Analysis of potential savings through surgical self-audit for colorectal cancer

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Summary

The likelihood of adverse events occurring as a result of surgery for colorectal cancer may be reduced by utilising surgical audit, thereby decreasing associated costs to the health care system. Surgical audit is highly endorsed by the Royal Australian College of Surgeons and consists of a closed loop process whereby an audit of current practice is followed by peer review and initiation of improved practice, and then the cycle is repeated.

This study aimed to estimate the potential cost-savings to hospitals relating to improved surgical outcomes for colorectal cancer surgery, attributed to a computerised self-audit program. A cost-analysis was conducted which compared costs associated to surgery over a 12-month period with or without surgical audit. A decision-analytical model took into account costs for colon and rectal surgical admissions with or without complications, derived from Australian-Refined Diagnostic Related Group (AR-DRG); as well as the cost of the self-audit program and personnel for data entry. Prior literature was used to estimate the percent colon (68.7-75.9%) or rectal cases (24.1-31.3%). Occurrence of a select group of adverse events was estimated based on low/high reported occurrence from nine Australian studies; although there was inconsistent reporting between these studies, and rates of adverse events differed widely. Cost-savings were calculated based on three potential levels of complication rates with self-audit compared to usual practice (50% base level; 75% small effect; and 25% large effect); and on the potential number of cases a surgeon may perform per year (1, 30, 60, or 80).

Outputs from the model demonstrated that if self-audit facilitated the reduction of adverse events by half, and a surgeon performed 30 cases per year, the potential cost-savings for that surgeon's hospital would on average be $66,000 annually and could range from $25,000 to $120,000. Extrapolating this, based on an annual incidence of colorectal cancer in Australia of 13,076 cases, self-audit could save Australian hospitals $28.8 million per year.

These findings should be viewed as exploratory, as they are limited by the availability of good quality data in the literature, particularly on the true effectiveness level of self-audit programs for surgery. A more robust future analysis would require results from a prospective randomised trial to evaluate the benefits of a self-audit program in comparison with usual practice.

Introduction & Aim

The definition of an 'adverse event' is the unintentional harm arising to patients arising from an episode of health care and not due to the disease process itself (1). Adverse surgical events are a function of the surgeon's skills and judgement, patient age and presence of comorbidities, elective versus emergency presentations and hospital systems of care.

Surgical audit is a quality improvement process considered an integral component to patient care and outcomes and for the ongoing professional development of surgeons. The Royal Australian College of Surgeons is firmly committed to and strongly endorses the daily practice of auditing in its various different forms within a supportive, legally protective environment (2). Ideally, surgical audit would be implemented with a modern medical record system, effective training and protected time (3). However, routine use of surgical audit is not widespread in Australia (2). Barriers to audit have been identified and include the lack of resources, lack of expertise in design and analysis, staffing communication problems and organisation impediments (3). Surgical audit requires a closed loop, that is, an audit is performed, peer review discussion follows, learning/improved practice initiated and the steps are repeated. All steps are required for successful and ongoing audit practice in surgery. Surgical audit has several potential benefits including better patient care and outcomes, higher professional satisfaction enhanced communication among colleagues and improved efficiency arising from significantly less resource use in hospitals.

The purpose of this study was to estimate the potential cost-savings relating to improved surgical outcomes for colorectal surgery attributed to a computerised self-audit program.

The key objectives of the study were to:

1. Identify the common types of surgical adverse events and their frequencies for surgery relating to colorectal cancer in Australia.
2. Identify the effectiveness of surgical audit for colorectal cancer surgery
3. Assign a dollar value to surgical adverse events following colorectal cancer surgery.
4. Calculate the expected incremental difference in cost between a typical cohort of colorectal cancer cases that reflect usual practice versus those following a surgical self-audit program.
5. Undertake analyses to address the potential range of incremental costs and surrounding uncertainty of the base findings.

Methods

A systematic literature review was undertaken to locate Australian studies reporting post-operative outcomes from colorectal surgery. Inclusion criteria were: studies published after 2000 (to reveal current practice) and studies involving surgeries for colorectal cancer patients where post-operative outcomes were reported. PubMed database was searched using terms: colorectal, colon, rectal surgery, adverse events, complications, post-operative morbidity, surgical performance, outcomes. For evidence relating to surgical audit, studies from any country were included and search terms included: surgical audit, surgical performance, quality, appraisal.

Scope of analysis

The study involves a cost-analysis rather than a full cost-effectiveness analysis and is confined to elective surgery for colorectal cancer. The time-frame is 12 months which influences the caseload per surgeon. Due to the reliance on published evidence of surgical outcomes, a selective group of common adverse events were included; anastomotic leakage, wound infection, deep vein thrombosis (DVT), respiratory problems (collective group including pneumonia, other infections, pulmonary embolism), unplanned return to operating theatre and 30-day mortality. Although 'length of stay' in hospital is a common outcome, this is implicit in the 'costs' (rather than an adverse event per se) and therefore was not used as a separate outcome measure.

Analysis

The cost-analysis took the hospital perspective and included costs for colon and rectal surgical admissions with or without complications. The cost of the self-audit computer program and data entry by a health information manager was also considered. Costs for surgical admissions were derived from the National Hospital Cost Data Collection 2006-2007 (4) listing Australian-Refined Diagnostic Related Group (AR-DRG) codes, separately assigned for standard and complicated hospital stays.

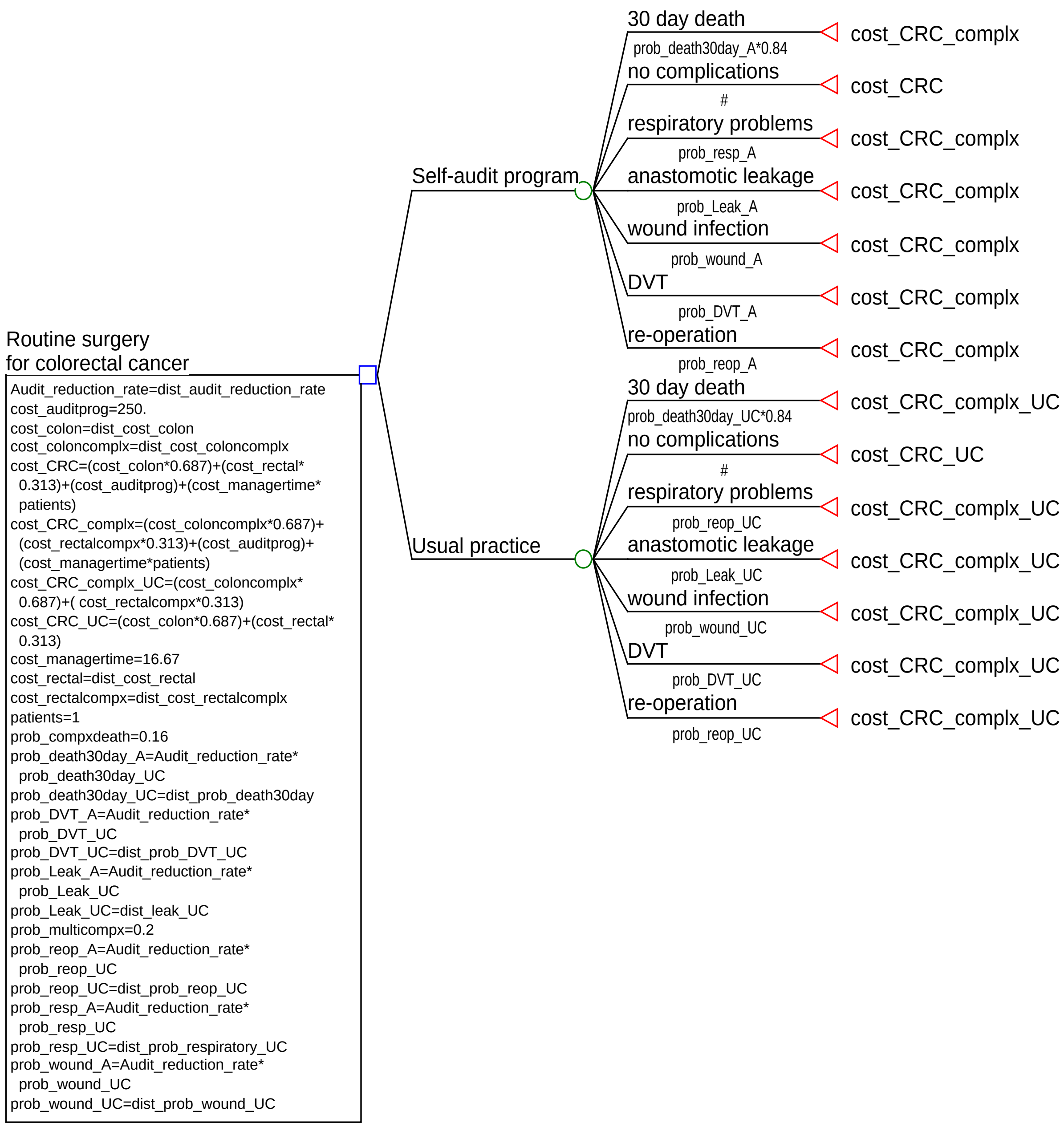
A decision-analytical model was constructed in TreeAge Pro 2009 software (TreeAge Software Inc, Williamstown, MA, USA) (Figure 1). The advantage of this type of model is that it explicitly identifies the options and parameters under consideration and allows detailed sensitivity and scenario analyses. Two strategies were modelled; 'self-audit program' vs 'usual practice'. It was expected that lower rates of adverse events arising from self-audit would incur lower costs than for usual practice and the difference between the two groups represents the expected cost-savings attributed to self-audit.

The model is calculated by summing the expected (mean) cost values at each tree node for each type of adverse event for the two arms 'self-audit' vs 'usual practice' aggregated separately. These values are based on the probabilities of the adverse events and attendant costs. This produces an expected mean cost for one case in each arm. One-way sensitivity analyses on all parameters were undertaken to investigate the robustness of the base results to plausible changes in the data estimates (range of estimates in Table 2).

Probabilistic sensitivity analyses were also performed with 5,000 second-order Monte Carlo simulations involving random selection of possible data estimates simultaneously from assigned distributions (multivariate analysis). Beta distributions were assigned to probability estimates (e.g., adverse event rates, effectiveness rate of surgical audit). Gamma distributions were assigned to surgery cost variables because in practice these would be normally right-skewed (5) with some cases incurring very high costs (in the case of multiple complications and very long hospital stay).

The mean incremental costs and 95% confidence intervals are extrapolated for different caseloads typically treated by surgeons in Australia to obtain the total cost-savings possible over 12 months. Finally, the results are extrapolated to all colorectal surgery undertaken in Australia during 1 year.

Figure 1. Illustration of decision model



Results & Discussion

a) Literature review for adverse surgical outcomes

The review found nine studies reporting surgical outcomes following surgery for colorectal cancer (Table 1). The studies were inconsistent in the use of standard definitions and methods used to measure the various types of adverse events. This is confirmed in a large UK review on the topic (6). Furthermore, each study uses a different set of adverse events, despite assessing the same disease (colorectal cancer), and few have adjusted for baseline (pre-operative) risk characteristics (e.g., age, comorbidities, general health). Therefore, comparisons across studies are problematic. It has also been stated that studies involving surveys of surgeons with self-reported data or retrospective medical chart reviews are both likely to underestimate the true prevalence of complications and may be unreliable (7).

Notwithstanding these measurement issues, the range of complication rates across studies was wide (Table 1). No study reported estimates on multiple complications occurring concurrently during the hospital stay and only two studies reported mortality rates arising from the complications (7, 8). Post-operative outcomes tend to be poorer for emergency presentations and for rectal surgery, the latter which involves more complex and difficult surgery. In the National Colorectal Cancer Survey, no statistically significant differences for post-operative morbidity and mortality were found for high- and low-volume surgeons (defined as ≥7 or <7 surgeries per quarter, respectively) although some pre-operative practice differences were evident (7). An editorial for the same paper claimed 'yet more evidence' to support the case for high-volume surgeons and specialisation but this did not appear clearly justified. A number of studies reported that high-volume surgeons treat a higher proportion of (referred) elective cases, and therefore are likely to yield better outcomes than low-volume surgeons, all else held constant. Findings from the recent report on the Australasian randomized controlled trial comparing laparoscopic and conventional open surgery was included in the estimates as there was no significant differences in the complication or mortality rates between the two options (9).

b) Literature review for surgical audit literature

The evidence-base for 'audit and feedback' interventions is very large for clinical studies across huge range of medical topics. A Cochrane systematic review of 118 studies on this topic showed small to moderate improvements in outcomes overall (median 5%, range 3-11%) (10). However, the evidence for the effectiveness of audit programs for surgery (for any disease) is scarce. In part, this is probably because of the legal and social ramifications, time pressures and possible reluctance of doctors to be involved in this kind of study. For colorectal cancer surgery, one Australian study by Bowles 2007 involved a pre-post study design over 4 years showing favourable improvements following the introduction of an audit program (Table 1) (11). For example, anastomotic leak rates decreased from 8.2% to 1.4%, re-operations from 12.2% to 5% and pneumonia rates from 10.7% to 8.5%. In a second Australian study involving surgery for all diseases, Kable *et al.* (2002) discuss the degree of preventability of adverse surgical events (12). It is possible to reduce complication rates by using prophylactic antibiotics (for wound infections), hospital infection control programs (wound or other infections), using prophylactic anticoagulants (for DVT) and through ongoing training of surgical skill/judgements. However, their results highlighted that it is not possible to fully eliminate all adverse events as 21% were not considered preventable (12). Some complications have low preventability (31.4%) while others were highly preventable (47.6%). The effectiveness level of surgical audit is also governed in part, by the initial adverse event rates with more potential for improvement possible when rates are relatively high to begin with, as seen in Bowles *et al.* (2007) (11).

Table 1. Australian studies reporting adverse events from surgery involving colorectal patients (ns = not stated)

Author & Year	**Study features**	**% elective cases**	**% surg adverse events (major)**	**% anast leak (AL)**	**% wound infection**	**% DVT**	**% return to theatre**	**% respiratory comps**	**% post-op deaths (<30 days)**
Semmens 2000	Population-based WA, n=9673, 1988-95	77%		6.5%	8.3% post-op infect	ns	Most of AL (est.5%)	ns	4.2%
Birks 2001	Rural surgeons Vic =69, SA, Albury – CRC in 64% of patients- may deal with more emergency presentations, 1996 1 year duration	68.5%	34.5%	3.3%	7.2%	ns	5.7%	ns	4.1% CRC patients
Kable 2002	National, 1992, 5432 surgical admissions (any), 28 hospitals	ns	21.9% (incl minor)	ns	2.1%	0.3%	ns	Pneu 0.2%	0.8%
Killingback 2002	Sydney, 1 centre, 1 specialist surgeon, n=1418, all open resections, 1976-1998	100%	8.1%	4.1%	2.1%	1.1%	2.7%	6.7% (incl various)	1.6%
McGrath 2004	National survey, 550 surgeons, 1911 cases, split by elective/emergency cases , 3mths in 2000	86-93%	10.8%	0.0-3.0%	6.6-9.1%	1.0-6.7%	ns	0-1.6% pulm emb	ns
McGrath 2005	National survey, 550 surgeons, split by high/low volume surgeons (diffs not sign)	“	9.2-10.1%	ns	ns	ns	ns	ns	4.0-4.3%
Bowles 2007	Pre and Post audit outcomes, Geelong hospital, regional VIC, 13 surgeons n=500 pre, n=100 post, risk-adjusted, gives AT=acceptable threshold, Pre and Post rates are stat. sign different. 4 years	63%	ns	AT 2-5% Pre 8.2% Post 1.4%	ns	ns	AT 4-11% Pre 12.2% Post 5%	ns	AT 4-7.5% Pre 6.38% Post 0%
Hewett 2008	Australian RCT on laparoscopic vs open surgery CRC (ALCCaS Trial), 1998-2005, n=592, 33 surgeons, no. sign diffs bw grps	100%	ns	1.4-3.4%	5.8-8.7%	ns	4.4-5.4%	Pneu 8.5-10.7%	1.4-0.7%
Frye 2009	Sydney hospital, focus on anast.leakage, specialist surgeons, n=1513 cases, 1995-2004	100%	ns	3.8%	ns	ns	ns	ns	0.2%
SUMMARY	**Summary of low-high values (excl 0%)**			**1.4-8.2%**	**2.1-9.1%**	**0.3-6.7%**	**2.7-12.2%**	**0.2-10.7%**	**0.2-6.38%**

c) Final estimates used in the model

The data used to populate the model included estimates reported in the published literature above, national hospital cost reports and government cancer statistics, however a number of assumptions were also necessary (Table 2).

Table 2. Data parameters used in calculations, plausible ranges, sources and assumptions

Description	Estimate (plausible range)	Source
No. cases per year (for one surgeon)	Scenario 1: 30 Scenario 2: 60 Scenario 3: 80	McGrath 2005 (<7, ≥7, over 15 per 3 months) Scenario 1 would apply to the majority.
% decrease in complication rates attributed to self-audit effectiveness:	Scenario 1: 50% (base effect) Scenario 2: 25% (small effect) Scenario 3: 75% (large effect)	Assumption , Bowles 2007 Assumption , Bowles 2007 Assumption , Bowles 2007 Implicit assumption is the potential for complication preventability, Kable 2002
% of colon and rectal surgery cases		
Colon	68.7-75.9%	McGrath 2005
Rectal	24.1-31.3%	
Baseline complication rates:		
Anastomotic leak	4.8% (1.4-8.2)	
Wound infection	5.6% (2.1-9.1%)	Mean of low/high value from 9 studies (7-9, 11-16) where relevant (see Table 1)
DVT	3.5% (0.3-6.7%)	
Respiratory complications (pulmonary embolism, infection, pneumonia)	5.5% (0.2-10.7%)	
Return to operating theatre	7.5% (2.7-12.2%)	
Post-op deaths (<30 days) %	3.3% (0.2-6.4%)	As above
(% attributed to complications)	(16%)	McGrath 2005
Hospital costs of colorectal surgery :		AR-DRGs code (ALOS):
Rectal resection with complications	$30,212	G01A (18.4 days)
Rectal resection with no complications	$16,428	G01B (9.8 days)
Colon procedures with complications	$28,053	G02A (17.8 days)
Colon procedures with no complications	$12,968	G02B (8.2 days)
12-month subscription to 'surgical performance' self-audit software	$250	www.surgicalperformance.com US$200
Data entry of surgical outcomes into audit software – performed by health information manager, 20 minutes per audit	$16.67 per audit	Based on salary $50 per hour

ALOS – average length of stay

Assumptions

1. Surgeries are assumed to include a mix of emergency and elective cases. The split is implicit in the plausible range of complication rates listed above.

2. Surgeries are assumed to include a mix of colon and rectal cases. The split is implicit in the plausible range of complication rates listed above.

3. As there is no evidence on extent/type of multiple complications occurring concurrently with colorectal surgery which may result in over-estimated costs, i.e., estimates assume mutually exclusive complication rates, which is not realistic. An exception is '30-day mortality' where the percentage of 30-day deaths

attributed to complications is 16% and costs were adjusted down to avoid double-counting. However, any over-estimation in costs is somewhat offset by the fact that the reporting of complications is likely to be inaccurate, i.e. under-reported.

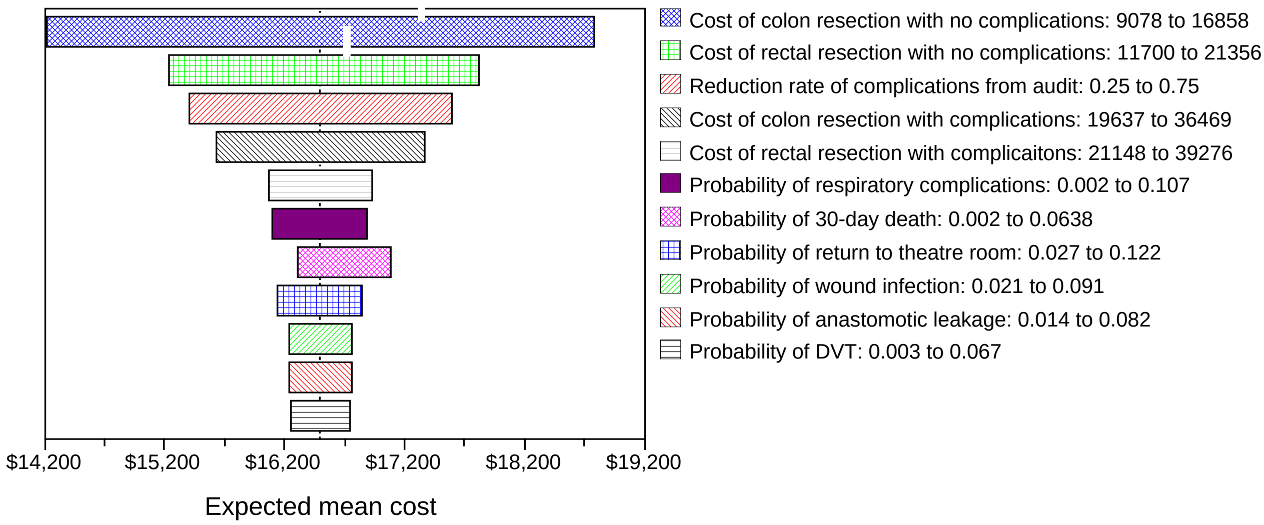
4. Self-audit process involves feedback with peers – any attendant costs here were not included. Data entry is assumed to incur the time of a health info manager at 20 mins per audit.

d) Results: estimated cost-savings attributed to self-audit and potential improved performance

The expected mean costs of surgical treatment for a single case of colorectal cancer, under usual practice was $18,700 compared to that for a self-audit program $16,495, if the self-audit program resulted in an improved surgical performance that halved common adverse events for colorectal surgery. A cost-savings of $2,204 per case is predicted.

Sensitivity analysis shows that changes to this expected mean cost of $16,495 is most sensitive to variation of ±30% in the cost of uncomplicated colon and rectal surgery followed by the level of effectiveness of a self-audit program (Figure 2).

Figure 2. Variation to expected mean costs for self-audit when base estimates are altered



Expected mean costs for the two options are more precise from a probability sensitivity analysis (Table 3). For each surgical patient, results from the probabilistic sensitivity analysis produced mean cost savings of $2,205 for a 50% reduction in complication rates, $1,107 for a 25% reduction and $3,272 for a 75% reduction (Table 3). These means and their 95% confidence intervals are extrapolated to annual caseloads of 30, 60 or 80 for annual cost-savings for one surgeon. Despite the wide 95% confidence intervals which reflects plausible values (based on complication rates in the literature and variations in cost), even with the most common caseload (up to 30 per year) (7) where complications may be infrequent, the potential cost-savings is substantial when considering the widespread incidence of this disease. The annual incidence of colorectal cancer in Australia 2005 was 13,076 cases. Extrapolating potential cost savings of $2,205 each person on average when 50% reduction in complication rates are achieved, would save the Australian hospitals $28.8 million dollars per year.

Table 3. Potential annual cost-savings for different effects from self-audit and surgical caseload for colorectal cancer

% decrease of complication rate in colorectal surgery	No. cases	Mean cost-saving $	(95% CI) $
50% (baseline)	1	2,205	823-3,988
	30	66,146	24,684-119,644
	60	132,292	49,368-239,288
	80	176,390	65,824-319,050
25% (small effect)	1	1,107	88-2,725
	30	33,208	2,628-81,736
	60	66,416	5,256-163,472
	80	88,554	7,008-217,962
75% (large effect)	1	3,272	1,399-5,431
	30	98,153	41,985-162,923
	60	196,306	83,970-325,846
	80	261,741	111,959-434,461

Limitations

The analysis is limited by the current availability of good-quality data estimates in the published literature, and in particular, the true effectiveness level of self-audit programs for surgery. As assumptions were made about this effect size, the findings should be considered as exploratory. A more robust analysis would require evidence from a prospective randomized intervention trial that evaluates the potential health benefits and precise cost-savings of self-audit benefits in comparison with usual practice. It would be important for surgical outcomes to be risk-adjusted (17). The analysis also relied on aggregated costing reports for complications in hospital. While there are a number of studies reporting costs of hospital-acquired surgical site infections, for consistency across the other complication types, a constant DRG cost (with complications) was assigned. A more detailed micro-level assessment of costs may have provided better estimates for each complication type. However, a recent review of surgical site infections reported that costs were on consistently twice that for a person with no infection and this is consistent with the estimates used here.

Conclusions

If self-audit facilitated the reduction of adverse surgical events by half those currently reported for colorectal cancer surgery in Australia, the potential annual cost-savings for the hospital for a surgeon treating 30 cases is predicted at $66,000 on average and could range from $25,000 to $120,000. With a higher caseload of 60 cases (which occurs in 3.7% of colorectal surgeons) (7), the cost-savings are $132,000 with a range $49,000 to $239,000. The wide range of potential cost-savings reflects the uncertainty of more robust estimates on adverse events rates and in the potential variation in mean costs.

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