

Cover Page



Universiteit Leiden



The handle <http://hdl.handle.net/1887/29079> holds various files of this Leiden University dissertation

Author: Snijders, Heleen Simone

Title: Towards patient-centered colorectal cancer surgery : focus on risks, decisions and clinical auditing

Issue Date: 2014-10-16

THE DUTCH SURGICAL COLORECTAL AUDIT

Snijders HS^{*1}, Van Leersum NJ^{*1}, Henneman D¹, Kolfschoten NE¹, Gooiker GA¹, ten Berge, M.G.¹, Eddes EH³, Wouters MWJM^{1,2} and Tollenaar RAEM¹ on behalf of the Dutch Surgical Colorectal Cancer Audit Group (W.A. Bemelman, R.M. van Dam, M. Elferink, Th.M. Karsten, J.H.J.M. van Krieken, V.E.P.P. Lemmens, H.J. T. Rutten, E.R. Manusama, C.J.H. van de Velde, W.J.H.J. Meijerink, Th. Wiggers, E. van der Harst, J.W.T. Dekker, J. Boerma)

1. Leiden University Medical Center, Leiden, Department of Surgery

2. Netherlands Cancer Institute-Antoni van Leeuwenhoek Hospital, Amsterdam, Department of Surgery

3. Deventer hospital, Deventer, Department of surgery

* both authors equally contributed to this manuscript.

Abstract

Introduction: In 2009, the nationwide Dutch Surgical Colorectal Audit (DSCA) was initiated by the Association of Surgeons of the Netherlands (ASN) to monitor, evaluate and improve colorectal cancer care. The DSCA is currently widely used as a blueprint for the initiation of other audits, coordinated by the Dutch Institute for Clinical Auditing (DICA). This article illustrates key elements of the DSCA and results of three years of auditing.

Methods: Key elements include: a leading role of the professional association with integration of the audit in the national quality assurance policy; web-based registration by medical specialists; weekly updated online feedback to participants; annual external data verification with other data sources; improvement projects.

Results: In two years, all Dutch hospitals participated in the audit. Case-ascertainment was 92% in 2010 and 95% in 2011. External data verification by comparison with the Netherlands Cancer Registry (NCR) showed high concordance of data items. Within three years, guideline compliance for diagnostics, preoperative multidisciplinary meetings and standardised reporting increased; complication-, re-intervention and postoperative mortality rates decreased significantly.

Discussion: The success of the DSCA is the result of effective surgical collaboration. The leading role of the ASN in conducting the audit resulted in full participation of all colorectal surgeons in the Netherlands. By integrating the audit into the ASNs' quality assurance policy, it could be used to set national quality standards. Future challenges include reduction of administrative burden; expansion to a multidisciplinary registration; and addition of financial information and patient reported outcomes to the audit data.

Introduction

Several clinical audits have been initiated internationally, acknowledging the importance of reliable and valid quality information in health care. Clinical auditing has been recognised as an important tool for quality assessment and improvement, consequently leading to demonstrable improvements in patient outcome¹⁻⁴ Moreover, clinical audits are increasingly appreciated as a source of information for research on evidence based medicine as they provide ‘real world’ data on patients often not eligible for clinical trials.⁵ However, the voluntary nature of existing audits may unintentionally lead to participation of mainly dedicated hospitals and underrepresentation of underperforming hospitals. Also, audit data are seldom transparent to other stakeholders involved in health care.

In 2009, the Dutch Surgical Colorectal Audit (DSCA) was initiated by the Association of Surgeons of the Netherlands (ASN) in collaboration with the Dutch Association for Surgical Oncology (NVCO), the Dutch Association for Gastrointestinal Surgery (NVGIC) and the Dutch Colorectal Cancer Group (DCCG). Their main goal was to evaluate and improve quality of care for primary colorectal cancer surgery in the Netherlands.

After one year of registration, participation in the audit had become a national performance indicator. Full participation of Dutch hospitals was realised within two years. Subsequent to this success, the Dutch Institute of Clinical Auditing (DICA) was founded in 2011 with the objective to facilitate and organise the start-up of new nationwide audits. This article illustrates the introduction of the DSCA in the Netherlands by describing its main features and presenting the results of three years of auditing.

Methods

Main features of the DSCA

This section describes the organisational and structural key elements of the DSCA.

1. The initiator: the professional organisation of surgeons

All surgeons in the Netherlands are united in a professional organisation, the Association of Surgeons in the Netherlands (ASN). The ASN serves as a central protector of common interests of surgeons. Membership of the ASN is compulsory to all surgeons in the Netherlands. One of its main objectives is to assure that every surgical patient in the Netherlands receives high quality care. Furthermore, ASN continuously attempts to improve the quality of surgical care. The ASN uses different instruments to accomplish this, for example the development of evidence-based guidelines, surgical training programs and accreditation of surgeons in their surgical specialty. The initiation of clinical audits was necessary to facilitate the uniform measurement of quality of care and enhance the Association's quality improvement efforts.

2. Dataset: involvement of all experts in the field

The ASN formed a scientific committee of mandated clinical experts in colorectal cancer care (surgeons, oncologists, pathologists, epidemiologists) to initiate the first clinical audit. The scientific committee defined performance indicators and outcome measures, based on pre-existing evidence based guidelines, to highlight potential quality concerns, identify areas that need further investigation, and track changes over time. The committee defined a dataset using a Delphi

method6. The dataset generally covers three aspects: case-mix variables (e.g. age, gender, co morbidity) necessary for hospital comparison; process variables (e.g. wait times and number of patients discussed in a multidisciplinary team); and outcomes of care (e.g. morbidity and mortality).

3. Organizational structure

In accordance with the format of the DSCA, the Dutch Institute of Clinical Auditing (DICA) was founded to enhance other clinical audit initiatives in the Netherlands. The main goal of the DICA was to support other clinical audits by facilitating on legal, technical, methodological and logistic issues. Three new audits have been initiated since the introduction of the DSCA: the breast cancer audit (NBCA), the upper GI cancer audit (DUCA) and the lung surgery audit (DLSA). The organization structure of the DICA is graphically presented in Figure 1.

4. Funding

The onset of the DSCA was funded by quality improvement grants donated by a health care insurance company. Since 2013, hospitals pay a subscription fee for participating in the DSCA. The subscription costs are returned to the hospitals as they are enclosed in the payments of treating patients with colorectal cancer. Costs of the data registration itself are not compensated and are borne by the hospitals.

5. Online data is self-registered in a secured web form

Each participating hospital appoints a surgeon responsible for (supervising) the data registration. The majority of the colorectal surgeons record the data themselves. The DSCA uses a generic internet

based program to enable data entry in a secured web environment⁷. Depending on the complexity of the patient and perioperative course, a number of 56 to 179 variables have to be completed; registration time is approximately 20 to 30 minutes per patient. Data-entry can be entered either throughout patient's management or at the end of each admission. Data can be updated when necessary; for example when follow-up data is available. A third trusted party anonymises data regarding patient identification directly after data entry⁸. Definitions and helping texts are appointed to each variable in the dataset and are available during data entry. These guarantee that registration is performed uniformly. Also, frequently asked questions (FAQs) are available on the website and a front office can be contacted by data registrants for questions on both technical and content issues.

6. Internal and external data verification

Data validity is achieved and verified in various ways. The surgeon receives direct feedback on erroneous, missing or improbable data items during data entry through quality control tools that are built in the program. Hospitals receive feedback information on the number of patients and completeness of the data to encourage the participants to correct them when needed.

Data are annually compared with an external data registration, the National Cancer Registry (NCR), on completeness and accuracy.¹ The NCR registers all newly diagnosed malignancies in the Netherlands. Information on patient characteristics (e.g. age, gender) tumour characteristics (TNM stage, localization, histology) treatment (surgical procedure, chemo and/or radiation therapy, laparoscopy, urgency of procedure) hospital of diagnosis, hospital of treatment and outcomes (30-day mortality, anastomotic leakage, CRM, lymph nodes), are collected from the medical records by specially trained registrars

9 months after diagnosis^{9,10}. The NCR has an automatic linkage to many important and solid databases, among which the Municipal Administration (GBA), which allow the full enrolment of patients eligible for registration and notification for postoperative mortality. Quality of the NCR data is high; completeness is estimated to be at least 95%.¹¹ The registration of the NCR is linked to the Municipal Administration, which by law receives notification on all patients that decease in the Netherlands. The quality of the data in comparison to the NCR is described elsewhere¹².

7. Online feedback is provided on a weekly basis

Information regarding volume, performance indicators and outcomes of care are presented online to individual hospitals. Each participating hospital has access to its own secured website. Data are weekly updated. Results of the hospital are presented in relation to the national average and in relation to results of other anonymised hospitals.

8. Outcomes are adjusted for differences in case-mix

The methods to measure quality of care are described in detail elsewhere.^{12,13} When comparing hospital outcomes differences in case-mix must be taken into account.¹⁴ Therefore, a set of relevant case-mix variables specific for each outcome measure is embedded in the database. A standardised co morbidity module was developed using the Delphi method with incorporation of the Charlson Co morbidity Index.^{15, 16} Case-mix adjusted hospital outcomes are presented in funnel plots using 95% confidence limits that vary in relation to the hospital volume.¹⁷

9. Results and targets for quality improvement are presented in an annual report.

An extensive national report presenting the results of the audit is published annually.¹² This report focuses on various themes for improvements in the scope of recent literature. The results are presented in a yearly conference accessible to clinicians, patients, patient advocates, health insurers and policy makers, politicians. The conference functions as a platform for all parties to address their (common) interests and to discuss diverse health care topics.

Analysis of results of the DSCA

The completeness of the data on a national level is described by the percentage of participating hospitals and case ascertainment for each audit year. Patient, tumour and treatment characteristics are shown separately for patients with colon and rectal cancer. Then, the results of performance indicators on both process and outcomes of care were evaluated using a Chi square trend test was used to analyse changes over time. Last, hospital variation for preoperative multidisciplinary team discussions for rectal cancer surgery are presented in a scatter plot, illustrating changes in variation over time.

Results

Dataset

From 2009 to 2011, 26,511 patients undergoing surgical resection for colorectal carcinoma were registered by all 92 hospitals providing colorectal cancer care in the Netherlands (8 university, 47 teaching and 37 non-teaching hospitals). The national case ascertainment and completeness of the data per patient record was high. Compared

with the data collected by the NCR, the DSCA included 80% of all eligible patients in 2009, 92% in 2010, and 95% in 2011. External data verification with the NCR showed nearly 100% completeness and high correspondence on almost all items of the dataset¹².

Patients

Information on tumour localisation, date of surgery and mortality are minimal requirements for analysis of patient records. In total, 752 patients (2.8%) were excluded for this reason. Hospitals that failed to register more than 10 patients were excluded to minimise selection bias. In 2009, this concerned 5 hospitals registering a total of 37 patients. In 2010 and 2011, none were excluded. In the results presented in this article, patients with multiple synchronous tumours (n=894) were excluded as well. A total of 24,828 patients were included in the analysis. Patient, tumour and treatment characteristics are shown in Table 1, stratified by tumour location: colon (n=17,729) and rectal cancer (n=7,099). Patients in both groups differ in age, prevalence of preoperative complications, urgency of the resection and tumour stage. Treatment patterns differ as well. For example, the percentage of diverting stomas is 4% in colon cancer surgery compared to 33% in rectal resections. Preoperative radiation therapy is applied in 84% of rectal cancer patients, which is very high from an international perspective.¹⁷

Performance indicators

A number of noticeable improvements on pre-defined performance indicators occurred since the introduction of the audit in 2009. These improvements concerned both processes as well as outcomes of care. Table 2 shows the results. Definitions of the various variables are provided in *table 3*.

Process

From 2009 to 2011, the percentage of patients discussed in a preoperative multidisciplinary team increased significantly both in colon (46 to 68%, $P<0.01$) and rectal cancer surgery (80 to 96%, $p<0.01$). Moreover, the in-between hospital variation decreased during this time period (*Figure 2*). There was a significant increase in the implementation of guideline-recommended preoperative MR-imaging for rectal cancer surgery (80 to 83%, $p<0.001$), as well as an improved standard of pathological reporting of the circumferential resection margins (48% to 80%, $p<0.01$).

Outcomes

Postoperative morbidity, length of hospital stay and postoperative mortality decreased significantly from 2009 to 2011 both for colon and rectal cancer surgery. The incidence of any postoperative complication decreased from 33 to 31% ($p<0.01$) after colon resections and from 40 to 38% ($p<0.01$) after rectal resections. The re-intervention rate decreased from 15 to 13% ($p<0.001$) after colon resections and from 17 to 14% ($p<0.01$) after rectal resections. Duration of hospital stay regressed with 2 days (both after colon and rectal resections). Postoperative mortality rates (both in-hospital and 30-day mortality) decreased from 5.8 to 4.0% ($p=0.012$) after colon resections and from 3.8 to 2.7% after rectal resections.

The percentage of patients with a positive circumferential resection margin (CRM) after rectal cancer surgery (≤ 1 mm distance tumour to CRM) decreased from 14% to 8.5% ($p<0.001$).

Discussion

This paper reports the key elements of the Dutch Surgical Colorectal Audit that have been crucial for its success. Quality of care regarding guideline compliance and clinical outcomes for colorectal cancer patients in the Netherlands improved significantly.

Numerous international audit projects leading to substantial improvements in quality of care have preceded the DSCA. Many examples of successful clinical audits have been described in detail.^{2,3,18-20} Often, the main goal of the audit is to generate valuable information for clinicians to receive feedback on the quality of care.

A unique feature of the DSCA is the use of the audit data to support the effectuation of the national quality assurance policy of the surgical professional association, the ASN. There is a common need for evidence based, professionally supported consensus on what high quality care means in order to set standards of care. Benchmarking hospital performances can support surgeons in determining the minimal requirements of the provided care. On a national level, outliers can be identified. The ASN initiated an independent audit committee to provide consultative advice to hospitals identified as negative outliers in the DSCA. Furthermore, the ASN can use the data for board certification of surgeons, accreditation of hospitals, national and local improvement projects and the provisioning of valid quality information for patients, health care insurers and policy makers.

The engagement of colorectal surgeons to participate was mainly achieved by a strong plea for auditing in national meetings and conferences. The ASN strongly believed that for a valid measurement of quality of care, quality measures should be designed, registered, and interpreted by surgeons themselves. From the onset, the initiative was supported by the majority of Dutch colorectal surgeons, despite the investment in time and costs. One year later, participation became a quality indicator for the health care inspectorate, which ensured an almost 100% participation rate.

The contents of the DSCA dataset as well as the pre-defined process and outcome measures are generally supported by colorectal surgeons in the Netherlands, since they are based on evidence based guidelines and developed by representatives of their own professional organization, who are experts in the field. The leading role of the professional association and its expert members in the design, development and conduct of the audit has important advantages. It produces meaningful and feasible quality information, valid in the face of participating surgeons. This may also have led to the high participation rate among colorectal surgeons and their tremendous efforts to enter high quality data in the registry.

In three years, a trend towards better performance indicator results was objectified. A significant reduction in postoperative morbidity and mortality was observed, as well as a reduced duration of hospital stay. Although promising, the continuation of these trends needs a longer period of registration to be confirmed.

Also, as was presented in *Figure 2*, the variation in guideline compliance between hospitals was reduced. Although, these improvements may have multifactorial causes, the active and integrated approach of the DSCA has at least resulted in increased awareness of surgeons for quality aspects of their practice and provided insight in areas of improvement. The potential of clinical registries to improve health care outcomes and lowering related costs was recently demonstrated in a study by Larsson et al.²¹

An important feature that supports the audit to function as a quality improvement tool, is the web based data collection system. This system facilitates timely registration of patients and automated feedback of benchmarked performance information on a weekly basis. These features may have contributed to the demonstrable improvements in quality of care presented here.

In recent years there has been an increasing demand for valuable and reliable information on the performance of health care providers from various perspectives. The ASN aimed at developing a

system that responds to the exigencies of all major stakeholders in hospital care: patients, clinicians, managers, policy makers and insurance companies. Dutch surgeons have recently agreed to gradually publish publicly their hospital-specific audit results to provide transparency to all parties concerned. For the ASN, an important condition for external transparency is the validity and reliability of the data. This is assured by consistent quality checks on the registered data in the online system and the annual external validation with the National Cancer Registry.

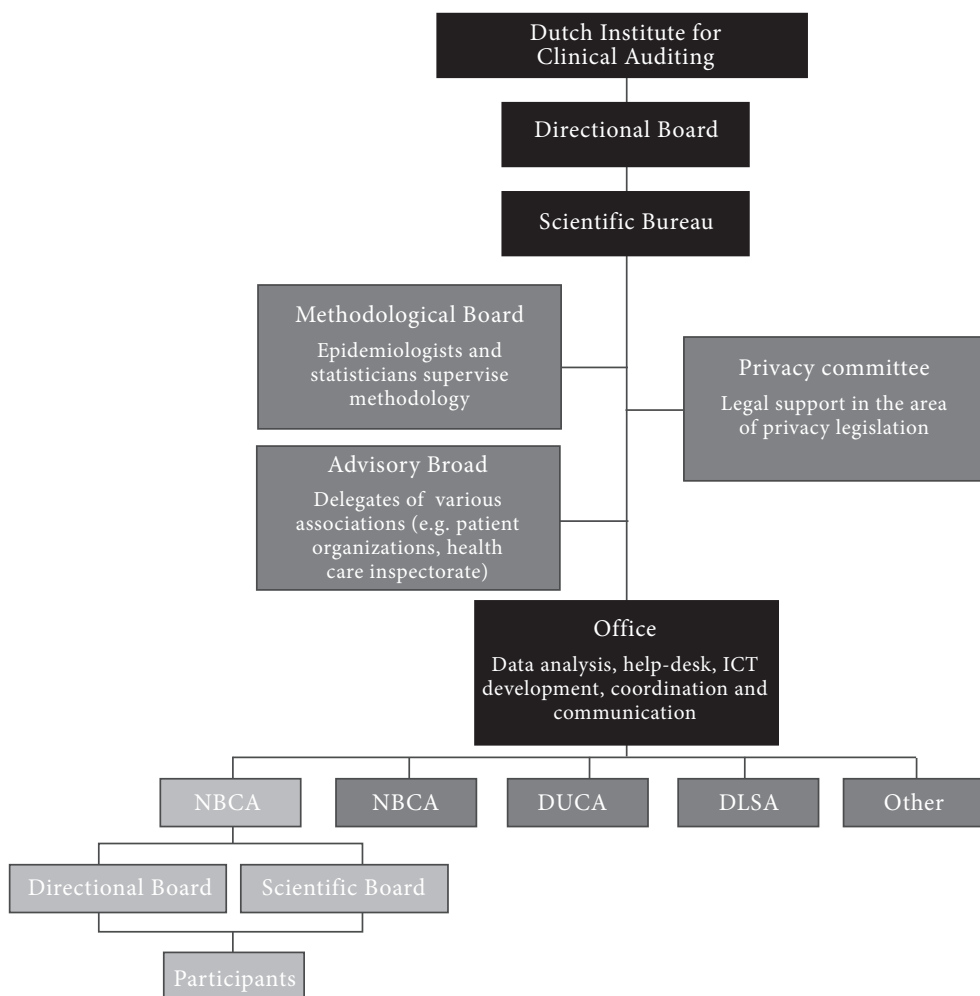
A limitation of the DSCA concept is the administrative burden that is associated with data collection. The measurement of quality of care is complex, and requires the collection of multiple data points from different phases of the care process. The dataset is limited, but still entails detailed information to perform case-mix adjustment and in-depth analysis of observed variation in care processes. Structural data management support for the health care professionals is essential for a sustainable auditing process. Automated retrieval of data from electronic patient files is the logical next step. However, apart from the technical difficulties that have to be solved to extract data from the varying electronic systems in Dutch hospitals, it is essential that synoptic reporting is implemented in the administrative process of hospitals. Links between other databases like the Dutch Pathological Anatomical District Automatized Archives (PALGA) are being established to minimise the registration burden and to automate as much as possible.

In the future, to reach full potential of the audit, information on outcomes of care should be linked to patient reported outcomes and financial information. Feedback to clinicians on patients' satisfaction and quality of life enables them to improve their practice, attitude, facilities and outcomes. Cancer patient organizations in the Netherlands have already committed themselves to collaborate in providing the clinical audits with patient reported outcomes in the near future.

Conclusion

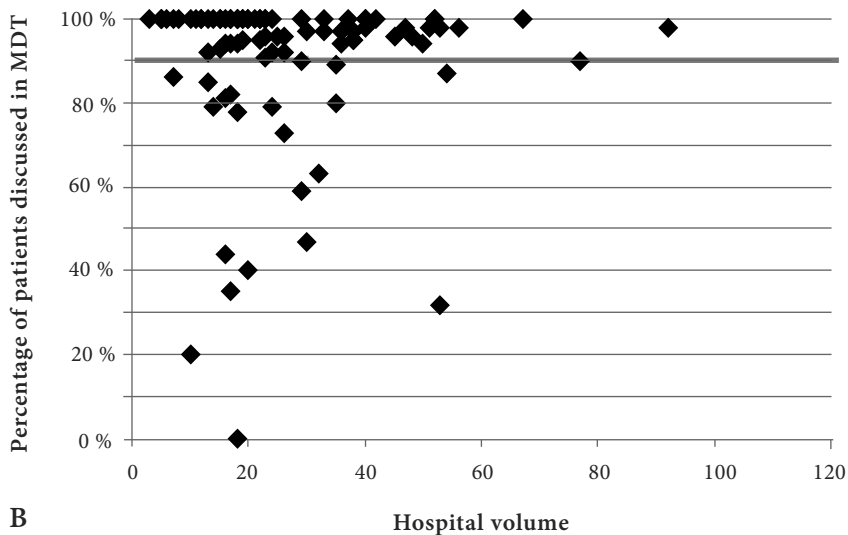
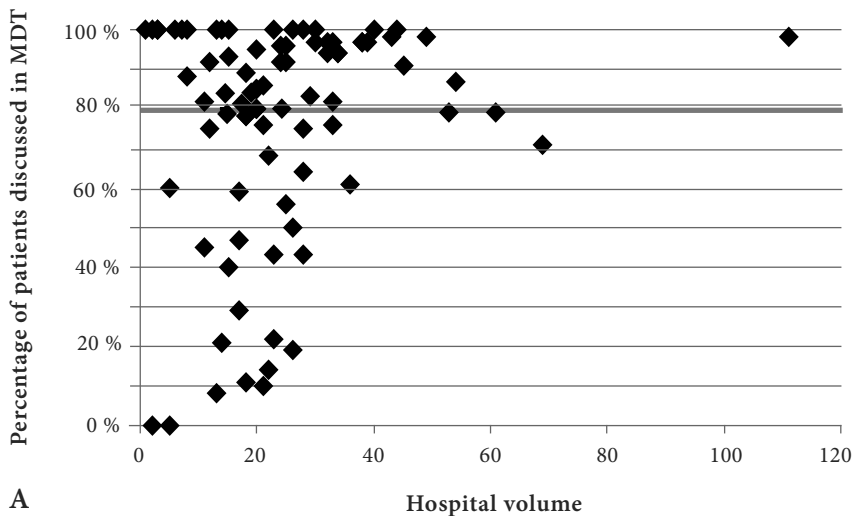
We demonstrated the feasibility of nationwide surgical audit programs, with national coverage and high case-ascertainment, accomplished in a relatively short period of time. The Dutch Surgical Colorectal Audit shows that substantial improvements can be realized within a time period of 3 years. Success factors include: a leading role for medical specialists, external data verification, weekly updated online feedback of benchmarked and meaningful quality information, and embedded in the quality assurance program of the professional association. In the Netherlands, this has been the recipe for the initiation of several other clinical audits, with a generic format consistent with the blueprint of the DSCA.

Figure 1. Organisational structure of the Dutch Institute for Clinical Auditing (DICA).

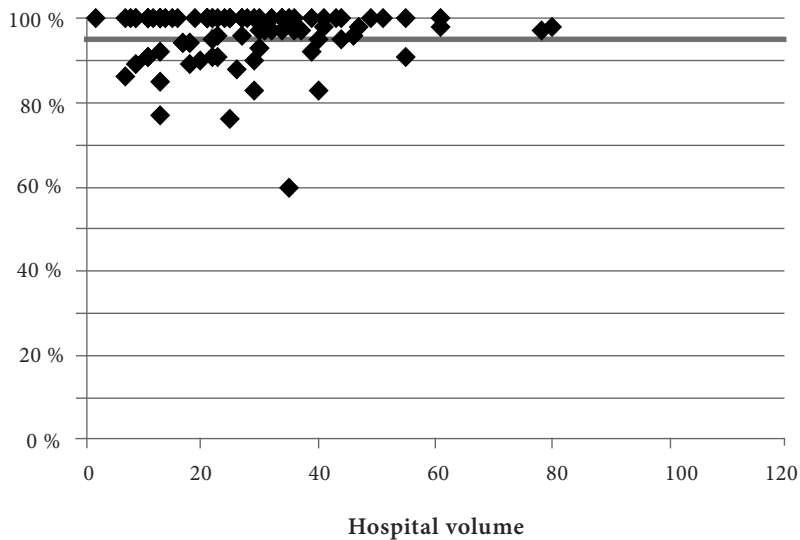


DSCA: Dutch Surgical Colorectal Audit; NBCA: Nabon Breast Cancer Audit; DUCA: Dutch Upper GI Audit; DLSA: Dutch Lung Surgery Audit.

Figure 2. Variation between hospitals in the percentage of patients with rectal cancer that was preoperatively discussed in a multidisciplinary team; a) 2009; b) 2010; c) 2011.



Percentage of patients discussed in MDT



C

The black line represents the average percentage of patients.

Table 1. Patient, tumour and treatment characteristics of patients included in the DSCA, stratified by colon and rectum.

	Colon		Rectum	
	N	%	N	%
Total	17729		7099	
Age				
>70	10192	57.5%	3155	44.4%
Gender				
Male	9212	52.0%	4394	61.9%
ASA classification				
III	4064	22.9%	1133	16.0%
IV-V	410	2.3%	65	.9%
Missing	426	2.4%	168	2.4%
Charlson score				
1	3965	22.4%	1409	19.8%
≥ 2	4313	24.3%	1327	18.7%
Body mass index				
25-30 kg/m ²	4701	26.5%	1935	27.3%
>30 kg/m ²	4752	26.8%	2204	31.0%
Missing	5982	33.7%	2073	29.2%
Abdominal surgical history	Yes	34.6%	2094	30.1%
Tumour location				
Right colon	7917	44.7%	-	-
Transversum/left colon	2884	16.3%	-	-
Sigmoid	6928	39.1%	-	-
Distance of tumour from anal verge				
< 5 cm	-	-	2379	37.1%
5 - 10 cm	-	-	2613	40.8%
> 10 cm	-	-	1417	22.1%
Missing	-	-	697	9.9%
Urgency of resection	Acute/urgent	20.1%	199	2.8%
Preoperative tumour complications				
Tumour perforation	354	2.0%	41	.6%
Abces	262	1.5%	33	.5%
Ileus	2290	12.9%	176	2.5%
Bleeding	983	5.5%	383	5.4%

Tumour stage	I	2974	16.8%	2054	28.9%
	II	6410	36.2%	1804	25.4%
	III	5500	31.0%	2030	28.6%
	IV	2319	13.1%	566	8.0%
	X	365	2.1%	259	3.6%
Surgical preoperative treatment	Stoma	182	9.6%	560	9.8%
	Stent	157	8.3%	16	.3%
	Metastectomy/RFA	35	1.8%	96	1.7%
	Other	24	1.3%	34	.6%
Preoperative radiotherapy	5x5 Gy	-	-	3312	46.7%
	Long course isolated radiotherapy	-	-	595	7.9%
	Chemoradiation	-	-	2033	28.6%
Surgical procedure	Ileocoecal resection	258	1.5%	-	-
	Right hemicolectomy	7785	43.9%	-	-
	Transversal resection	553	3.1%	-	-
	Left hemicolectomy	1762	9.9%	-	-
	Sigmoid/Low anterior resection	6489	36.6%	4371	61.6%
	Abdominoperineal resection	-	-	2168	30.5%
	Laparoscopic	6606	37.4%	2690	38.1%
	Primary anastomosis	14845	86.2%	1146	17.0%
	With diverting stoma	698	4.1%	2208	32.7%
	End colostomy	1684	9.8%	3405	50.4%
	Minimal local extended resection	1036	6.2%	258	3.9%
	Maximal local extended resection	810	4.8%	280	4.2%
	Metastectomy	591	3.5%	202	3.0%

ASA: American Society of Anaesthesiologists risk score. RFA: radiofrequency ablation. *Includes abdominoperineal resections;
 **percentage is related to the performed anastomoses.

Table 2. Results of performance indicators for colorectal cancer care from 2009 – 2011.

	Colon						
	2009		2010		2011		P-value
Process							
Cases discussed in preoperative MDT	2286	46%	3504	56%	4255	68%	<0.01
Total colonoscopy	2931	61%	3816	62%	4149	67%	<0.01
Preoperative MRI							
CRM reported in pathology rapport							
>10 lymph nodes in sample	3623	73%	4902	78%	5423	84%	<0.01
Outcomes							
All complications	1595	33%	2062	33%	1918	31%	<0.01
Reinterventions	706	15%	917	15%	699	13%	<0.01
Anastomotic leakage	352	7,4%	456	7,5%	370	6,1%	<0.01
Hospital stay (mean in days)	13		12		11		<0.01
CRM positive margin							
30-day mortality	223	4,5%	255	4,1%	210	3,4%	<0.01
In-hospital mortality	232	4,7%	276	4,4%	230	3,6%	0.02
In-hospital mortality/30 day mortality	289	5,8%	300	4,8%	256	4,0%	<0.01
Total	4960		6293		6263		

MDT: Multidisciplinary Team; MRI: Magnetic Resonance Imaging; CRM: Circumferential Resection Margin * only for patients with a primary anastomosis.

Rectum

<i>2009</i>		<i>2010</i>		<i>2011</i>		<i>P-value</i>
1625	80%	2249	91%	2400	96%	<0.01
1467	76%	1858	77%	2016	83%	<0.01
1625	80%	2016	81%	2129	85%	<0.01
980	48%	1472	59%	2066	80%	<0.01
1182	58%	1520	61%	1700	68%	<0.01
793	40%	1007	41%	945	38%	<0.01
351	17%	435	18%	352	14%	<0.01
159	7,9%	217	8,8%	175	7,1%	<0.01
16		14		14		<0.01
138	14,0%	175	12,0%	168	8,5%	<0.01
48	2,4%	48	1,9%	54	2,2%	<0.01
55	2,7%	55	2,2%	64	2,5%	0.663
77	3,8%	58	2,3%	69	2,7%	0.035
2035		2484		2494		

Table 3. Definitions used in the DSCA.

Term	Definition
Tumour perforation	Preoperative tumour perforation with clinical signs of faecal peritonitis.
Abscess	Preoperative abscess formation in the intraperitoneal or extraperitoneal spaces.
Ileus	Preoperative presence of (partial) mechanical bowel obstruction with symptoms of abdominal cramping, abdominal distention, nausea, vomiting or failure to pass gas or stool.
Bleeding	Preoperative tumour related blood loss that requires an intervention (transfusion, urgent operation) or leads to anemia (Hb <7 mmol/L in male patients and <6.5 mmol/L in female patients).
Total colonoscopy	Preoperative visualization of the entire colon including the ascending colon by colonoscopy or CT colonography.
(Low) anterior resection	Rectosigmoid or rectal resection according to the TME principle with anastomosis of the colon to the intra- or extraperitoneal rectum or anal canal.
Multidisciplinary team	A team that consists of all mentioned specialists: a surgeon, an oncologist, a radiologist, a radiotherapist, and a gastroenterologist.
Urgent procedure	Non-elective colorectal resection that was required and performed within 24 hours of admission.
Anastomotic leakage	Clinically relevant anastomotic leak requiring a radiological or surgical reintervention.
Reintervention	An invasive (surgical, radiological or endoscopic) measure to treat a complication (excluding superficial drainage abscess of a wound abscess on the patient ward; introduction of a nasogastric tube; a central venous catheter; or tracheostomy).
Positive CRM	A circumferential resection margin of 1 mm or less.
Negative outlier	A hospital with a significantly worse (adjusted) outcome than the population average of all hospitals in the registration.

Hb=haemoglobin. CT=computed tomography. TME=total mesorectal excision. CRM=circumferential resection margin.

REFERENCES

1. Ozhathil DK, Li Y, Smith JK, et al. Colectomy performance improvement within NSQIP 2005-2008. *The Journal of surgical research* 2011;171:e9-13.
2. van Leersum NJ, Kolfshoten NE, Klinkenbijl JH, Tollenaar RA, Wouters MW. ['Clinical auditing', a novel tool for quality assessment in surgical oncology]. *Ned Tijdschr Geneesk* 2011;155:A4136.
3. Khuri SF, Henderson WG, Daley J, et al. Successful implementation of the Department of Veterans Affairs' National Surgical Quality Improvement Program in the private sector: the Patient Safety in Surgery study. *Ann Surg* 2008;248:329-36.
4. Pahlman L, Bohe M, Cedermarck B, et al. The Swedish rectal cancer registry. *Br J Surg* 2007;94:1285-92.
5. Dreyer NA, Garner S. Registries for robust evidence. *Jama* 2009;302:790-1.
6. Boukdedid R, Abdoul H, Loustau M, Sibony O, Alberti C. Using and reporting the Delphi method for selecting healthcare quality indicators: a systematic review. *PLoS One* 2011;6:e20476.
7. <http://www.msbi.nl/promise>
8. <http://www.zorgttp.nl>
9. Elferink MA, Krijnen P, Wouters MW, et al. Variation in treatment and outcome of patients with rectal cancer by region, hospital type and volume in the Netherlands. *Eur J Surg Oncol* 2010;36 Suppl 1:S74-82.
10. Elferink MA, Wouters MW, Krijnen P, et al. Disparities in quality of care for colon cancer between hospitals in the Netherlands. *Eur J Surg Oncol* 2010;36 Suppl 1:S64-73.
11. Schouten LJ, Jager JJ, van den Brandt PA. Quality of cancer registry data: a comparison of data provided by clinicians with those of registration personnel. *Br J Cancer* 1993;68:974-7.
12. Dutch Institute for Clinical Auditing. Annual Reports 2011. <http://www.clinicalaudit.nl>.
13. Kolfshoten NE, van Leersum NJ, Gooiker GA, et al. Successful and Safe Introduction of Laparoscopic Colorectal Cancer Surgery in Dutch hospitals. *Ann Surg* 2012.
14. Kolfshoten NE, Marang van de Mheen PJ, Gooiker GA, et al. Variation in case-mix between hospitals treating colorectal cancer patients in the Netherlands. *Eur J Surg Oncol* 2011;37:956-63.
15. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987;40:373-83.
16. Charlson M, Szatrowski TP, Peterson J, Gold J. Validation of a combined comorbidity index. *J Clin Epidemiol* 1994;47:1245-51.
17. Spiegelhalter DJ. Funnel plots for comparing institutional performance. *Statistics in medicine* 2005;24:1185-202.
18. Cornish JA, Tekkis PP, Tan E, Tilney HS, Thompson MR, Smith JJ. The national bowel cancer audit project: the impact of organisational structure on outcome in operative bowel cancer within the United Kingdom. *Surg Oncol* 2011;20:e72-7.
19. Jung B, Pahlman L, Johansson R, Nilsson E. Rectal cancer treatment and

outcome in the elderly: an audit based on the Swedish Rectal Cancer Registry 1995-2004. *BMC Cancer* 2009;9:68.

20. van Gijn W, van den Broek CB, Mroczkowski P, et al. The EURECCA project: Data items scored by European colorectal cancer audit registries. *Eur J Surg Oncol* 2012;38:467-71.

21. Larsson S, Lawyer P, Garellick G, Lindahl B, Lundstrom M. Use of 13 disease registries in 5 countries demonstrates the potential to use outcome data to improve health care's value. *Health Aff (Millwood)* 2012;31:220-7.

