Cost impact analysis of enhanced recovery after minimally invasive gynecologic oncology surgery

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ABSTRACT

Objective The implementation of a peri-operative care program based on enhanced recovery after surgery principles for minimally invasive gynecologic oncology surgery led to an improvement in same day discharge from 29% to 75% at our center. This study aimed to determine the program's economic impact.

Methods Our initial enhanced recovery quality improvement program enrolled consecutive patients undergoing minimally invasive hysterectomy at a single center during a 12-month period and compared them to a pre-intervention cohort. The primary outcome was overall costs. The secondary outcomes were surgical and post-operative visit costs. The surgical visit costs included pre-operative and operating room, post-operative stay, pharmacy, and interventions costs. The 30-day post-operative visit costs included clinic and emergency room, and readmission costs. The costs for every visit were collected from the case-cost department and expressed in 2020 Canadian dollars (CAD).

Results A total of 96 and 101 patients were included in the pre- and post-intervention groups, respectively. The median total cost per patient for post-intervention was $7252 compared with $8381 pre-intervention (p=0.02), resulting in a $1129 cost reduction per patient. The total cost for the program implementation was $134 per patient for a total cost of $13 106. The median post-operative stay cost was $816 post-intervention compared with $1278 pre-intervention (p<0.05). Statistically significant savings for the post-intervention group were also found for operative visit, operating room costs, and pharmacy (p<0.05). On multivariate analysis, surgical approach was the only factor associated with operating room costs, whereas both surgical approach and group (pre- vs post-intervention) impacted the total and post-operative stay costs (p<0.05).

Conclusion In addition to increasing the same day discharge rate after minimally invasive gynecologic oncology surgery, an enhanced recovery-based peri-operative care program led to significant reductions in cost.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Enhanced recovery after surgery leads to cost savings in gynecologic oncology laparotomies.
⇒ A quality improvement project using enhanced recovery principles in minimally invasive gynecologic oncology surgery led to improvement in same day discharge from 29% to 75%.

WHAT THIS STUDY ADDS

⇒ The quality improvement project using enhanced recovery principles specifically for minimally invasive gynecologic oncology surgery led to savings in total ($1129.55 CAD per patient, p=0.02) and surgical visit ($1321.37 CAD per patient, p<0.05) costs.
⇒ After adjusting for surgical approach, intervention group, and comorbidities, the post-intervention group assignment remained a significant predictor of total and post-operative stay costs (p<0.05).

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Increasing hospital investment in quality improvement projects to optimize same day discharge after minimally invasive gynecologic oncology surgery is valuable.

INTRODUCTION

Surgical management of gynecological malignancy has been increasingly performed using a minimally invasive surgical technique, either via a laparoscopic or robotic approach. The rate of same day discharge after minimally invasive hysterectomy has been described to be as high as 90% in benign gynecology,[1] but lower in gynecologic oncology at 48–83%.[2–4] This lower rate is driven by the complexity of the procedures such as longer operative times and the older patient population with higher comorbidities.[3 4] The literature supports same day discharge after minimally invasive gynecologic oncology surgery.[5–7]

Enhanced recovery after surgery is a comprehensive program composed of evidence-based interventions aimed to improve patient outcomes and shorten hospital stay.[8–12] The program has been implemented in multiple surgical specialties including gynecologic oncology, where a recent meta-analysis showed that enhanced recovery principles were associated with a 30% reduction in post-operative complications after laparotomy and reduced length of stay of 1.6 days.[13] While enhanced recovery program implementation has been found to be associated with overall cost savings in gynecologic oncology, the literature has

primarily examined patients undergoing laparotomy.[13 14] Indeed, less is known about the cost implications of enhanced recovery programs in minimally invasive gynecology oncology surgery and the specific components driving costs in this patient population.[5]

Our group recently published on the implementation of a peri-operative care program based on enhanced recovery principles to improve same day discharge after minimally invasive gynecologic oncology surgery.[7] Our original quality improvement study resulted in an improvement in the same day discharge rate from 29% to 75% (p<0.001), with no difference in 30-day peri-operative complications, readmissions, reoperations, emergency room visits, or mortality.[7] The current project aimed to identify whether there are cost savings associated with this enhanced-recovery peri-operative care program in patients selected for same day discharge after minimally invasive gynecologic oncology surgery.

METHODS

The study was approved by the Research Ethics Board at University Health Network (#19–5151). The current study is a micro-costing analysis of an enhanced-recovery quality improvement project[7] implemented at a publicly funded tertiary cancer center in Ontario, Canada, in a team of seven gynecologic oncologists who see approximately 1000 new consultations and operate on 500 cases annually including 200 minimally invasive surgeries. Patient consent was not required given the retrospective nature of the study.

Study Population

A cohort of 100 consecutive patients prior to implementation of enhanced-recovery interventions were compared with a cohort of 102 patients post-intervention.[7] The inclusion criteria were patients undergoing minimally invasive hysterectomy for endometrial cancer, suspicious pelvic mass less than 10 cm, or microinvasive cervical cancer. The exclusion criteria were age over 80 years old, limited social support, living more than 2 hours away, body mass index >50 kg/m^2, diagnosis of dementia, or two or more of: uncontrolled hypertension, atrial fibrillation, obstructive sleep apnea, renal failure, previous stroke, or significant coronary artery disease.[7] Those patients missing a surgical visit in the case-cost department were also excluded.

Intervention and Outcomes

We used a micro-costing approach to calculate individual patient hospital costs. Micro-costing methodology is considered an accurate method of assessing costs in healthcare and particularly useful for identifying cost-drivers.[15] Specifically, the surgical and 30-day post-operative visit costs were retrieved from the case-cost department. Costs related to pathology and genetic costs, as well as chemotherapy and radiotherapy visits, were excluded. The primary outcome was total cost, and the secondary outcomes were surgical visit, operating room, post-operative stay, pharmacy, and investigations costs. The total cost per patient was calculated from a hospital perspective as the sum of surgical visit and any post-operative visit within 30 days of surgery, as well as program implementation costs if applicable. Surgical visit cost components are illustrated in Figure 1. Costs for the pre-intervention group were adjusted to inflation according to the Bank of Canada consumer price index, therefore all costs are presented in 2020 Canadian dollars (CAD).[16] As well, it is important to note that robotic surgery is not funded in the Canadian healthcare but rather acquired by hospitals through philanthropic donations; as such, the use of robotic surgery is carefully selected and is often reserved for obese patients.

For missing post-operative stay values, the cost was estimated using the time spent in a specific unit (post-operative care unit, short stay unit, ward) and a calculated hourly cost for each respective unit. The hourly cost was calculated based on patients where data for which both cost and time spent in the specific unit were available. Missing values for post-operative clinic or emergency room visits were estimated from within-group patients with available data. The implementation costs for the program were divided equally among post-intervention patients and added to their total cost. The implementation did not include costs of nursing care for calling patients at 24 hours post-surgery as this initiative was already in place at our institution prior to project initiation. In addition, no costs were included for the multidisciplinary meetings held with hospital employees as part of the project implementation, as they are expected to participate in quality improvement initiatives to improve patient care as part of their employment responsibilities.

Statistical Analyses

Baseline characteristics. Descriptive statistics were reported for all baseline characteristics including age, body mass index, etiology, pathology, and comorbidities, in the initial publication on the clinical outcomes.[7] Similarly, the proportions of post-intervention versus pre-intervention patients requiring overnight stay, emergency room or unplanned clinic visits, and readmission were reported previously.[7] These clinical and demographic characteristics are reprinted in Table 1 with permission.

Cost analyses. This study took the perspective of the healthcare system and included only direct health care-related

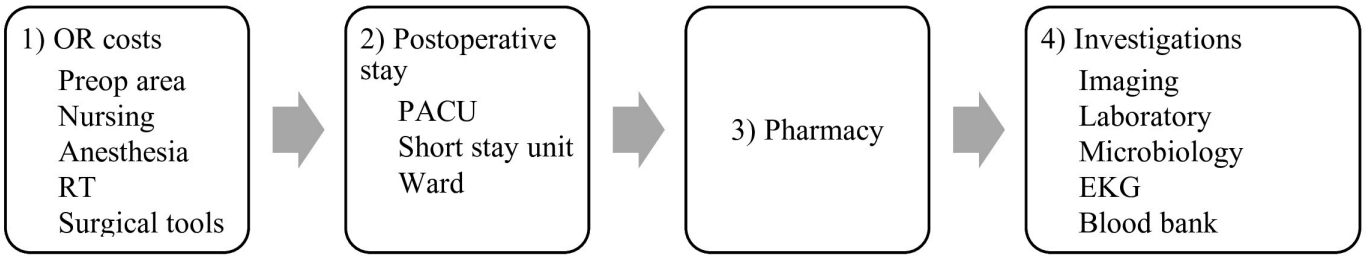

Figure 1 Components of the surgical visit cost. EKG, electrocardiogram; OR, operating room; PACU, post-operative care unit; Preop, pre-operative; RT, respiratory therapy/therapist.

Table 1 Demographics and outcomes of patients before and after project implementation—from the original study[7]

	Pre-intervention (n=100)	Post-intervention (n=102)	P value
Mean age (SD), years	62 (10.6)	59 (10.5)	0.038
Mean BMI (SD), kg/m^2	32 (9.5)	32 (9.2)	0.8
Charlson Comorbidity Index			
0	14 (14%)	16 (16%)	0.54
1	19 (19%)	27 (26%)	
2	33 (33%)	30 (29%)	
3 or higher	34 (34%)	29 (28%)	
Pre-operative diagnosis, n (%)			
Uterine cancer	85 (85%)	72 (71%)	0.015*
Ovarian cancer	1 (1%)	10 (10%)	
Cervical cancer	3 (3%)	3 (3%)	
Ovarian neoplasm	11 (11%)	15 (15%)	
Other	0	2 (2%)	
MIS approach, n (%)			
Laparoscopic	63 (63%)	81 (79%)	0.015*
Robotic	37 (37%)	21 (21%)	
Conversion, n (%)	8 (8%)	1 (1%)	0.018*
Final FIGO stage, n (%)			
Benign/borderline	1 (1%)	19 (19%)	<0.001*
1	80 (80%)	64 (63%)	
2	15 (15%)	11 (11%)	
3	3 (3%)	7 (7%)	
4	1 (1%)	1 (1%)	
Same day discharge, n (%)	29 (29%)	77 (75%)	<0.001*
Overnight stay, n (%)	71 (71%)	25 (25%)	
1 night	56	23	
2 nights or longer	15	2	
Unplanned clinic visits <30 days, n (%)	6 (6%)	8 (8%)	1
ER visits <30 days, n (%)	8 (8%)	8 (8%)	1
Readmissions <30 days, n (%)	2 (2%)	2 (2%)	1
Re-operation <30 days, n (%)	3 (3%)	1 (1%)	0.37

BMI, body mass index; ER, emergency room; FIGO, International Federation of Obstetrics and Gynecology; MIS, minimally invasive surgery; m^2/kg, meter squared by kilogram; n, number; sd, standard deviation.

costs. Societal costs (eg, time costs for patients and relatives, patient transport costs) were not captured and therefore were not included. Discounting was not used given the short time horizon. Median costs and IQRs were reported by program type (pre-intervention vs post-intervention) and compared using Wilcoxon rank sum test, with two-tailed p value <0.05 indicating statistical significance. These analyses were conducted using R studio (version 4.1.3).[17]

The potential association between clinical and cost data was compared using log-linear models. Clinical information included program type (ie, pre-intervention, post-intervention), surgical approach (ie, laparoscopy, robotics), age, body mass index, and Charlson Comorbidity Index (ie, 0=no comorbidity, 1 and 2=mild comorbidity, 3 and higher=moderate to severe comorbidity).[18] Cost data included surgical, post-operative stay and total cost. Bivariate analyses were conducted and the variables that were statistically significant were retained in the multivariate model. These analyses were conducted using Statistical Package for the Social Sciences (SPSS) version 28.0.1.1.[19]

Table 2 Overview of costs before and after project implementation

	Pre-intervention (CAD$) (n=96)	Post-intervention (CAD$) (n=101)	Difference (post-pre)	P value
Total cost				
Median (IQR)	8 381.58 (6593.97–19 367.19)	7 252.03 (6470.28–10 096.13)	−1129.55	0.02*
Surgical, median (IQR)				
Total OR visit	8061.82 (6273.96–19 053.43)	6 740.45 (5958.70–9584.55)	−1321.37	<0.05*
OR costs†	6054.56 (4665.01–17 301.62)	5 271.00 (4407.92–7243.47)	−783.56	0.02*
Post-operative stay†	1278.10 (891.60–1800.80)	816.00 (639.38–1188.87)	−462.1	<0.05*
Pharmacy costs	47.06 (22.82–98.86)	23.20 (12.98–31.75)	−19.14	<0.05*
Investigations†	166.95 (121.21–198.09)	194.00 (139.73–259.60)	+27.05	0.06
Readmission				n/a
Total (median)	16 036.62 (8018.82)	22 637.00 (11 318.00)		
Outpatient visits				
Total (median)	n/a (113.00)	10 513 (96.00)		
ER visits				
Total (median)	2768.97 (305.40)	n/a		
Implementation				
Total	n/a	13 106.52		
Per patient	n/a	134.38		

*Statistically significant.
†The OR cost includes costs of the operating room, Da Vinci robot use if applicable, respiratory therapist and anesthesia costs. The postoperative stay cost includes PACU stay, short stay unit, and ward admission if applicable; calculated from available cost and estimates on time spent in each location. The investigations costs include laboratory, electrocardiogram, radiology, blood bank, and microbiology if applicable
CAD$, Canadian dollars; ER, emergency room; n/a, not available or applicable; OR, operating room; PACU, post-operative care unit.

RESULTS

Surgical cost information was available for 96 of 100 patients pre-intervention and 101 of 102 patients post-intervention. The clinical and demographic characteristics of the initial cohort

were previously published and are illustrated in Table 1.[7] The primary and secondary outcomes are illustrated in Table 2 for the pre-intervention and post-intervention patients. For the primary outcome total cost, there was a statistically significant cost saving of $1129.55 per patient, with a median cost of $8381.58 pre-intervention and $7252.03 for post-intervention (p=0.02). For the secondary outcomes, there were statistically significant differences for the total operative visit as well operating room costs (p=0.02), postoperative stay (p<0.05), and pharmacy costs (p<0.05). The investigations cost was not different between the groups (p=0.06). The operating room cost contributed the most to the total cost, followed by post-operative stay cost, whereas pharmacy and investigations contributed the least.

In terms of 30-day post-operative visits, only descriptive costs are presented in Table 2 given the low numbers of patients requiring readmission or emergency room visits, and the lack of cost information for the pre-intervention outpatient clinic and the post-intervention emergency room visit which were missing in the case-cost department. The readmission costs were $22 637.00 for the two post-intervention patients compared with $16 036.62 for the two pre-intervention patients, with one patient in the post-intervention group being medically complex due to a previous organ transplant. The implementation costs for the cohort were $13 106.52 ($134.38 per patient) including the costs of an educational patient video ($10 500), a poster to highlight the enhanced-recovery principles for clinicians ($146.52), and carbohydrate drink ($30 per patient) given pre-operatively to all patients as part of pre-operative enhanced recovery principles.[20]

Factors associated with costs were analyzed using linear models (Table 3). Bivariate analyses found that intervention group (pre- vs post-) and surgical approach (laparoscopic vs robotic) were associated with total, operating room, and post-operative stay costs (p<0.05). On the multivariate analysis, surgical approach and group remained significant for total and post-operative costs (p<0.05). For operating room costs, only surgical approach remained statistically significant (p<0.05). Body mass index was found to be associated

Table 3 Unadjusted and adjusted linear models looking at factors impacting costs

Factor	Unadjusted		Adjusted	
	Effect estimate (95% CI)	P value	Effect estimate (95% CI)	P value
Total cost				
Group*	0.98 (0.97 to 0.99)	<0.001†	0.98 (0.97 to 0.99)	<0.001
Robotic‡	1.02 (1.01 to 1.03)	<0.001†	1.02 (1.00 to 1.03)	<0.007†
Charlson Comorbidity moderate and higher§	1.00 (0.98 to 1.01)	0.793		
Charlson Comorbidity mild§	0.99 (0.97 to 1.01)	0.238		
BMI	1.00 (1.00 to 1.00)	0.061		
Age	1.00 (1.00 to 1.00)	0.511		
OR cost				
Group*	0.92 (0.86 to 0.98)	0.007†	0.99 (0.96 to 1.01)	0.303
Robotic‡	1.61 (1.57 to 1.65)	<0.001†	1.60 (1.56 to 1.65)	<0.001†
Charlson Comorbidity moderate and higher§	1.00 (0.90 to 1.10)	0.977		
Charlson Comorbidity mild§	0.98 (0.88 to 1.09)	0.719		
BMI	1.01 (1.01 to 1.02)	<0.001†	1.00 (1.00 to 1.00)	0.591
Age	1.00 (1.00 to 1.00)	0.511		
Post-operative stay cost				
Group*	0.85 (0.79 to 0.91)	<0.001†	0.87 (0.81 to 0.93)	<0.001†
Robotic‡	1.15 (1.05 to 1.25)	0.002†	1.12 (1.03 to 1.22)	0.007†
Charlson Comorbidity moderate and higher§	0.98 (0.87 to 1.10)	0.754		
Charlson Comorbidity mild§	0.92 (0.81 to 1.05)	0.214		
BMI	1.00 (1.00 to 1.01)	0.063		
Age	1.00 (1.00 to 1.01)	0.179		

*Pre-intervention.
†Costs log transformed and all effect estimates (adjusted and unadjusted) derived from generalized estimating equations, normal distribution, identity link, independent model.
‡Laparoscopy.
§Charlson Comorbidity, no comorbidity (level 0).
BMI, body mass index; OR, operating room.

with operating room costs in the unadjusted model, but was not significant in the multivariable analysis.

Table 4 reflects the primary and secondary outcomes according to surgical approach. For laparoscopy, the post-intervention group had lower costs for post-operative stay and pharmacy, and higher investigations costs ($p<0.05$). For robotics, only pharmacy costs were significantly different, favoring savings for the post-intervention group ($p<0.05$). Other costs were not statistically significant between groups when looking at subgroups based on surgical approach ($p>0.05$).

DISCUSSION

Summary of Main Results

This study demonstrates that a comprehensive peri-operative program based on enhanced recovery principles for selected patients undergoing minimally invasive gynecologic oncology surgery leads to cost savings from a healthcare system perspective. Precisely, the post-intervention group had significant cost reductions in total costs, as well as surgical visit costs, specifically operating room, post-operative stay, and pharmacy costs. In a multivariable analysis, the post-intervention group remained significantly associated with cost savings in terms of total and post-operative stay, and the robotic approach was significantly associated with increases in total, operating room, and post-operative stay costs.

Results in the Context of Published Literature

The cost-savings associated with the implementation of enhanced recovery principles in minimally invasive gynecologic oncology surgery are an important addition to the previously published quality improvement initiative that resulted in improved same day discharge from 29% to 75% over a 12-month period, whereas the rates for 30-day readmission, reoperation, emergency room visits, and morbidity and mortality remained low.[7] Patient satisfaction surveys completed by the post-intervention group had shown good overall experience with length of stay and care received.[7] The result of the previous study added a minimally invasive gynecology oncology perspective to the known list of surgical benefits associated with enhanced recovery programs.[8 12 14 21]

When reviewing the literature related to the economic impact of enhanced recovery initiatives, prior studies showed beneficial results.

Table 4 Overview of median costs per patient before and after project implementation for laparoscopy and robotics in 2020 CAD$

Laparoscopy	Pre-intervention (n=61)	Post-intervention (n=80)	Difference (post-pre)	P value
Total median cost (IQR)	7011.00 (6281–7312)	6933.00 (6284–7750)	−78.00	0.69
Surgical median cost (IQR)				
Total OR visit	6692.00 (5962–7473)	6422.00 (5773–7239)	−270.00	0.22
OR costs*	5036.00 (4306–5947)	4905.00 (4205–5472)	−131.00	0.62
Post-operative stay*	1181.9 (829.70–1745.50)	814.70 (619.00–1092.50)	−367.20	<0.05†
Pharmacy costs	42.37 (21.78–77.99)	22.83 (13.44–35.42)	−19.57	<0.05†
Investigations*	159.72 (119.59–192.30)	206.80 (149.70–271.00)	+47.08	<0.05†
Robotics	**Pre-intervention (n=35)**	**Post-intervention (n=21)**		
Total median cost (IQR)	20 134.00 (19 149–21537)	21 555.00 (17 734–23239)	+1421.00	0.76
Surgical median cost (IQR)				
Total OR visit	19 814.00 (18 829–21217)	21 044 (17 223-22 727)	+1230.00	0.93
OR costs*	17 688.00 (16 829–18448)	19 791.00 (14 787-21 181)	+2 1030.00	0.48
Post-operative stay*	1 289.80 (976.9–1975.4)	876.5 (713.1–1862.7)	−413.30	0.12
Pharmacy costs	59.88 (26.52–117.46)	26.24 (10.50–28.80)	−33.64	<0.05†
Investigations*	169.64 (126.79–221.14)	150.00 (80.01–200.83)	−19.64	0.22

*The OR cost includes costs of the surgical equipment, robot cost if applicable, respiratory therapist cost. The post-operative cost includes recovery room stay, short stay unit, and ward admission if applicable. The investigations include laboratory, electrocardiogram, microbiology, and blood bank costs if applicable.
†Statistically significant;
OR, operating room.

Specifically, a study looking at return of investment of enhanced-recovery programs in pooled surgical cohorts in Alberta, Canada found a net healthcare system savings per patient that ranged from $26.35 to $3606 CAD and a return of investment ranging from $1.05 to $7.31 CAD for every dollar invested in enhanced recovery programs.[22] Specifically in gynecologic oncology, a systematic review published in 2021 found enhanced recovery programs to be associated with US$2129 (95% CI 712 to 3544) cost savings per patient.[13] However, most of the gynecologic oncology literature relates to enhanced recovery for laparotomy, with only one study looking specifically at minimally invasive surgery in this review.[5 14 23–27] Indeed, Chapman et al found an overall hospital cost decrease of 12%, from US$15649 to US$13771 post-enhanced recovery program implementation.[5] These costs reported by Chapman et al in 2014 are higher than the current study. This is potentially due to several differences in methodology and data for the Chapman et al study, that is: (1) both direct and indirect costs were reported; (2) the rate of robotic approach was higher; (3) private and public health systems can have potential differences; and (4) pathology and genetic costs were excluded in the present study. Overall, the current study is an important addition to limited literature relating to cost implications of enhanced-recovery programs in minimally invasive gynecology oncology surgery. Although there is an initial implementation cost related to enhanced recovery program transition, this one-time cost leads to prolonged benefits.[7]

Strengths and Weaknesses

The current study has several limitations, in particular the fact that several costs are not captured. Specifically, the study took a healthcare system perspective involving only direct costs and did not include physician fees or time off work. One can hypothesize that increased rates in same-day discharge means patients rely more on their family or friends in the initial post-operative phase, and these caregivers time off work has societal cost implications. As well, the program implementation involved a multidisciplinary team which may not be available or involve an additional cost at another institution; however, with increasing patient participation,

this cost decreases. As well, there were more conversions in the pre-intervention group; however, this study is based on a quality improvement initial study which involves a real-life clinical population where there is a risk of conversion to laparotomy. In addition, the post-operative group has less robotic surgery. To counteract this limitation, subgroup analyses and bivariate and multivariate analyses were conducted. Another limitation is that within the robotic subgroup, there was a non-significant trend towards higher cost post-intervention, which we attribute to higher anesthesia and robotic cost during the COVID-19 pandemic, as well as higher body mass index in these patients.

Despite its limitations, the study has several strengths. It provides detailed costs results regarding minimally invasive gynecology oncology surgical care in Ontario. Indeed, this micro-cost approach provided more detailed understanding of costs associated with enhanced recovery program implementation in minimally invasive gynecology oncology. Specifically, this allowed for identification of post-operative stay as the most influential cost driver leading the cost reductions in the enhanced recovery quality improvement project.

Implications for Practice and Future Research

From a health policy perspective, it is encouraging to see positive impacts that go beyond clinical advantages for projects focusing on improving surgical care. In a post-pandemic healthcare system showing significant limitations in terms of hospital bed availability, healthcare worker retention, and increased surgical backlog,[28] a comprehensive peri-operative care program using enhanced recovery principles associated with hospital cost reductions is an important argument to increase administrative and political support of such surgical care programs in selected patients. Future studies should evaluate sustainability of such healthcare projects in gynecology oncology, both to assess sustainability and identify ways to strengthen it.

CONCLUSION

This study illustrates cost reductions with implementation of a comprehensive peri-operative care program focusing on improving same day discharge in minimally invasive gynecology oncology surgery. From a healthcare perspective, investing in a long-term enhanced recovery initiative in this population is worthwhile as it leads to both health and economic benefits. The study's economic perspective provides an additional argument towards increasing participation of gynecology oncology centers in enhanced recovery principles.

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