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In-hospital mortality, 30-day readmission, and length of hospital stay after surgery for primary colorectal cancer: A national population-based study

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Abstract

Introduction: The simultaneous assessment of multiple indicators for quality of care is essential for comparisons of performance between hospitals and health care systems.

The aim of this study was to assess the rates of in-hospital mortality and 30-day readmission and length of hospital stay (LOS) in patients who underwent surgical procedures for colorectal cancer between 2005 and 2014 in Italy.

Methods: All patients in the National Italian Hospital Discharge Dataset who underwent a surgical procedure for colorectal cancer during the study period were included. The adjusted odd ratios for risk factors for in-hospital mortality, 30-day readmission, and LOS were calculated using multilevel multivariable logistic regression.

Results: Among the 353 941 patients, rates of in-hospital mortality and 30-day readmission were 2.5% and 6%, respectively, and the median LOS was 13 days. High comorbidity, emergent/urgent admission, male gender, creation of a stoma, and an open approach increased the risks of all the outcomes at multivariable analysis. Age, hospital volume, hospital geographic location, and discharge to home/non-home produced different effects depending on the outcome considered. The most frequent causes of readmission were infection (19%) and bowel obstruction (14.6%).

Conclusions: We assessed national averages for mortality, LOS and readmission and related trends over a 10-year time. Laparoscopic surgery was the only one that could be modified by improving surgical education. Higher hospital volume was associated with a LOS reduction, but our findings only partially support a policy of centralization for colorectal cancer procedures. Surgical site infection was identified as the most preventable cause of readmission.

Keywords: Colorectal cancer; Colorectal surgery; In-hospital mortality; 30-day readmission; Length of stay

Introduction

Colorectal cancer (CRC) is the second most common malignancy in Europe with 446 800 new cases in 2012 and ranks as the second-leading causes of cancer death.[1] With increases in health care costs, there is great interest in strategies that reduce costs while improving short- and long-term outcomes. Because surgery is the mainstay of CRC treatment, the evaluation of perioperative quality indicators is relevant, particularly if performed on large population-based databases by examining objective and comparable data.

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Among the many perioperative quality indicators, in-hospital mortality, unplanned readmission, and length of hospital stay (LOS) are the most studied because they are easily measured and strongly associated with both the quality of care and health care spending. While the use of in-hospital mortality as a quality indicator can be misleading,[2] the LOS and rates of unplanned readmission are interdependent outcomes that, when examined together, can help to determine the optimal path to minimizing costs and increasing health gains.[3−5]

Indicators of surgical quality may be used to compare performances between hospitals and may influence health care policy. For example, if optimal perioperative care is found to be associated with the surgeon or hospital volume, a policy of centralization of CRC surgery may be preferred. Moreover, because health care delivery and socio-economic background vary among countries, it is relevant to evaluate markers of quality of care in different health care systems and within each national health care context.

Despite a large number of studies that have assessed the rates of postoperative mortality and readmission and LOS after CRC surgery, the majority include only one or two of these quality indicators,[3,4,6−11] have small sample sizes,[8−11] are not population-based,[8−10] and include patients with both benign and malignant colorectal diseases.[3,8,12]

To overcome these limitations, we conducted a national-based investigation with the aim of simultaneously evaluating three surgical care indicators. This study included all Italian patients with a diagnosis of primary CRC who underwent surgery from 2005 to 2014.

The principal end-points of the study were assessments of the rates of in-hospital mortality and 30-day readmission and the LOS. The predictors of each of these outcomes and the causes of 30-day readmission were also investigated.

Methods

Study design and data source

In this observational retrospective national-based study, the data were retrieved only from the administrative National Italian Hospital Discharge Dataset. The Dataset, which has been established in 1996, is utilised by the Italian Ministry of Health for administrative purpose (reimbursement of hospitals, based on the DRG system); the Ministry also produces a national annual report on hospital admissions, available on-line for epidemiologic studies and supplies researchers with anonymized and de-identified data from the database.[14]

The hospital discharge form reports of patient demographics, dates of admission, surgical procedure and discharge, codes for primary and five secondary diagnoses and up to six procedures performed, surgical approach (open or laparoscopic), acuity of the admission (emergent, urgent or elective), status at discharge (died or alive), and discharge destination (home, non-home).

After approval of the study design by the Italian Ministry of Health, we had access to the data for this specific study. The analysis and interpretation of the data are the responsibility of the authors and do not represent the view of the Italian Ministry of Health.

Patients selection and definitions

Patients were identified according to the International Classification of Diseases, Ninth Revision, Clinical Modification 2007 (ICD-9-CM). The study included all patients aged 18 + years who were admitted into any Italian hospital with a diagnosis of primary colon (ICD9-CM 153.x) or rectal cancer (ICD9-CM 154.x) who underwent an elective or emergent/urgent surgical procedure from January 2005 to November 2014. The following ICD9-CM procedures were included: 45.7x, 45.8, 48.35, 48.49, 48.5, 48.6x, and 4595.

The exclusion criteria were the following: discharge to acute-hospitals if the record of the second hospitalization was unavailable, cancer of the anus (ICD9-CM 154.2, 154.3), date of cancer diagnosis before January 1, 2005, and placement of a stoma before the index hospitalization.

Patients who died during the index hospitalization were excluded from the analysis of readmission.

Outcome measures

The main outcomes of interest were in-hospital mortality, 30-day readmission, and LOS of the index hospitalization, which was defined as the hospitalization at which the original CRC surgery was performed. In-hospital mortality was defined as the death due to any cause during the index hospitalization prior to discharge. Thirty-day readmission was defined as any unplanned, distinct hospitalization within 30 days after the discharge of the index hospitalization. This outcome has been found to be a reliable surrogate of overall unplanned readmission because most preventable readmissions occur within one month of discharge.[15] LOS was defined as the interval between the date of the admission and the date of discharge.

The secondary outcomes were the following: the assessments of risk factors for mortality, readmission, and prolonged LOS; the assessments of the cause, mortality and reoperation rate; and the LOS of 30-day readmissions.

Risk factors for in-hospital mortality, 30-day readmission and LOS

The following variables were assessed for the prediction of in-hospital mortality, 30-day readmission and LOS: age, gender, geographic area of the hospital, indexes of comorbidity, elective or emergent/urgent admissions, site of the tumour, year of the index hospitalization, stoma creation during the index hospitalization, open or laparoscopic approach, and hospital volume of the procedures selected for this study.

Age was subdivided into five classes: 18–49, 50–59, 60–69, 70–79, and 80+ years. The geographic locations of the hospitals were divided into Northern, Central, and South/Islands areas. Comorbidities were measured as non-CRC-related hospitalizations in the year prior to the index hospitalization, and admissions for abdominal non-CRC-related surgery and the Charlson Index both referred to the three years prior to the index hospitalization.[16] The tumour site was recorded as the colon or rectum. The median annual CRC procedure volumes for each hospital and LOS were subdivided into quartiles.

Causes of the 30-day readmission

Using ICD-9CM diagnosis codes, the causes of 30-day readmission were subdivided as follows: infection, obstruction, urinary tract (excluding infection), cardiovascular, haemorrhage-related (haemorrhage, anaemia and haemorrhagic shock), malnutrition/dehydration, abdominal pain, stoma-related, neurologic, thromboembolism, other abdominal diagnoses, and other/unclassified. Infections were subdivided as likely related to abdominal complications, urinary tract infection or infectious colitis, infection of the abdominal wound, sepsis, and other unspecified infections. The surgical procedures performed, modality of discharge and LOS of the readmission hospitalization were recorded.

Statistical analysis

The chi-square test was used to assess differences in demographics and clinical characteristics according to in-hospital mortality and 30-day readmission, and a median regression was applied for the LOS. Multilevel multivariate logistical regression was used to calculate the adjusted odd ratio (OR). The use of multilevel regression was necessary due to the hierarchical structure of the data (first level: patient; second level: hospital). In the multilevel analysis, the LOS was categorized into two levels, i.e., under and over the median. The Stata 13.0 statistical package (Stata Corporation, College Station, TX) was used to perform all analyses. A p value of ≤ 0.05 was considered significant.

Results

Main outcomes

A flow-chart with the patients included in the study is reported in Fig. 1. Among the 353 941 patients who meet the inclusion criteria, 8867 (2.5%) patients died in the hospital. Among the 345 074 patients who were discharged alive, 20 808 (6%) patients were readmitted within 30 days after discharge. The median (IQR range) LOS of the 353 941 patients was 13 (9–19) days. As illustrated in Table 1 and Fig. 2, a linear decreasing was observed over time in the LOS ($p = 0.0001$), the rate of in-hospital mortality decreased in the last two years of observation ($p = 0.016$), and the rate of 30-day readmission increased from 5.8% during the 2005–06 to 6.2% during the 2013–14 ($p = 0.0001$).

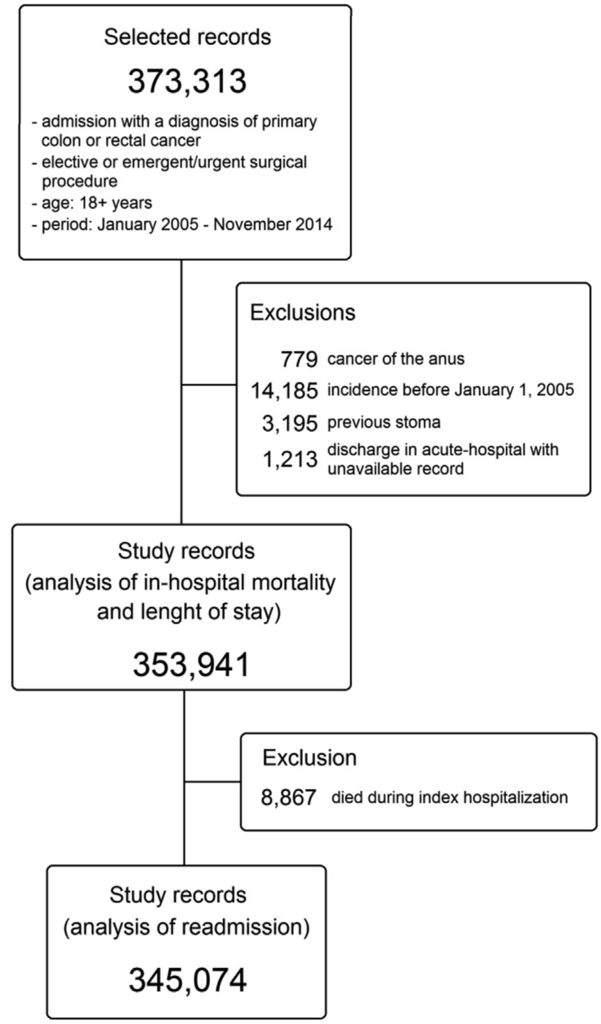

Figure 1. Study flow-chart.

Predictors of in-hospital mortality

Univariable analysis (Table 1) revealed that all of the variables exhibited a statistically significant association with in-hospital mortality.

On multivariable analysis (Table 2), such association was confirmed for only older age, male gender, northern/centre location of the hospital, comorbidities, stoma creation, emergent/urgent surgery, open approach, and colon site (Fig. 3).

Predictors of 30-day readmission

Univariable analysis (Table 1) revealed that all of the variables with the exception of geographic area exhibited a statistically significant association with the 30-day readmission.

On multivariable analysis (Table 2), male gender, northern location of the hospital, comorbidities, emergent/urgent

Table 1
Main characteristics of study patients, according to each outcome evaluated, and association* with study variables.

	In-hospital mortality					30-day readmission					Length of hospital stay				
	All patients		Died			All patients		Readmitted			All patients		LOS		
	n	Column %	n	Row %	p Value	n	Column %	n	Row %	p Value	n	%	Median	IQR	p Value
Patients	353 941	100.0	8867	2.5		345 074	100.0	20 808	6.0		353 941	100.0	13	(9–19)	
Age categories															
18–49	18 209	5.1	82	0.5	0.001	18 130	5.3	1048	5.8	0.001	18 209	5.1	11	(9–16)	0.001
50–59	46 375	13.1	316	0.7		46 062	13.3	2375	5.2		46 375	13.1	11	(9–16)	
60–69	94 333	26.7	1032	1.1		93 302	27.0	5011	5.4		94 333	26.7	12	(9–17)	
70–79	120 946	34.2	2875	2.4		118 071	34.2	7348	6.2		120 946	34.2	13	(10–20)	
80+	74 078	20.9	4562	6.2		69 509	20.1	5026	7.2		74 078	20.9	15	(11–23)	
Gender															
Male	197 130	55.7	5160	2.6	0.001	191 971	55.6	12 634	6.6	0.001	197 130	55.7	13	(9–19)	1.000
Female	156 811	44.3	3707	2.4		153 103	44.4	8174	5.3		156 811	44.3	13	(9–19)	
Geographic area of hospitals															
North	181 719	51.3	4579	2.5	0.001	177 131	51.3	10 811	6.1	0.176	181 719	51.3	12	(9–18)	0.001
Centre	91 846	25.9	2496	2.7		89 355	25.9	5312	5.9		91 846	25.9	13	(9–19)	
South/Islands	80 376	22.7	1792	2.2		78 588	22.8	4685	6.0		80 376	22.7	15	(11–21)	
Hospitalization in the year prior to the index surgery															
None	246 864	69.7	5273	2.1	0.001	241 587	70.0	13 092	5.4	0.001	246 864	69.7	13	(9–19)	0.001
One	77 824	22.0	2326	3.0		75 501	21.9	5230	6.9		77 824	22.0	13	(10–19)	
More than one	29 253	8.3	1268	4.3		27 986	8.1	2486	8.9		29 253	8.3	14	(10–21)	
Abdominal surgery in the 3 years prior to the index surgery															
No	323 377	91.4	7356	2.3	0.001	316 016	91.6	18 408	5.8	0.001	323 377	91.4	13	(9–19)	0.001
Yes	30 564	8.6	1511	4.9		29 058	8.4	2400	8.3		30 564	8.6	15	(10–22)	
Charlson score															
0	272 277	76.9	5103	1.9	0.001	267 169	77.4	14 524	5.4	0.001	273 000	76.9	12	(9–18)	0.001
1–2	70 855	20.0	2758	3.9		68 098	19.7	5140	7.5		71 183	20.0	15	(10–22)	
3+	10 809	3.1	1006	9.3		9807	2.8	1144	11.7		10 890	3.1	17	(11–26)	
Admission modality															
Elective	261 954	74.0	3605	1.4	0.001	258 346	74.9	13 741	5.3	0.001	261 954	74.0	12	(9–16)	0.001
Emergent/urgent	91 987	26.0	5262	5.7		86 728	25.1	7067	8.1		91 987	26.0	19	(13–27)	
Year of index Hospitalization															
2005–2006	71 460	20.2	1833	2.6	0.016	69 625	20.2	4063	5.8	0.001	71 460	20.2	14	(10–21)	0.001
2007–2008	74 700	21.1	1887	2.5		72 812	21.1	4315	5.9		74 700	21.1	13	(10–20)	
2009–2010	72 742	20.6	1824	2.5		70 916	20.6	4159	5.9		72 742	20.6	13	(9–19)	
2011–2012	70 136	19.8	1816	2.6		68 323	19.8	4345	6.4		70 136	19.8	12	(9–18)	
2013–2014	64 903	18.3	1507	2.3		63 398	18.4	3926	6.2		64 903	18.3	11	(9–17)	
Stoma creation in the index hospitalization															
No	301 777	85.3	6341	2.1	0.001	295 433	85.6	15 760	5.3	0.001	301 777	85.3	12	(9–18)	0.001
Yes	52 164	14.7	2526	4.8		49 641	14.4	5048	10.2		52 164	14.7	16	(11–25)	
Surgical approach															
Open	278 180	78.6	8384	3.0	0.001	269 793	78.2	16 935	6.3	0.001	278 180	78.6	14	(10–20)	0.001
Laparoscopy	75 761	21.4	483	0.6		75 281	21.8	3873	5.1		75 761	21.4	10	(8–14)	
Hospital volume															
1st quartile (1–43)	92 181	26.0	2483	2.7	0.001	89 694	26.0	5545	6.2	0.002	92 181	26.0	15	(11–21)	0.001
2nd quartile (44–82)	86 009	24.3	2440	2.8		83 568	24.2	5164	6.2		86 009	24.3	13	(10–20)	
3rd quartile (83–150)	87 628	24.8	2234	2.5		85 394	24.7	4976	5.8		87 628	24.8	12	(9–18)	
4th quartile (151+)	88 123	24.9	1710	1.9		86 418	25.0	5123	5.9		88 123	24.9	11	(9–17)	
Length of hospital stay															
1st quartile (1–9)	Not applicable					89 502	25.9	3858	4.3	0.001	Not applicable				
2nd quartile (10–13)						97 420	28.2	4926	5.1						
3rd quartile (14–19)						76 693	22.2	4873	6.4						
4th quartile (20+)						81 459	23.6	7151	8.8						
Modality of discharge															
Home	Not applicable					338 391	98.1	20 254	6.0	0.001	347 258	98.1	13	(9–19)	0.001
Non-home						6683	1.9	554	8.3		6683	1.9	21	(12–34)	
Site															
Colon	27 324	78.9	7488	2.7	0.001	271 834	78.8	15 160	5.6	0.001	279 324	78.9	13	(9–19)	0.001
Rectum	74 617	21.1	1379	1.8		73 240	21.2	5648	7.7		74 617	21.1	13	(10–20)	

*p Values estimated by univariable analysis.

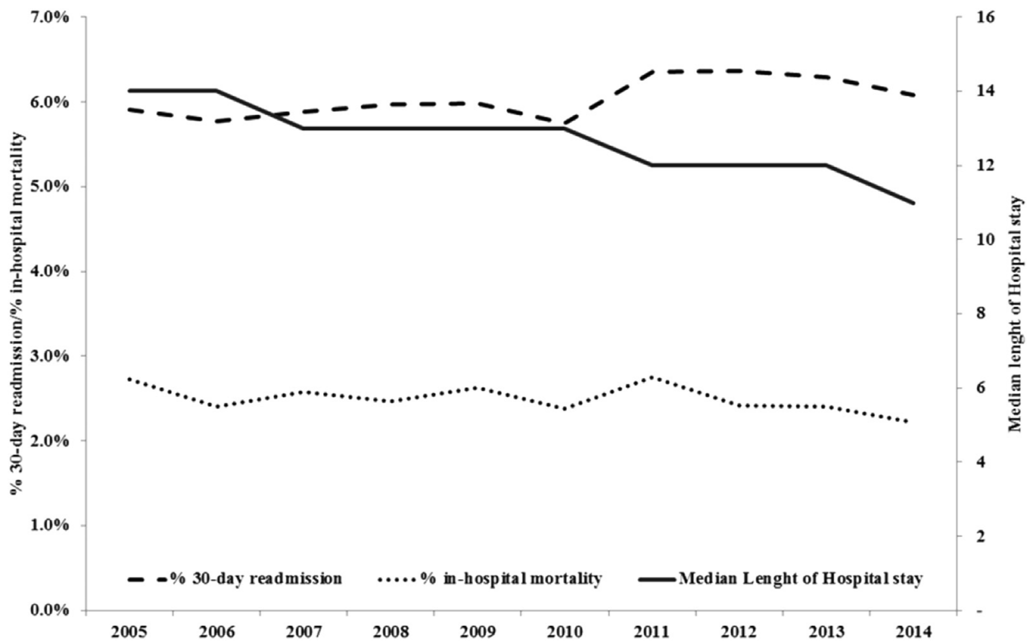

Figure 2. Crude 30-day readmission rate, in-hospital mortality rate and median length of stay, per year.

surgery, stoma creation, open approach, rectal tumour location, and longer LOS were found to be associated with an increased risk of 30-day readmission (Fig. 4).

Predictors of LOS

Univariable analysis (Table 1) revealed that all of the variables exhibited a statistically significant association with the LOS.

According to multivariable analysis (Table 2), older age categories, male gender, southern hospital location, comorbidities, emergent/urgent surgery, stoma creation, open approach, rectum tumour location, non-home discharge, early period index hospitalization and low hospital volume were found to be independent risk factors for a longer LOS. The ORs revealed linear correlations with the age category, the year of the index hospitalization, and the hospital volume (Fig. 5).

Overall, some variables (those indicating a high comorbidity, emergent/urgent admission, male gender, stoma creation during the index surgery, and open approach) increased the risks for all of the outcomes, and others (age, hospital volume, early period of index hospitalization, geographical locations of the hospitals, discharge at home/non home) exhibited different effects depending on the outcome considered (Fig. 3).

Cause, reoperation and outcome of 30-day readmission

The causes, rates of reoperation and mortality, and LOS of the readmissions are summarized in Table 3. The two most frequent causes of 30-day readmission were infection (n = 3 962, 19%) and abdominal obstruction (n = 3 028, 14.6%). During the readmission hospitalization, 4079 (19.6%) patients underwent a surgical procedure, and 1345 (6.5%) patients died. The median (IRQ range) LOS of the readmitted patients was 8 (4—13) days.

Discussion

In-hospital mortality, 30-day readmission, and LOS have been widely used as quality indicators in colorectal surgery. The evaluation of these outcomes over a ten-year period and in a national setting was the main goal of this study.

We found an in-hospital mortality rate for CRC surgery of 2.5% (Table 1), which is comparable with the results of other similar studies in which the in-hospital or 30-day mortality rates ranged between 0.9% and 9.9%.[4,6,7,10,12,13,17—22] The inclusion of patients younger than 65 and those who underwent minor colorectal procedures may explain the low rate of postoperative mortality found in the present study. A progressive decrease in postoperative mortality has also been reported by others[6] and may simply reflect improvements in perioperative care over time.

We found a 30-day readmission rate of 6% that slightly increased over time (Table 1). Although the rate of readmission favourable compares with the 7—25% readmission rates reported by two recent reviews and meta-analyses,[23,24] the finding of an increasing 30-day readmission rate is unexpected. This finding may be secondary to different factors, including the selection of patients as candidates for major surgery (presently, surgeons rarely refuse to operate on very old patients or patients with severe comorbidities). Moreover, although early discharge has been

Table 2
Multivariable analysis showing the association of study variables with in-hospital mortality, 30-day readmission and length of hospital stay.

	In-hospital mortality		30-day readmission		Length of hospital stay	
	OR	95% CI	OR	95% CI	OR	95% CI
Age categories						
18–49	1.00		1.00		1.00	
50–59	1.66	1.29–2.12	0.89	0.83–0.96	1.07	1.03–1.11
60–69	2.43	1.93–3.05	0.89	0.83–0.95	1.27	1.23–1.32
70–79	4.42	3.53–5.55	0.94	0.88–1.01	1.84	1.77–1.91
80+	9.74	7.78–12.21	1.02	0.95–1.10	2.45	2.35–2.55
Gender						
Male	1.00		1.00		1.00	
Female	0.84	0.80–0.88	0.84	0.82–0.87	0.95	0.94–0.97
Geographic area of hospitals						
North	1.00		1.00		1.00	
Centre	1.02	0.95–1.08	0.94	0.90–0.98	1.14	1.07–1.21
South/Islands	0.68	0.63–0.72	0.84	0.80–0.88	1.8	1.70–1.91
Hospitalization in the year prior to the index surgery						
None	1.00		1.00		1.00	
One	1.22	1.15–1.28	1.23	1.19–1.27	1.04	1.02–1.07
More than one	1.44	1.33–1.54	1.43	1.36–1.50	1.16	1.13–1.20
Abdominal surgery in the 3 years prior to the index surgery						
No	1.00		1.00		1.00	
Yes	1.14	1.06–1.22	1.08	1.02–1.13	1.07	1.03–1.10
Charlson score						
0	1.00		1.00		1.00	
1–2	1.43	1.36–1.51	1.22	1.17–1.26	1.34	1.31–1.36
3+	2.84	2.61–3.08	1.69	1.58–1.81	1.79	1.70–1.88
Admission modality						
Elective	1.00		1.00		1.00	
Emergent/urgent	3.03	2.89–3.17	1.36	1.31–1.41	4.03	3.95–4.12
Year of index Hospitalization						
2005–2006	1.00		1.00		1.00	
2007–2008	1.00	0.92–1.08	1.02	0.97–1.08	0.81	0.76–0.88
2009–2010	0.97	0.90–1.05	1.04	0.99–1.10	0.67	0.62–0.72
2011–2012	1.01	0.93–1.10	1.13	1.08–1.20	0.56	0.52–0.61
2013–2014	0.94	0.86–1.02	1.13	1.07–1.20	0.44	0.41–0.48
Stoma creation in the index hospitalization						
No	1.00		1.00		1.00	
Yes	2.37	2.25–2.50	1.68	1.62–1.74	1.9	1.86–1.95
Surgical approach						
Open	1.00		1.00		1.00	
Laparoscopy	0.31	0.28–0.34	0.94	0.90–0.97	0.58	0.56–0.59
Hospital volume						
1st quartile (1–43)	1.00		1.00		1.00	
2nd quartile (44–82)	1.16	1.08–1.24	1.03	0.98–1.07	0.81	0.76–0.86
3rd quartile (83–150)	1.16	1.08–1.24	1.00	0.95–1.05	0.69	0.64–0.74
4th quartile (151+)	0.97	0.90–1.06	1.04	0.99–1.09	0.55	0.50–0.61
Length of hospital stay						
1st quartile (1–9)	Not applicable		1.00		Not applicable	
2nd quartile (10–13)			1.13	1.08–1.18		
3rd quartile (14–19)			1.34	1.28–1.41		
4th quartile (20+)			1.68	1.60–1.76		
Modality of discharge						
Home	Not applicable		1.00		1.00	
Non-home			0.95	0.87–1.04	2.09	1.96–2.23
Site						
Colon	1.00		1.00		1.00	
Rectum	0.81	0.76–0.86	1.28	1.24–1.33	1.45	1.42–1.48

OR, Odds Ratio; CI, Confidence Intervals.

associated with an increased risk of the readmission among patients with multiple comorbidities or postoperative complications,[18] in accordance with others,[25] we did not observe this relationship.

The median LOS in our study was 13 days, and it decreased over time (Table 1). Because private practice is only a minor fraction of the Italian health system, our findings are comparable to population-based studies performed

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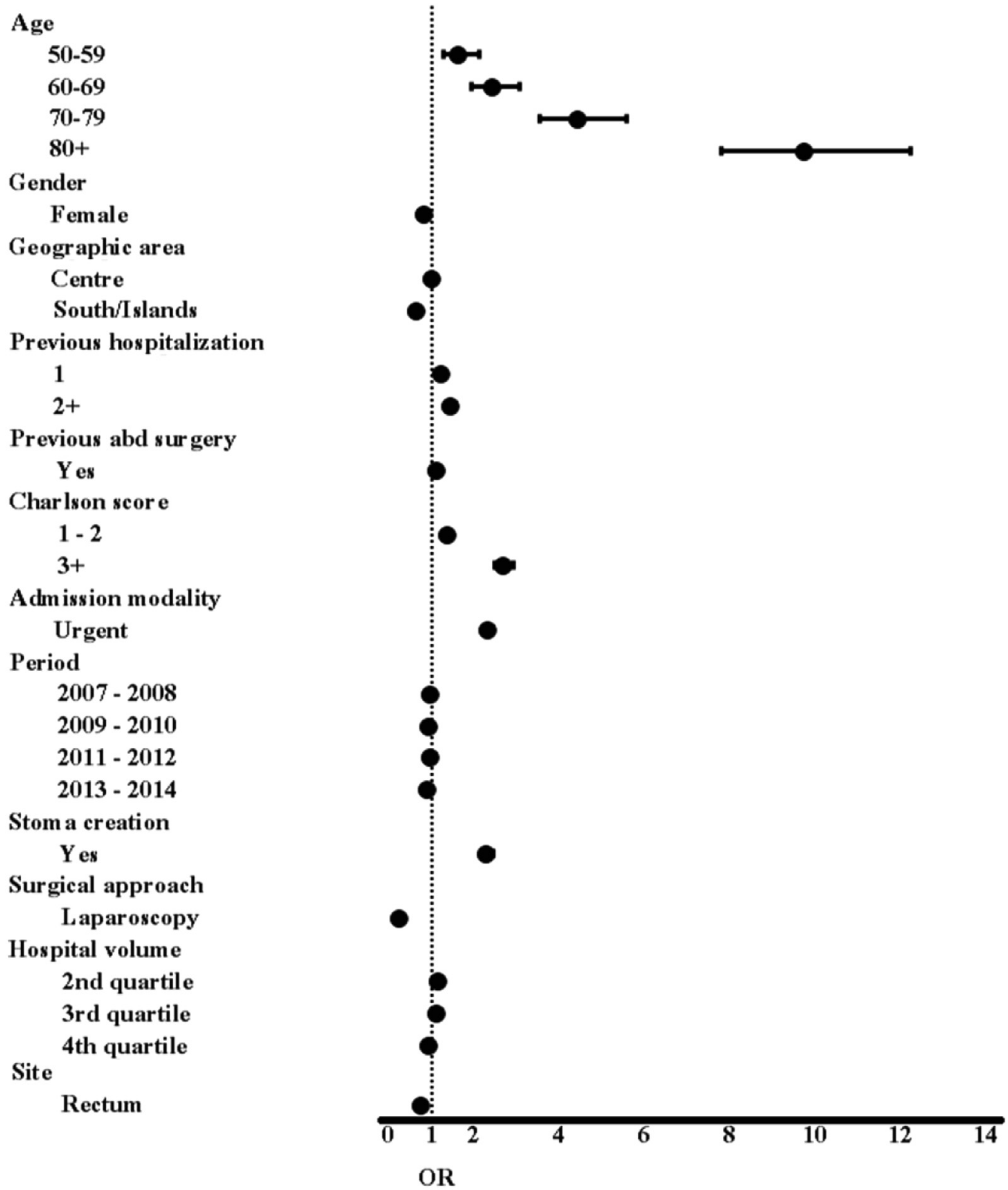

Figure 3. Risk factor for in-hospital mortality.

in countries with similar public health care.[3,26] Moreover, as in other reports,[3,18,26] the median LOS progressively decreased over time. Improvements in postoperative hospital care, a policy of cost-containment and the implementation of fast-track programs[27] in many hospitals likely explain this trend.

The risk for all three examined factors was independently increased according to several variables (Table 2): those reflecting high comorbidity, emergent/urgent admission, and stoma creation. These results are in line with the findings of previous studies.[3,4,7,19,21,23] Notably, the laparoscopic approach significantly reduced the risks for all the outcomes (Table 2). Although the benefits of the laparoscopic approach may be attributable to patient selection, our finding that this approach was an independent protective factor is relevant and confirms the results of other studies.[4,7,11–13,25,28–30] Consequently, efforts should be made to implement nationwide structured training in laparoscopic surgery[31] as well as the objective assessment tools for analysing technical performance.[32]

Other variables exhibited different associations depending on the specific outcome considered. Although older age was a strong risk factor for in-hospital mortality and LOS, it did not independently affect the 30-day readmission. Indeed, although there is wide agreement that older age is a risk factor for postoperative mortality,[7] its influence on 30-day readmission is controversial.[3,8,23,24,26] Indeed, old patients who neither die after the surgical procedure nor

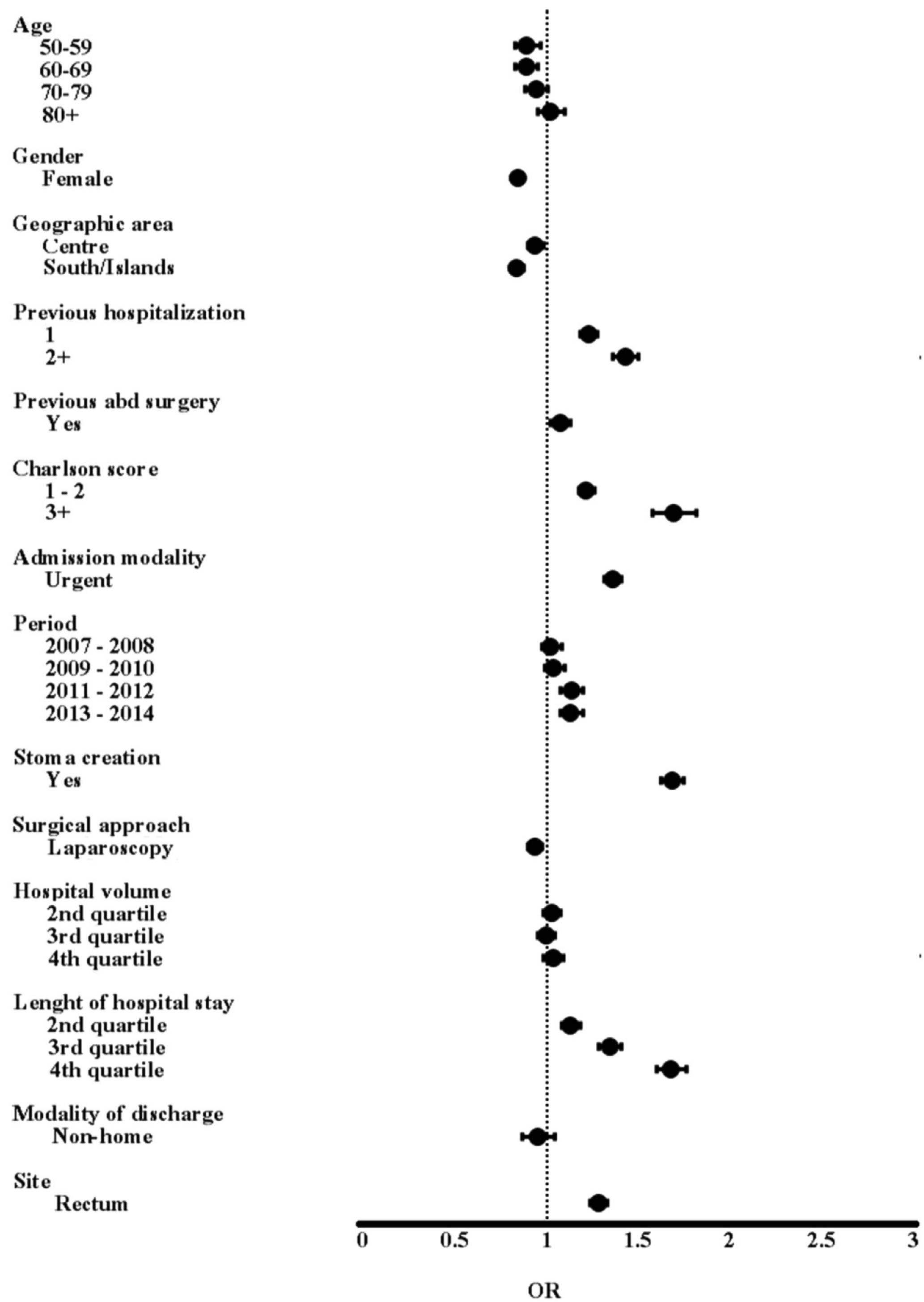

Figure 4. Risk factors for 30-day readmission.

are transferred to nursing facilities or hospice tend to have characteristics similar to younger patients. Moreover, these findings may reflect the utilization of less aggressive surgical approaches (i.e., local excision) in the elderly.

The association between hospital volume and LOS in favour of high volume hospitals has already been reported.[3,17] However, like others,[10,17] we did not demonstrate clear associations of hospital volume with in-hospital mortality or 30-day readmission. Accordingly to our previous findings,[17] the overall impact of this variable on short-term outcomes after CRC surgery remains controversial. Further studies that include data regarding the surgical complexity of CRC procedures and long-term outcomes may help to clarify this issue. Interestingly, in a recent study, a higher hospital volume

Figure 5. Risk factors for length of stay.

for laparoscopic surgery was found to be significantly associated with a decreased 30-day re-operation rate.[33] Therefore, it is possible that associations between hospital volume and short-term outcomes may be evident only in subgroups of patients, such as those with mid-low rectal cancer or those subjected to the laparoscopic approach.

In agreement with other studies,[3] we found that patients with colon cancer were at lower risks of 30-day readmission and prolonged LOS than those with rectal cancer (Table 1). Like others,[6,19,21,22,34] we also found that the location of the tumour in the colon independently increased the risk of in-hospital mortality compared with rectal cancer (Table 2). However, this finding requires further evaluation in the light of different pathologic stages of disease (this information was not available from this database) and of the inclusion of minor surgical procedures (e.g., local excisions for rectal cancer), which might actually have lowered the mortality solely in the rectal cancer group. Moreover, the anatomical definition of the rectum is known to not coincide with that of the "surgical" rectum. Surgical resections for mid-low rectal tumours are more technically demanding and pose a higher risk for post-operative

Table 3
Main characteristics of readmissions.

	N	%
Readmitted	20 808	100
Causes		
Infections	3962	19.0
Likely related to intra-abdominal complications	1886	–
Urinary tract or infectious colitis	519	–
Abdominal wound	215	–
Sepsis	364	–
Other	978	–
Abdominal obstruction	3028	14.6
Urinary tract	1890	9.1
Cardiovascular	1663	8
Anemia, haemorrhage, hypovolemic shock	1286	6.2
Malnutrition, dehydration	1258	6
Abdominal pain	1019	4.9
Stoma-related	728	3.5
Neurological or psychiatric diagnoses	563	2.7
Thromboembolism	457	2.2
Abdominal diagnoses excluded infections and haemorrhage	2999	14.4
Other/unclassified	1955	9.4
Reoperation		
Any reoperation	4079	19.6
Abdominal procedures	3310	15.9
Procedures on GI tract or stoma	1796	8.6
Modality of discharge		
In-hospital mortality	1345	6.5
Home	18 391	88.4
Non-home	1072	5.2
LOS		
Median (IRQ)	8	(4–13)

morbidity than those performed for tumours of the upper rectum or rectosigmoid junction. Notably, in line with this consideration, we found that stoma creation (usually performed in patients with mid-low rectal cancer) was a significant risk factor for all of the outcomes considered in this study (Table 2).

Although a policy of early discharge after CRC surgery raises concerns about the risk of higher rates of readmission and has been a debated topic, our findings, in agreement with others,[4,23,25,35] demonstrate the opposite. This finding is not surprising because a prolonged LOS is often associated with postoperative complications, advanced age and preoperative comorbidity.[5,18,28]

We also found contradictory findings regarding the influence of the geographic location of the hospital on this outcome. Although in-hospital mortality and 30-day readmission were significantly higher in the Northern compared with the South/Islands hospitals, the opposite was found regarding LOS. Geographic variations have also been reported by others[5] and likely depend on cultural, socioeconomic and organizational factors. For example, it is customary in the southern regions to transfer patients who are dying to their homes.

In our study, approximately 20% of the readmitted patients required a surgical procedure (Table 3); 6.5% of these patients died during the readmission stay, and the median LOS was eight days. Similar to others,[24,36] we found that the most frequent reasons for readmission were surgical site infections and bowel obstruction. Although one-third of readmissions have been considered as preventable,[35] the data retrieved from large databases are generally not adequate to identify preventable readmissions. While readmissions of patients with a stoma and dehydration are clearly preventable and may be reduced by improving the quality of discharge instruction, the timing of the postoperative clinic visit, and telephone follow-up, bowel occlusion is not easily preventable. Wound infection is at least partially preventable and can be reduced through multiple interventions whose implementations should be accurately tracked.[37] However, due to the lack of information about postoperative complications, we were not able to highlight any direct link between postoperative complications and preventable readmission.

Strengths and limitations

The strengths of this study are related to the large number of patients included who represented all patients who underwent CRC surgery in Italy from 2005 to 2014. The data are robust and may be used as a reference for public health care organizations.

A further strength of this study is its generalizability, as it includes all the admissions that took place in a whole country during a long period of time. This is slightly limited by the missed inclusion of Pull-through resection of rectum (ICD9-CM code 48.4), which has fallen into disuse in Italy but that could be still in use in other countries.

These data also provide insights into variations in CRC surgery and short-term outcomes over time and may form the basis for further studies of subgroups of CRC patients. Moreover, because a single measure of performance has been criticized as not reflecting the overall quality of CRC surgery,[38] the simultaneous use of three outcome markers of CRC surgery quality adds value to our study.

The limitations of this study are related to its retrospective design and, as with studies employing an administrative database, the lack of data that may have influenced the evaluated outcomes. The patients' income, tumour stage, surgical complexity, postoperative complications, and surgeon volume were not available, but these parameters are often reported as risk factors for short-term outcomes following CRC surgery. A further limitation is related to the ICD-9 coding system, which may have generated confusion in the definition of colon and rectal cancer because it does not account for the different clinical approaches employed for rectosigmoid junction and high and mid-low rectal tumours. A further potential weakness may be related to the accuracy of the coding of the diagnoses of the causes of readmission. However, because our findings are consistent with those of previous studies, the coding of the diagnoses of the causes of readmission was plausibly accurate.

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In conclusion, we demonstrated that the rate of in-hospital mortality for CRC procedures is low (2.5%) as is the rate of the readmission (6.5%). The LOS during the course of the study decreased from 14 to 11 days. The variables associated with comorbidity increased the risks of all considered outcomes. The effects of other variables were not univocal, and in some cases, these variables exhibited opposite influences on different outcomes, which suggest that a single measure of performance may be misleading when evaluating the overall performance of CRC surgery. Our findings only partially support a policy of centralization for all CRC procedures. Finally, surgical site infection and bowel occlusion were the most frequent reasons for readmission, and the latter is partially preventable, which justifies financial investments in both research and performance improvement programmes.

Conflict of interest

All authors disclose any financial and personal relationships with people or organisation that could inappropriately influence the paper.

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