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Outcomes following colorectal cancer surgery: Results from a population-based study in Queensland, Australia, using quality indicators

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Abstract

Rationale, aims and objectives: Colorectal cancer (CRC) is one of the most common cancers diagnosed worldwide, and rates are continuing to rise. Surgery is the primary treatment for CRC, and our aim was to examine clinical outcomes following major resection using a series of established quality indicators and to identify factors associated with poor clinical outcomes.

Method: This population-based retrospective study included 4321 patients with diagnosed with CRC in 2012 and 2014 in Queensland, Australia, who underwent a major resection. Primary outcomes included in-hospital mortality, 30-day unplanned readmission, extended hospital stay (>21 days), and 30- and 90-day mortality. Multivariable logistic regression modelling was conducted to establish factors independently associated with each outcome of interest.

Results: Overall, in-hospital mortality was 1.5%, 3.0% had an unplanned readmission, 8% had an extended hospital stay, and 30- and 90-day postoperative mortality was 1.6% and 3.1%, respectively. After adjustment, we found that factors such as older age, presence of comorbidities, emergency admission, and stoma formation were significantly associated with poorer outcomes with these findings being consistent across each of the outcomes of interest. In addition to these factors, the risk of 90-day mortality was significantly elevated for patients with advanced stage disease (OR = 1.95, CI 1.35-2.82). Sex, primary site, hospital volume, residential location, nor socioeconomic status was found to be associated with any of the outcomes of interest.

Conclusion: Overall, the risk of poorer clinical outcomes for CRC patients in Queensland, Australia, is low. There is however a subgroup of patients at particularly elevated risk of poorer outcomes following CRC. Strategies to reduce the poorer clinical outcomes this group of patients experience should be explored.

KEYWORDS

clinical audit, colorectal cancer, outcomes, population-based, quality indicators

1 | INTRODUCTION

Colorectal cancer (CRC) is the fourth most common cancer worldwide (excluding nonmelanoma skin cancers) with an estimated 1 136 000 people diagnosed in 2012.[1] Highest incidence is observed in countries within more developed regions. In Australia, over 15 000 new cases of CRC were diagnosed in 2014 with over 4000 deaths in the same year for a population of approximately 23.5 million.[2]

Surgery is the primary treatment for CRC usually involving resection of the primary tumour.[3] Clinical audits are a commonly used tool where outcomes, procedures, and/or processes are assessed against a set of agreed standards. Audits are viewed as part of the continuous improvement process.[4,5] In the oncology setting, surgical audits are widely used to compare practitioner and institutional performance to identify areas for improvement.[6]

A recent systematic review reporting on the quality of colorectal surgery summarized quality indicators into four categories including "structural factors" (eg, hospital volume, surgeon training and subspecialization, accessibility, models of health care delivery), "process markers" (eg, adherence to clinical practice guidelines, type of surgery, length of hospital stay), "outcome measures" (eg, in-hospital and 30-day, 1- and 2-year survival, postoperative complications), and "the patient perspective" (eg, health-related quality of life).[7] Clinical outcomes can also be influenced by patient factors such as age, sex, and the extent of comorbidities.[8] Understanding variations in outcomes and their causes is a first step towards improving quality of care.

In Australia, two models of health care exist, one a fully funded public health care system whereby residents have access to free medical and hospital care. Additionally, residents may pay for private health insurance through various providers. It is estimated that approximately 57% of Australians 18 years and over have some level of private health insurance.[9] Those with private health insurance can elect to be treated in a public or private hospital. Australian State and Territory governments are primarily responsible for the delivery and management of public health services including public hospitals and are also responsible for the regulation of private health care facilities.[10] Australia is also a geographically large country where tertiary hospitals are located in major cities and smaller hospitals offering fewer services are located in regional centres. Lack of access to tertiary care has been suggested as a factor in the poorer outcomes rural and regional patients experience following a diagnosis of CRC.[11] In Queensland, over 40% of the population of 4.9 million live outside the capital city[12] where access to tertiary care can be limited.

This large population-based study in Queensland, Australia, describes outcomes following surgical resection for CRC using a dataset of linked registry and health care administrative data. Our aim was to identify factors associated with poorer outcomes to help improve quality of cancer care.

2 | MATERIALS AND METHODS

In Queensland, mandatory notification of all cancer diagnoses (with the exception of keratinocyte cancers) to the Queensland Cancer Register (QCR), a data source within the Queensland Oncology Repository (QOR), managed by the Queensland Cancer Control Analysis Team (QCCAT) is mandatory.[13] This centralized repository accesses multiple data collections including hospital admissions, treatment systems, pathology, comorbidities, and death data which are matched and linked to the QCR. QCCAT's established partnerships with clinical teams of specialists have developed a "quality index" for CRC surgery focused on indicators of safe, quality cancer care using measures such as in-hospital mortality, 30- and 90-day mortality, and surgical survival.[14]

2.1 | Sample and data sources

This retrospective study included all cases of CRC (ICD-10 AM codes C18-20) reported to the QCR for Queensland residents diagnosed from 1 January 2012 to 31 December 2012 and 1 January 2014 to 31 December 2014 who underwent a major surgical resection for CRC. These two years represented the most recent data to include cancer stage as part of our regular clinical audits. Major resection was defined as an abdominoperineal resection, anterior resection, colectomy, Hartmann's, or total proctocolectomy.

2.1.1 | Variables included

Cancer site, histology, and stage were extracted from the QCR with stage assigned according to the TNM classification and then collapsed into two groups: early (included stages I and II) and late stage (included stages III and IV). We were unable to assign a stage to 26 cases (0.6%). To allow comparisons across studies, hospital volume was categorized as low (<20), medium (20-50), and high (>50) CRC cases annually.

Socioeconomic status (SES) was assigned according to the Australian Bureau of Statistics (ABS) Socio-Economic Indexes for Areas (SEIFA), a census-based measure of social and economic well-being.[15] Residence at the time of diagnosis was categorized into three groups: major city, inner regional, outer regional/remote/very remote based on the Australian Geographical Classification (ASGC).[16]

Comorbidity was derived from hospital admissions data and included any comorbid condition in the period 1 month prior to, and up to 12 months after surgery. American Society of Anaesthetic (ASA) physical status classification system was used for assessing physical fitness prior to surgery,[17] and mortality included all causes of death.

2.2 | Analysis

Outcomes of interest included in-hospital mortality, unplanned readmission, extended hospital stay (>21 days), and 30- and 90-day mortality. Postoperative mortality was calculated as the number of days from major resection to death. To investigate factors independently associated with outcomes of interest, multivariable logistic regression models were undertaken. Covariates included age, sex, place of 2residence, SES, cancer site and stage, comorbidities, ASA score, neoadjuvant radiotherapy, surgical approach (open or laparoscopy), and hospital volume. We additionally adjusted the model for the type of facility (public versus private). Results are presented as odds ratios (OR) along with 95% confidence intervals (95% CI). Analyses were conducted using Stata V15.1 (Stata Corp, College Station, TX, USA).

3 | RESULTS

Overall, 5608 Queensland residents were diagnosed with CRC in the years 2012 and 2014. Of those, 8.8% (n = 494) did not receive any surgery and 13.3% (n = 746) had a local excision only. Of the remaining 4368 patients, 77.9% had a major resection and 4321 (98.9%) had complete data for this analysis. Of those who did not have surgery, the majority (75%) had disseminated disease.

In the final cohort, just over half were male (56.2%), median age at diagnosis was 70 years (range 19 to 100), and about 1.0% (n = 42) were Indigenous (Table 1). Over half (59.7%) lived in a major city, and just under one-quarter (22.4%) were from areas of disadvantage. About 1 in 10 patients had two or more comorbidities (10.9%), and 13.6% of admissions were as an emergency. Of the cohort, 70.6% had colon cancer, and over half (59.0%) had early stage cancers (similar for colon and rectal) (Table 1). Over one-third of rectal cancer patients (38.4%) received adjuvant radiotherapy compared with 0.6% of colon cancer patients ($P < 0.001$). We found some differences across categories of residential location for variables such as socioeconomic status ($P < 0.001$) and age ($P = 0.01$). Additionally, the percentage of patients having laparoscopic surgery was lower for rural patients compared with those living in major cities (42.6% and 48.8%, respectively, $P = 0.007$) (Table 1). We found no significant differences in the proportion of patients presenting with later stage disease according to residential location.

3.1 | In-hospital mortality, emergency readmission, and extended hospital stay

Overall, 64 in-hospital deaths were recorded (1.5%). After adjustment (Table 2), the odds of in-hospital mortality was higher for those aged 70 to 79 years and 80+ years (OR = 3.01, 1.01-8.97 and OR = 3.76, 1.24-11.37, respectively). Additionally, patients with one or more

TABLE 1 Study population characteristics according to residential location

Factors	Total, %	Major City	Inner Regional	Outer Regional/Remote/Very Remote	P Value
Total	n = 4321	n = 2555	n = 1038	n = 728	
Age group					0.01
<60 years (n = 921)	21.3	21.1	20.4	23.2	
60-69 years (n = 1204)	27.9	27.4	27.7	29.8	
70-79 years (n = 1282)	29.7	28.8	30.8	31.0	
80+ years (n = 914)	21.2	22.7	21.0	15.9	
Sex					0.04
Male (n = 2429)	56.2	54.9	56.7	60.2	
Female (n = 1892)	43.8	45.1	43.3	39.8	
Indigenous status					0.05
Indigenous (n = 42)	1.0	0.7	1.0	1.9	
Nonindigenous (n = 4120)	95.4	95.7	94.9	94.6	
Not stated/unknown (n = 159)	3.7	3.6	4.1	3.4	
Socioeconomic status					<0.001
Affluent (n = 553)	12.8	19.9	2.3	2.9	
Middle (n = 2801)	64.8	67.4	58.1	65.4	
Disadvantaged (n = 967)	22.4	12.7	39.6	31.7	
Comorbidity					0.02
0 (n = 2950)	68.3	69.0	64.9	70.6	
1 (n = 901)	20.9	21.0	21.8	19.1	
2+ (n = 470)	10.9	10.0	13.3	10.3	
Admission type					0.36
Elective (n = 3732)	86.4	85.9	86.5	87.9	
Emergency (n = 589)	13.6	14.1	13.5	12.1	
Primary site					0.07
Colon (n = 3050)	70.6	71.4	71.1	67.0	
Rectum (n = 1271)	29.4	28.6	28.9	33.0	
Surgical approach					0.007
Open (n = 2294)	53.1	51.1	54.6	57.4	
Laparoscopy (n = 2027)	46.1	48.8	45.4	42.6	
Tumour stage					0.67
Early (stages I and II) (n = 2548)	59.0	59.1	59.6	57.6	
Late (stages III and IV) (n = 1773)	41.0	40.9	40.4	42.4	
Type of hospital					0.02
Public (n = 2187)	50.6	49.0	51.6	54.8	
Private (n = 2134)	49.4	51.0	48.4	45.2	
Hospital volume					<0.001
Low (<20 cases/year) (n = 342)	7.9	5.5	14.3	7.3	
Medium (20-50 cases/year) (n = 815)	18.9	15.7	27.5	17.6	
High (>50 cases/year) (n = 3164)	73.2	78.8	58.3	75.2	

TABLE 2 Multivariable logistic regression analysis showing factors associated with in-hospital mortality, 30-day readmission, and length of hospital stay for 4321 CRC patients following major resection

Factors	In-Hospital Mortality (n = 64)		30-day Readmission (n = 125)		Extended Hospital Stay[a] (n = 347)	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Age group		0.001		0.29		<0.001
<60	1.00		1.00		1.00	
60-69	0.55 (0.13-2.25)		0.64 (0.39-1.04)		1.24 (0.82-1.88)	
70-79	3.01 (1.01-8.97)		0.69 (0.42-1.14)		1.76 (1.19-2.62)	
80+	3.76 (1.24-11.37)		0.72 (0.40-1.29)		2.11 (1.39-3.20)	
Sex		0.69		0.93		0.33
Female	1.00		1.00		1.00	
Male	0.90 (0.53-1.52)		1.02 (0.70-1.48)		0.89 (0.69-1.13)	
Residence		0.86		0.78		0.16
Major city	1.00		1.00		1.00	
Inner regional	1.06 (0.56-2.02)		0.92 (0.58-1.45)		1.19 (0.89-1.61)	
Rural	0.83 (0.37-1.88)		0.83 (0.49-1.41)		0.81 (0.56-1.17)	
SES		0.98		0.68		0.20
Affluent	1.00		1.00		1.00	
Middle	1.06 (0.45-2.47)		1.06 (0.59-1.90)		0.72 (0.50-1.03)	
Disadvantaged	1.10 (0.41-2.98)		1.28 (0.65-2.51)		0.77 (0.50-1.19)	
Comorbidity		<0.001		0.42		<0.001
0	1.00		1.00		1.00	
1	2.39 (1.22-4.67)		0.83 (0.51-1.36)		2.22 (1.67-2.95)	
2+	5.50 (2.88-10.50)		1.28 (0.73-2.26)		3.95 (2.90-5.38)	
ASA score		0.10		0.59		<0.001
1-2	1.00		1.00		1.00	
≥3	2.14 (1.03-4.47)		1.16 (0.76-1.75)		1.79 (1.35-2.39)	
ASA unknown	2.45 (0.92-6.53)		0.83 (0.43-1.60)		1.67 (1.10-2.54)	
Admission type		<0.001		0.07		<0.001
Elective	1.00		1.00		1.00	
Emergency	3.29 (1.84-5.91)		0.52 (0.26-1.06)		2.48 (1.83-3.36)	
Primary site		0.56		0.88		0.34
Colon	1.00		1.00		1.00	
Rectum	0.79 (0.36-1.76)		0.96 (0.56-1.65)		0.84 (0.59-1.20)	
Type of surgery		0.07		0.71		0.008
Open	1.00		1.00		1.00	
Laparoscopic	0.57 (0.31-1.05)		1.07 (0.74-1.55)		0.70 (0.54-0.92)	
Stoma formation		0.04		<0.001		<0.001
No	1.00		1.00		1.00	
Yes	1.88 (1.01-3.51)		2.51 (1.54-4.10)		4.83 (3.58-6.53)	
Neoadjuvant therapy[b]		0.99		<0.001		0.92
No	1.00		1.00		1.00	
Yes	1.01 (0.30-3.33)		2.19 (1.28-3.77)		1.02 (0.68-1.47)	
Stage		0.44		0.004		0.25
Early (I and II)	1.00		1.00		1.00	
Late (III and IV)	1.23 (0.73-2.07)		1.64 (1.14-2.37)		1.15 (0.91-1.47)	

(Continues)

TABLE 2 (Continued)

Factors	In-Hospital Mortality (n = 64)		30-day Readmission (n = 125)		Extended Hospital Stay[a] (n = 347)	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Hospital volume[c]		0.39		0.19		0.007
High	1.00		1.00		1.00	
Medium	0.96 (0.48-1.93)		1.16 (0.71-1.90)		0.60 (0.35-1.02)	
Low	0.36 (0.09-1.54)		1.81 (0.95-3.44)		0.61 (0.42-0.87)	

Model additionally adjusted for type of facility (public vs private).

Abbreviations: OR, odds ratio; CI, confidence interval; SES, socioeconomic status.

[a] >21-day hospital stay following major resection.

[b] Presurgical radiotherapy.

[c] High volume (>50 cases/year), medium volume (20-50 cases/year), low volume (<20 cases/year).

comorbidity (OR = 2.39, 1.22-4.67 and OR = 5.50, 2.88-10.50, respectively), patients having an emergency admission (OR = 3.29, 1.84-5.91), and patients who had a stoma formation (OR = 1.88, 1.01-3.51) were at increased risk of in-hospital mortality. Hospital volume, type of surgical procedure, and primary site were not independently associated with in-hospital mortality.

Approximately 3% of patients had an unplanned 30-day readmission. The odds of readmission was higher for patients having a stoma (OR = 2.51, 1.54-4.10), if they received neoadjuvant radiotherapy (OR = 2.19, 1.28-3.77), and if they were diagnosed with a late, compared with early stage, cancer (O = 1.64, 1.14-2.37).

Median length of hospital stay was 8 days (range 0 to 170 days) with 8% (n = 347) staying beyond 21 days. Hospital stay was marginally lower for patients receiving laparoscopic surgery compared with an open procedure (7 compared with 9 days). The median stay for laparoscopic patients reduced to 6 days in the more recent period (2014) with no change for patients having an open procedure over the two time periods. There was a higher odds of an extended hospital for those aged 70 to 79 years older age patients (O = 1.76, 1.19-2.62), with two or more comorbidities (OR = 3.95, 2.90-5.38), emergency admission (OR = 2.48, 1.83-3.36), and where they had a stoma formed (OR = 4.83, 3.58-6.53). Patients had a lower odds of an extended stay if they had laparoscopic compared with open surgery (OR = 0.70, 0.54-0.92).

3.2 | 30-day and 90-day mortality

Overall 1.6% (n = 71) of patients died within 30 days and 3.1% (n = 133) died within 90 days of major resection (Table 3). Patients had a higher odds of 30-day mortality if they were aged 70 to 79 or 80+ years (OR = 3.11, CI = 1.17-8.27 and OR = 4.39, 1.65-11.69, respectively), had two or more comorbidities (OR = 5.14, 2.85-9.25), and if the admission was emergent (OR = 3.71, 2.15-6.40). A similar pattern emerged for 90-day mortality with older age, the presence of a comorbidity increasing the odds of 90-day mortality. Additionally, patients with a stoma and those with late stage disease were at increased risk (OR = 1.65, 1.05-2.66 and OR = 1.95, 1.35-2.82, respectively). No association with hospital volume or type of facility (public versus private hospital) and increased risk of either 30- or 90-day mortality was observed.

4 | DISCUSSION

Our aim was to examine a series of clinical indicators to identify factors associated with poorer outcomes in a large population-based cohort of patients who underwent major resection for CRC.

The in-hospital mortality rate for our cohort was 1.5% which is at the lower end of that observed in other studies where rates range between 0.9% and 10.0%,[18-22] but within the range reported in clinical audit data.[23-25] We found no significant differences in in-hospital mortality according to hospital volume. In a recent meta-analysis, lower in-hospital (and 30-day) mortality rates were found for higher hospital and higher surgeon volume.[26] However, authors of that systematic review suggested that high volume hospitals likely have many

TABLE 3 Multivariable logistic regression analysis showing factors associated with 30-day and 90-day mortality for 4321 CRC patients following major resection

Factors	30-day Mortality (n = 71)		90-day Mortality (n = 133)	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Age group		<0.001		<0.001
<60	1.00		1.00	
60-69	0.62 (0.18-2.20)		1.59 (0.64-3.93)	
70-79	3.11 (1.17-8.27)		4.73 (2.10-10.65)	
80+	4.39 (1.65-11.69)		7.61 (3.37-17.15)	
Sex		0.38		0.66
Female	1.00		1.00	
Male	0.80 (0.49-1.32)		1.09 (0.75-1.58)	
Residence		0.83		0.13
Major city	1.00		1.00	
Inner regional	1.20 (0.66-2.19)		1.21 (0.76-1.93)	
Rural	1.04 (0.50-2.17)		1.66 (1.02-2.72)	
SES		0.99		0.56
Affluent	1.00		1.00	
Middle	1.01 (0.46-2.26)		0.74 (0.42-1.29)	
Disadvantaged	0.99 (0.40-2.51)		0.73 (0.38-1.42)	
Comorbidity		<0.001		<0.001
0	1.00		1.00	
1	2.17 (1.18-4.01)		1.63 (1.04-2.56)	
2+	5.14 (2.85-9.25)		3.58 (2.32-5.52)	
Admission type		<0.001		<0.001
Elective	1.00		1.00	
Emergency	3.71 (2.15-6.40)		3.21 (2.11-4.87)	
Primary site		0.67		0.98
Colon	1.00		1.00	
Rectum	0.84 (0.38-1.86)		0.99 (0.57-1.71)	
Type of surgery		0.09		0.22
Open	1.00		1.00	
Laparoscopic	0.62 (0.35-1.09)		0.78 (0.52-1.16)	
Stoma formation		0.32		0.03
No	1.00		1.00	
Yes	1.43 (0.74-2.52)		1.65 (1.05-2.60)	
Had neoadjuvant radiotherapy		0.99		0.56
No	1.00		1.00	
Yes	0.99 (0.30-3.27)		0.78 (0.35-1.76)	
Stage		0.32		<0.001
Early (I and II)	1.00		1.00	
Late stage (III and IV)	1.28 (0.78-2.10)		1.95 (1.35-2.82)	
Hospital volume[a]		0.41		0.89
High	1.00		1.00	
Medium	1.15 (0.62-2.13)		0.96 (0.59-1.56)	
Low	0.49 (0.15-1.61)		0.84 (0.41-1.73)	

Model additionally adjusted for type of facility (public vs private).

Abbreviations: OR, odds ratio; CI, confidence interval; SES, socioeconomic status.

[a]High volume (>50 cases/year), medium volume (20-50 cases/year), low volume (<20 cases/year).

surgeons, while lower volume hospitals have few surgeons who perform more procedures. Thus, it may be that surgeon volume is a more critical factor in surgical outcomes. In our cohort, we identified that older age, presence of comorbidities, ASA score, and emergency admission were all independently associated with in-hospital mortality. All these variables have been shown to be risk factors for poorer outcomes following CRC.[22,27,28] Emergency admission was amongst the strongest predictors of in-hospital mortality. Bowel perforation and/or obstruction and bleeding have been reported as the main causes of emergency admission for CRC patients.[29] Improving the management of patients with comorbidities and those admitted as an emergency may help reduce this identified disparity. It has also been suggested that improving knowledge and uptake of population-based bowel cancer screening may help to reduce the number of patients admitted as an emergency.[8]

4.1 | 30-day readmission and extended hospital stay

Overall, about 3% of patients had an unplanned readmission within 30 days of discharge following major resection. Readmission rates for our cohort were relatively low compared with other studies reporting rates between 7% and 19%.[30-32] Patients were more likely to be readmitted if they had a stoma formed, had neoadjuvant radiotherapy, and had more advanced disease which is in keeping with results of a recent systematic review and meta-analysis.[18] Another

Australian-based study also reported higher risk of unplanned readmission amongst patients with late-stage disease and for those who received prior adjuvant therapy.[8] Unlike some studies reporting older age as a risk factor for readmission,[30,31] we found no association with older age. This may reflect ongoing improvements in preoperative assessment and management.[33] We were unable to assess all reasons for unplanned readmission based on the data available. However, about one in five were for an anastomotic leak. The most common causes of unplanned readmission are reported to be bowel obstruction, surgical site infections, and intraabdominal abscess,[34] while anastomotic leaks are less commonly reported (less than 10%).

About 8% of our cohort had an extended hospital stay (>21 days) with the overall median number of days being eight. This figure is similar to that observed in another Australian-based study,[8] but slightly lower than studies conducted in other countries where median hospital stays are reported to be 11 to 13 days.[8,30,35] The shorter length of hospital stay in Australian cohorts may reflect the larger role of private health care. We found that while the difference was relatively small, the length of hospital stay was slightly shorter for patients treated in a private hospital. Patients were more likely to have an extended hospital stay if they were older age, had comorbidities, were an emergent admission, and had a stoma formed as part of their surgical approach, and again, this is in keeping with results from other studies.[30,32] Our finding that patients undergoing a laparoscopic procedure were about 30% less likely to have an extended hospital stay likely reflects the nature of laparoscopic surgery. A significantly reduced length of hospital stay has been reported across a number of studies.[36,37] While the reduced risk of extended hospital stay for patients undergoing laparoscopic surgery found in this study may be a result of patient selection, this result remained significant following adjustment for other covariates such as age, comorbidity, and admission type. While some studies have found that extended hospital stay is less likely for patients attending high volume hospitals,[35,38] others have not demonstrated any significant relationship between hospital volume and length of hospital stay.[20,32] In our study, patients were in fact less likely to have an extended hospital stay if their resection was conducted in a lower volume hospital. While these findings may reflect the nature of the surgery (ie, less complex cases managed in lower volume hospitals), the smaller hospitals in our patient cohort did not tend to transfer all complex cases to the higher volume hospitals.

4.2 | 30- and 90-day mortality

Our 30-day and 90-day postoperative mortality rates were quite low (1.6% and 3.1%, respectively) compared with other reports. In a large study in the United Kingdom using NHS data, 30-day mortality for the most recent included period (2006) was 5.8%,[39] and a Swiss study reported 30-day mortality rates of 3.6%.[40] In a large study combining data across four European countries and the United States, overall 30-day mortality for colorectal surgery was 3.9% with a range of 0.9% to 7.5%.[41] While a further NHS study reported 90-day postoperative mortality of 13.9%,[42] their data included cases from 2001 to 2007 whereas our data are from a more recent time period. The results in our study may reflect improvements in surgical procedures and short-term and longer term postoperative management of CRC patients.

In this study, factors independently associated with 30- and 90-day postoperative mortality included older age, presence of comorbid conditions, and emergency admission. Older age and emergency admission have consistently been found to be risk factors for postoperative mortality.[8,20,39,43,44] The main reasons for emergency admission for CRC patients are reported to be obstruction, bleeding, and perforation.[45] Surgical management of patients presenting with these conditions can be complex, and patients additionally have a high probability of receiving a stoma.[3] The findings in this study, comparable with those observed in other similar studies, highlight the need to identify how to better manage this group of patients. Further research to better understand the underlying factors leading to emergency presentation may help to improve these outcomes. In this study, we also found that later stage (stage III/IV) was significantly associated with 90-day mortality independent of other factors (such as age and emergency admission). While it is well known that stage is strongly associated with survival, Byrne and colleagues argue that 90-day postoperative mortality may be an indicator of poorer surgical outcomes.[42]

A recent systematic review found reduced 30-day mortality for patients treated in high volume hospitals (and by high volume surgeons); however, we found no such relationship in our data. These results may reflect consistency of care throughout Queensland hospitals, irrespective of capacity. While our data did not show a significantly elevated risk for 90-day mortality amongst patients living outside a major city, a slightly elevated risk (nonsignificant for trend) was observed for patients living in outer regional, remote, and very remote locations. Beckman and colleagues using data from South Australia[8] found a significantly elevated risk of 30-day mortality for nonmetropolitan patients. However, other studies conducted in other Australian[44] and Canadian populations have found no increased risk for nonmetropolitan patients.[46] These inconsistencies may be the result of how metropolitan (or urban) and rural areas are defined across studies, thus making comparisons difficult. Further, while our analysis was adjusted for a number of covariates reflecting casemix of patients, it is possible that rural patients are more likely to be referred to a major centre when their case is more complicated.

4.3 | Strengths and limitations

The strengths of this study are the inclusion of all cases of CRC diagnosed throughout Queensland in 2012 and 2014. This is in contrast to other studies reporting outcomes following colorectal surgery using self-reported institutional and clinician data, which while useful are limited in their ability to generalize findings and are at risk of some degree of bias.[19] A further strength is the linking and inclusion of data from a number of clinical and administrative sources into a central repository. Clinical teams of specialists provide guidance and advice on the collection and management of data in this repository including routine data checks and validation. Additionally, the inclusion of a number of outcome measures (clinical indicators), rather than a single measure of the surgical outcome, is a further strength.

Some potential limitations need to be considered. While coding errors may have occurred for both disease and procedures, extensive validation checks are routinely conduced with our datasets. Additionally, we did not have detailed information on preoperative or postoperative chemotherapy. While we have identified some limitations, our results are consistent with other population-based studies.

5 | CONCLUSION

In this study, we found that the risk of in-hospital and 30- and 90-day postoperative mortality for CRC patients following a major resection in Queensland, Australia, was low; however, we did identify a subgroup of patients for whom the risk of poorer outcomes was significantly elevated. These subgroups include older patients, those with comorbidities, patients having a stoma, and where the admission was an emergency. Identifying and quantifying subgroups at risk of poorer outcomes provides the necessary information to inform the development and implementation of strategies to continue to improve clinical care for all patients.

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