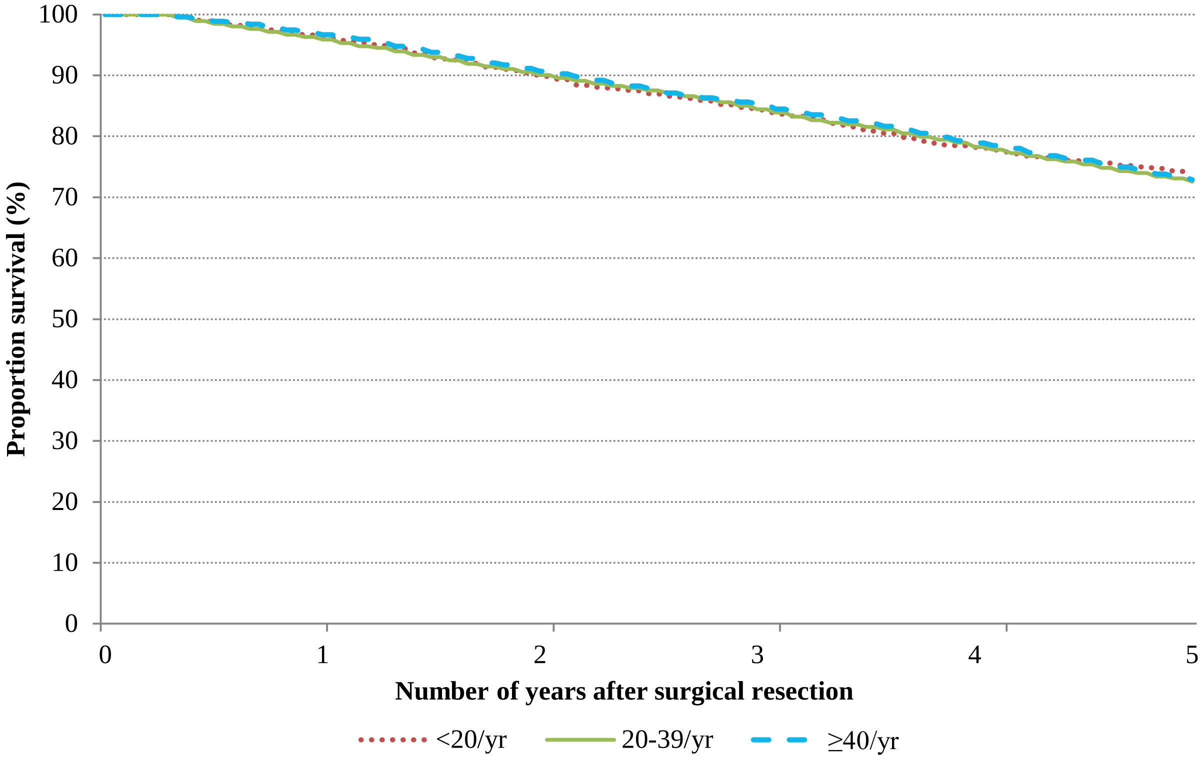


b.

Figure 1. The annual average hospital volume, per hospital, in the period 2005-2012, combined with the annual minimum and maximum (range) hospital volume, per hospital, for colon cancer (a) and rectal cancer (b) (n=58,218).



a.



b.

Figure 2. Crude overall survival of patients with colon (a) and rectal (b) cancer according to hospital volume categories in the Netherlands, 2005-2012 (n=58,218).