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Variation in resource utilization associated with the surgical management of ovarian cancer

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HIGHLIGHTS

- We identified significant variation in resource utilization among hospitals who treat women for ovarian cancer.
- Operating room and supply costs are the largest drivers of variation.
- Operating room costs were the fastest growing component of total costs.
- We found a significant association between high costs and lower quality of care.

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ABSTRACT

Objective. Identify the major factors that drive standardized cost in providing surgical care for women with ovarian cancer, characterize the magnitude of variation in resource utilization between centers, and to investigate the relationship between resource utilization and quality of care provided.

Methods. Retrospective cohort study of hospitals across the United States reporting to the Premier Database who cared for patients with ovarian cancer diagnosed between 2007 and 2014.
The primary outcome was standardized total cost of the index hospitalization. To assess the relationship between hospital standardized costs and patient outcomes, we identified four measures of quality: 1) complications, 2) reoperation, 3) length of stay > 15 days, and 4) unplanned readmission.

Results. The study population included 15,857 patients treated at 226 hospitals. The median standardized cost for hospitalizations was $13,267 (IQR = $3342). Reoperation was associated with 49% increase (95% CI = 43%–56%), and having minor complication was associated with 10% (95% CI = 8%–12%) increase in standardized cost, a moderate complication was associated with 36% (95% CI = 33%–38%) increase, and a major complication was associated with 83% (95% CI = 76%–89%) increase. The average risk-adjusted hospital standardized costs for hospitals in the highest resource use quartiles was 56% higher than the average hospital costs for hospitals in the lowest quartile ($10,826 vs. $16,933). The largest variation was in operating room standardized cost (45.5% of the total variation in operating room cost is explained by differences in hospital practices) and supplies (41.7%).

Conclusions. We identified significant variation in standardized costs among women who underwent surgery for ovarian cancer, operating room and supply costs are the largest drivers of variation.

1. Introduction

The United States spends more than $3 trillion (18% of the national budget) on healthcare [1]. Annual expenditures for cancer care in particular in the United States are projected to exceed $170 billion by

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2020 [2], explained in part by rising costs of cancer-related surgery and post-operative care [3]. Analyses of the cost of care are essential to understand the economic burden of particular surgical interventions, identify the drivers for the rising costs of these interventions, and understand, as well as minimize or eliminate, unwanted variation in costs [4]. The existence of institutions that have high resource utilization and high costs, relative to their peers, represents substantial inefficiency in the healthcare system, particularly if these costs vary independently of patient-related factors or outcomes [5].

The rising cost of health care is exerting increasing pressure on the budgets of the government, health care organizations, companies, and individuals. As commercial and public-sector payers seek to improve the efficiency of the health care system, there is a growing need to improve the quality of care delivery and bend the cost curve. Programs such as the National Surgical Quality Improvement Programs (NSQIP) have been instituted to generate data and identify metrics of quality and safety. These initiatives aim at identifying specific cost drivers and efficiencies to improve quality and mitigate the cost of surgical care. This charge is imperative and of critical relevance across all health care delivery spaces, especially academic medical centers, committed to the tripod of clinical care, research, and education. To the degree that clinical care does not become more affordable and of higher quality, support for education and research will become more challenging to secure, and these two missions, which are integral to the future of health care and medicine face substantial risks. We present a framework using the example of ovarian cancer surgical treatment to identify drivers of cost and metrics of care quality.

Ovarian cancer is associated with the highest case-fatality ratio of all gynecologic cancers. The initial treatment is multimodal and complex, generally including extensive surgical procedures and chemotherapy. Ovarian cancer has a propensity for early peritoneal dissemination and advanced-stage disease at clinical diagnosis, and therefore resource utilization for the initial surgical management of ovarian cancer is high [6]. The severe morbidity associated with the surgical management of patients with ovarian cancer provides a unique opportunity for surgical episode-of-care evaluation. The objective of the present study was to identify the major factors that drive standardized costs in providing surgical care for patients with ovarian cancer and characterize the magnitude of variation in resource utilization among hospitals. Furthermore, we aimed to investigate the relationship between resource utilization and the quality of care provided by hospitals.

2. Materials and methods

2.1. Data collection

We analyzed data from the Premier database, an all-payer, fee-supported database created to measure resource utilization and quality. This database has been used by the Centers for Medicare & Medicaid Services (CMS) for measurement of hospital quality and has been widely used in previous health outcomes and health economics studies. The database includes complete billing and coding history for >45 million hospital inpatient discharges [7–12]. All data received from hospitals are validated against Premier standards [13]. The present study was granted exempt status by the Institutional Review Board.

We selected patients with a diagnosis of ovarian cancer [International Classification of Diseases, 9th Revision (ICD-9) codes 183.x] who underwent primary surgery that included ovarian resection, hysterectomy, or both [14] between 2007 and 2014. Among the 17,160 patients who underwent surgery, we excluded patients aged <18 years (n = 69). We also excluded those treated at 250 hospitals that had fewer than 10 cases (n = 987) because the reliability of such estimates is low. We also excluded patients who died during the index admission (n = 150) and those discharged to hospice (n = 53) from our analyses of cost and prolonged length of stay (LOS) because we could not reliably predict what would have been their cost for an entire admission if the patients had stayed alive or were not transferred to hospice. We included them in the analysis of post-operative complications (except for readmissions). We applied additional restrictions when analyzing certain models. For the cost analysis, we excluded patients with a reported cost of <$100 (n = 111) or >$500,000 (n = 3) and patients with a LOS >30 days (n = 151) to minimize the impact of outliers. For the analysis of 90-day readmission, we excluded patients admitted after March 2014 (n = 534); and for the prolonged LOS analysis we excluded patients admitted after May 2014 (n = 145), because the database had complete data for each patient only through the end of June 2014.

2.2. Outcome measures

The primary outcome measure was standardized total cost of the index hospitalization. Premier collects data directly from the cost accounting systems at participating hospitals. Hospital cost accounting systems represent the facilities' best efforts to assign direct and indirect clinical expenditures to patients to manage resources and set prices. Costs were not based on the charges, which have little relationship to true underlying resource utilization [15], and included direct (variable) costs of the resource used and indirect costs (a portion of the hospital's fixed costs). Both variable and fixed costs can vary across hospitals for a variety of reasons including differences in local input prices, hospitals' bargaining power, overhead costs, and long-term investments [5,16]. This makes comparison of resource utilization based on hospital-reported costs difficult. To adjust for this factor, we employed standardized cost as reported by Lagu et al. [5]. We first calculated the median cost across hospitals for each item in the database during a given year and set this as the "standardized" unit cost of that item at every hospital. Once standardized costs were assigned at the item level, we summed the costs of all items assigned to each patient to get the total cost of a hospitalization per patient at each hospital. We hereafter refer to "standardized costs" as "costs." All cost figures were inflation adjusted to 2014 dollars.

To assess the relationship between costs and patient outcomes, we identified four measures of quality: 1) post-operative complications, 2) re-operation, 3) prolonged LOS of >15 days, and 4) unplanned readmission. We used ICD-9 codes to identify post-operative complications, based on the Clavien classification system [17]. The highest Clavien grade represented the severity of the complication for each patient [18]. Re-operation was identified if there was a second billing code for use of the operating room (OR). We identified unplanned readmissions to acute care hospitals within 90 days of discharge from the hospital following primary surgery. To define unplanned readmission we followed an algorithm developed by CMS [19,20].

We grouped risk adjustment factors into two categories: those that existed before the patient was admitted to the hospital (baseline factors) and those that developed during hospitalization (hospitalization related factors). Baseline factors included age, race, insurance (Medicare, Medicaid, commercial, none), discharge year, comorbidities, major psychiatric illness (schizophrenia, bipolar disorder, major depression) [21–23], surgical approach (laparotomy vs. laparoscopy), and number of surgical procedures. We used the comorbidity index proposed by Elixhauser et al. [24]. For number of procedures, a composite score based on the number of surgical procedures each patient underwent was calculated as previously described by Wright et al. [14,25]. We added the number of ovarian cancer-related surgical procedures to baseline factors because we assumed these were primarily driven by the patient's pre-admission condition. Our rationale was that the number of procedures might reflect the patient's preoperative burden of disease and condition. Hospitalization-related factors included hospital teaching status, region, number of beds, re-operation, and post-operative complications.

Both groups of risk adjustment factors (baseline and hospital-related) are potential predictors of standardized costs and patient outcomes. Because we were interested in the drivers of cost and comparing hospitals on the basis of cost and patient outcomes, we included both groups when analyzing drivers of cost, but included only baseline characteristics when examining (a) cost variation among hospitals, and (b) the association between hospital spending and patient outcomes [26].

2.3. Statistical analysis

We estimated several models. However, the general framework for all models is the same. First, since cost and patient outcomes within a given hospital are likely to be similar than those across other hospitals, we used two-level hierarchical framework to account for the clustering of patients within hospital. Second, since the distribution of cost was right skewed, we specified a gamma distribution with long link to account for the nonmoral distribution of cost. Within this general framework, we estimated three set of models.

The first set of models was designed to identify drivers of cost. We estimated two models: one that adjusted for baseline factors only and one that adjusts for baseline and hospital level factors.

The second set of models was designed to measure variation in resource utilization across hospitals. For these models, we adjusted only for baseline factors i.e., factors that were potentially outside the control of hospitals' decisions. Since variation in total cost may hide variation in individual cost categories, we estimated a model for total cost as well as for each of the five cost categories in the Premier dataset: room and board, pharmacy, supplies, OR, and others [8–12].

To quantify variation in costs across hospitals, we calculated the intraclass correlation coefficient (ICC), which measures the proportion of total variance explained by hospitals [27]. We also reported the average reliability index. This index provides a measure of accuracy of estimated variation to distinguish true differences from random variation. In general, a reliability index below 0.7 is considered unreliable [28].

The third set of models was designed to assess whether high cost hospitals deliver better patient outcomes. First, to minimize endogeneity bias (i.e., poor patients outcomes leading to higher costs), we dived the data into two time periods: 2007–2010 and 2011–2014. We used data from the first period to estimate hospital-level costs and data from the second period to evaluate the association of hospital-level costs and patient outcomes [29]. Risk-adjusted hospital cost is a hospital level average cost that accounts for potential risk factors and differences in sample size. We followed the CMS approach in calculating the average risked adjusted hospital cost [26]. We considered four measures of patient outcome: unplanned admission within 90 days of discharge as defined by an algorithm developed by CMS [20,30], prolonged LOS, re-operation, and postoperative complications. To test the association between hospital cost and patient outcome, we regressed patient outcome on patient characteristics and risk-adjusted hospital cost.

All statistical tests were two-sided and P-values of <0.05 were considered statistically significant. Regression results are reported as odds ratios or rate ratios depending on the outcome variable. All analyses were conducted using SAS, version 9.4 (SAS Institute, Inc, Cary, NC).

Table 1
Hospital and patient characteristics by quartiles of hospital standardized cost.

Covariate	Full sample	Risk-adjusted hospital cost quartiles (lowest to highest)				
		Q1	Q2	Q3	Q4	P-value[a]
Hospital characteristics						
Median adjusted spending	$13,591	$10,826	$12,541	$14,072	$16,933	
Number of hospitals	226	56	57	57	56	
Teaching hospitals	43.8%	44.6%	35.1%	52.6%	42.9%	0.6
Urban hospitals	91.6%	83.9%	96.5%	94.7%	91.1%	0.2
Median number of beds	384	352	409	382	422	0.3
Median number of patients	41	37	36	40	53	0.3
Patient characteristics						
Number of patients	15,857	3691	3953	3573	4640	
Median age (years)	59	60	59	59	59.0	0.2
Race						
Non-Hispanic white	69.9%	76.2%	72.3%	66.9%	65.1%	<0.001
None-Hispanic black	8.4%	7.4%	9.2%	9.8%	7.3%	0.8
Hispanic	2.80%	0.41%	3.1%	2.7%	4.5%	<0.001
Other	19.0%	16.1%	15.4%	20.6%	23.1%	<0.001
Payer						
Commercial	50.1%	49.3%	48.7%	50.1%	51.8%	0.007
Medicaid	8.4%	8.6%	7.6%	9.0%	8.5%	0.5
Medicare	34.5%	35.9%	34.4%	34.4%	33.5%	0.02
Uninsured	7.0%	6.2%	9.2%	6.5%	6.2%	0.059
Number of procedures						
0	82.4%	83.4%	86.2%	83.7%	77.5%	<0.001
1	12.0%	11.2%	10.3%	12.0%	13.9%	<0.001
2	4.1%	4.1%	2.8%	3.3%	6.0%	<0.001
≥3	1.5%	1.3%	0.7%	1.0%	2.7%	<0.001
Median Elixhauser score	2.0	2.0	2.0	2.0	3.0	<0.001
Laparotomy	83.9%	84.8%	84.6%	85.4%	81.6%	<0.001
Median surgery time in minutes	197	180	180	210	223	<0.001
Psychiatric Illness	5.3%	6.1%	4.6%	4.8%	5.6%	0.6
Patient outcomes						
90 day readmission	14.9%	13.0%	13.1%	15.6%	17.5%	<0.001
Prolonged length of stay	5.3%	2.6%	3.3%	4.8%	9.6%	<0.001
Re-operation	5.4%	4.8%	3.6%	5.3%	7.6%	<0.001
Complications						
No complication	37.8%	42.8%	41.6%	36.2%	31.7%	<0.001
Minor complication	15.2%	16.4%	14.8%	15.1%	14.7%	0.07
Moderate complication	30.5%	28.8%	29.1%	32.4%	31.6%	<0.001
Major complication	15.6%	11.4%	13.5%	15.3%	20.8%	<0.001
Death	0.95%	0.62%	0.96%	1.1%	1.1%	0.02

[a] The P-values are for tests for trends across the four quartiles. For binary variables, we used the Armitage test, and for continuous variables, we used the Jonckheere-Terpstra test.

3. Results

The study population included 15,857 patients treated at 226 hospitals. The median hospital had 384 beds (Interquartile Range [IQR] = 237) and performed 41surgeries (IQR = 79) for ovarian cancer during the period studied. Forty-seven percent of the hospitals had data for all study years. The median age of patients was 59 years (IQR = 18), 83.9% of patients had a laparotomy and 17.6% had more than one procedure. The median cost for hospitalizations was $13,591 (IQR = $3342). Overall, 14.9% of patients were re-hospitalized within 90 days, 5.3% were hospitalized for >15 days, 5.4% had a re-operation, and 62.2% experienced some degree of complication (Table 1).

Table 2 presents the adjusted associations of baseline factors and hospitalization-related factors with total costs for the hospitalization. The largest drivers of costs were surgical approach, number of procedures, re-operation, and complications. Laparotomy was associated with a 29% increase in costs (95% confidence interval [CI] = 25%–33%), re-operation was associated with a 49% increase (95%CI = 43%–56%), and one or more procedure was associated with 29% to 49% increase. Relative to no complications, minor complications were associated with a 10% increase in costs (95%CI = 8%–12%), moderate complications were associated with a 36% increase (95%CI = 33%–38%), and major complications were associated with an 83% increase (95%CI = 76%–89%). Age, black race, Medicaid and Medicare insurance, psychiatric

Table 2
Patient and hospital factors associated with an increased standardized cost of hospitalization.

Predictor	Adjusting for baseline factors only		Adjusting for baseline and hospital related factors	
	Rate ratio[a]	(95% CI)	Rate ratio[a]	(95% CI)
Patient age (in decades)	1.02	(1.01–1.02)	1.01	(1.01–1.01)
Race (ref = white)				
Black	1.07	(1.04–1.10)	1.03	(1.01–1.05)
Hispanic	1.00	(0.94–1.07)	1.00	(0.94–1.06)
Other	1.01	(0.98–1.04)	1.00	(0.98–1.03)
Payer (ref = commercial)				
Medicaid	1.07	(1.03–1.10)	1.06	(1.03–1.08)
Medicare	1.03	(1.01–1.05)	1.03	(1.00–1.03)
Uninsured	1.08	(1.05–1.11)	1.05	(1.03–1.08)
Psychiatric illness	1.05	(1.02–1.09)	1.04	(1.01–1.07)
Laparotomy	1.44	(1.39–1.49)	1.29	(1.25–1.33)
Elixhauser score	1.13	(1.12–1.14)	1.07	(1.06–1.07)
Number of procedures (ref = 0)				
1	1.41	(1.37–1.45)	1.29	(1.26–1.32)
2	1.63	(1.55–1.71)	1.42	(1.37–1.47)
≥3	1.69	(1.56–1.83)	1.49	(1.40–1.57)
Secular trend[b]	0.99	(0.99–1.00)	1.00	(0.99–1.01)
Re-operation			1.49	(1.43–1.56)
Complication (ref = none)				
Minor			1.10	(1.08–1.12)
Moderate			1.36	(1.33–1.38)
Major			1.83	(1.76–1.89)
Teaching hospital			0.99	(0.94–1.05)
Rural hospital			0.96	(0.86–1.07)
Number of beds			1.00	(0.98–1.02)
Region (ref = South Atlantic)				
East North Central			1.02	(0.93–1.11)
East South Central			1.00	(0.90–1.11)
Middle Atlantic			1.01	(0.93–1.10)
Mountain			0.95	(0.83–1.09)
New England			1.07	(0.96–1.19)
Pacific			1.03	(0.95–1.11)
West North Central			0.95	(0.82–1.10)
West South Central			0.99	(0.92–1.07)

CI = confidence interval. Ref = reference.
[a] Rate ratios presented here are estimated from a hierarchical model with log link and gamma distribution.
[b] The secular trend was specified as a continuous variable with a value of 1 for 2007 and 8 for 2014.

illness, and preoperative comorbidities were also associated with increased hospitalization costs, but the impact was relatively small compared with the above-mentioned factors. Hospital characteristics such as region, teaching status, setting, and number of beds were not significantly associated with costs.

We found notable variation in risk-adjusted hospital costs among hospitals (Table 1 and Appendix Fig. 1). The average risk-adjusted hospital costs for hospitals in the highest cost quartile were 56% higher than the average hospital costs for hospitals in the lowest quartile ($10,826 compared with $16,933). We did not observe significant differences in cost by teaching status, region, setting, hospital size, or number of patients treated between hospitals in the lower cost quartiles and hospitals in the higher cost quartiles. After adjusting for baseline patient characteristics, we found that 18% of the remaining variation in total costs was attributable to hospitals (Table 3). The average reliability index for this model was 0.89, indicating that most of the observed variation among hospitals was due to real difference rather than random variations.

We found more variation across hospitals by cost category than we did for total costs (Table 3). The largest variation was in OR costs (45.5% of the total variation in OR costs was explained by differences in hospital practices) and supplies (41.7%). There was also variation among hospitals in pharmacy (23.2%) and room and board costs (20.8%).

OR costs were also the fastest growing component of total costs. Over the 8 years studied, OR costs increased by 3.1% (95%CI = 2.3–3.9) annually (Table 3). Pharmacy costs, in contrast, declined by 4.2% (95%CI = −5.4% to −2.9%) annually. Because costs were adjusted for annual inflation, these changes represent real changes in resource utilization rates. There was no statistically significant change in total costs over the period studied.

We found that high hospital costs in 2007–2010 were associated with major complications, re-operations, and prolonged LOS in 2011–2014 (Fig. 1A–C). Higher hospital costs were not associated with re-admissions (Fig. 1D). In a hierarchical regression model adjusting for pre-admission characteristics, we found that every $1000 increase in hospital costs was associated with a 17% increase (95%CI = 10%–24%) in prolonged LOS rate, an 18% increase (95%CI = 7%–30%) in the re-operation rate, and an 8% increase (95%CI = 5%–10%) in the complication rate (Table 4).

4. Discussion

Understanding the drivers of variation in the costs of ovarian cancer care and which components are contributing to rising costs is important in planning and setting priorities for allocating resources. Among women with newly diagnosed ovarian cancer, approximately 40% of the costs of first-line treatment are related to surgery and postoperative care [31]. In the present study of 226 hospitals providing primary ovarian cancer surgery, we found that standardized costs, as a measure of resource utilization, varied substantially across hospitals, even after accounting for important patient and hospital characteristics. Unexplained variation in

Table 3
Proportion of variation in hospitalization cost explained by hospitals and annual growth of hospitalization cost over the study period (2007–2014).

Cost category	Proportion of variation explained by hospitals[a]	Reliability index[b]	Annual growth in costs % (95% CI)[c]
Total costs	18.3	0.89	−0.2 (−0.9, 0.5)
Cost categories			
Operating room	45.5	0.96	3.1 (2.3, 3.9)
Pharmacy	23.2	0.91	−4.2 (−5.4, −2.9)
Supply	41.7	0.95	−0.5 (−2.6, 1.6)
Room and board	20.8	0.89	−1.2 (−2.2, −0.2)
Other[d]	24.4	0.91	−1.5 (−2.6, −0.5)

CI = confidence interval.
[a] Proportion of variance explained by hospitals was measured using Intra Class Correlation Coefficient (ICC). The ICC measures the proportion of total variance in the outcome variable explained by differences in hospitals after adjusting for baseline factors. Since variation in total cost can hide variation in individual cost categories, we estimated variation in total cost as well as in the five cost categories by estimating separate model for each cost category.
[b] Reliability index provides a measure of the accuracy of the estimated variation due to hospitals. In general, a reliability index of >0.7 is considered as reliable [28].
[c] Annual growth in hospital cost is measured using the coefficient for secular trend included in the model. Secular trend was specified as a continuous variable with a value of 1 for 2007 and 8 for 2014.
[d] Other costs included laboratory analyses, electrocardiograms, radiological studies, respiratory studies and therapy, therapy, labor, Emergency Room use, and other miscellaneous costs.

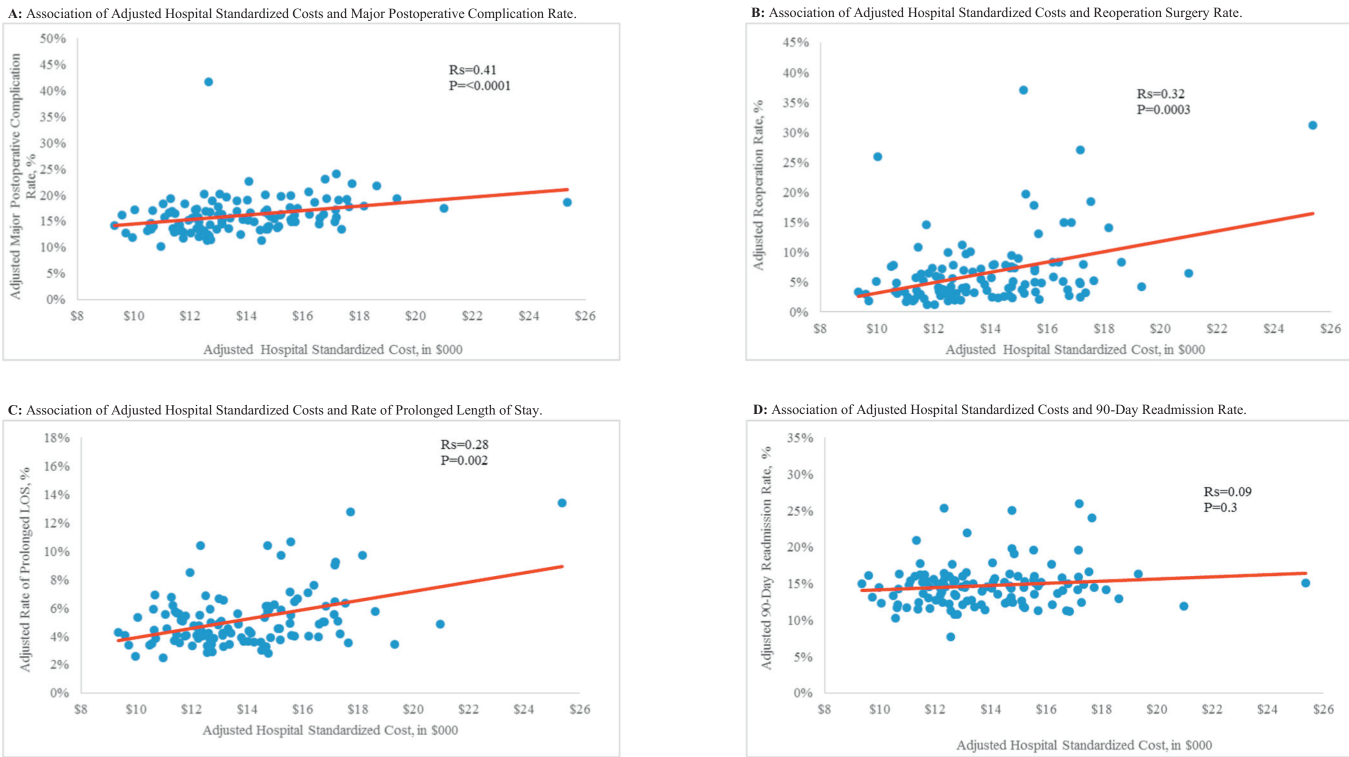

Fig. 1. Association of adjusted hospital standardized costs and quality measures.

costs across hospitals was particularly high for OR use and supplies. Additionally, we found a significant association between high costs and lower quality of care. These findings raise important questions about the quality and consistency of care and are an important starting point for quality improvement and service development.

Standard methods of healthcare cost estimation have important limitations, and before determining the reasons for the observed variation, it is important to emphasize the importance of cost standardization. Cost measurement using charges or cost-to-charge ratios estimates only the total costs, and not the marginal costs of services, and this method ignores cost shifting that occurs regularly in hospital accounting [32]. Additionally, hospital-reported costs are not useful for comparing resource utilization across hospitals because costs reported by hospitals for a treatment or service vary widely across institutions for many reasons, including differences in standard of living, bargaining power, and long-term investments [5]. Thus, to estimate resource utilization and variation across all hospitals, we analyzed standardized costs. Using this approach and adjusting for pre-admission patient factors, we found considerable variation in standardized costs (and thus resource utilization) across hospitals. When we included pre-admission and hospitalization factors in the model, the largest modifiable drivers of hospital standardized costs were reoperation and post-operative complications.

Variation in the use of services has been well documented and may suggest opportunities to reduce unnecessary care [33]. Recent studies have linked variations in surgery use to varying payment models, provider preferences, and patient-level factors, and such differences have been associated with variations in post-operative outcomes [34–36]. Similar to prior studies among patients undergoing surgery [37], we also identified substantial variation in risk-adjusted hospital standardized costs. The persistent variation after standardizing costs and adjusting for risk factors closely represents the potentially unwarranted differences in services provided for patients with similar risk and cost profiles. Furthermore, we observed that the largest variation in such costs was in the OR costs and costs of supplies. OR and supply costs have been shown to comprise large portions of a procedural hospitalization charge [38]; therefore, surgeons play a crucial role in the cost efficiency of the OR through total operative time, use of supplies, and patient outcomes.

In our study, OR costs increased by almost 3% every year, even after adjusting for inflation, whereas costs in other categories decreased. Although a decrease in LOS from 7 days to 5 days between 2007 and 2014 in our cohort could explain the decrease in costs in categories such as room and board and pharmacy, the reason for the significant increase in OR costs and significant variation across hospitals is unclear. This increase in the rate might have significant implications for hospitals and surgeons. To succeed under current bundled payment models, hospitals and surgeons must collaborate to control both direct and indirect costs. Currently, most early participants in payment bundling are focusing on direct costs, such as expenses related to surgery, inpatient care, post-acute care, and readmissions. The indirect costs associated with increases in OR costs receive less attention. As has been shown in other bundled payment models, considering these indirect costs will be important if cancer-related surgery is included in future oncology models. Further studies are needed to better understand the reasons for rising OR costs and identify effective solutions to contain these costs.

The association between health care quality and costs has been an important consideration in policy debates on whether decreases in health care spending will negatively impact quality or whether quality improvement initiatives will decrease health care spending [39,40]. The financial realities facing hospitals, including rising costs and

Table 4
Association between adjusted hospital standardized cost (in $1000)[a] and patient outcomes.

Outcome	Odds ratio	
	Mean	(95% CI)
90 day readmission rate	1.03	(0.99–1.07)
Extended length of stay (>15 days)	1.17	(1.10–1.24)
Re-operation	1.18	(1.07–1.30)
Complication	1.08	(1.05–1.10)

CI = confidence interval.
[a] For every $1000 increase in adjusted hospital standardized cost.

lowered reimbursements, make value essential in all surgical procedures. The shift toward coordinated care, risk sharing, bundled payments, and a higher percentage of the patient pool supported by government insurance all necessitate tight cost controls to maintain positive margins [41]. In the present study we observed that hospitals with the highest standardized costs for ovarian cancer surgery had poorer quality of care than those with lower standardized costs, as measured by complications, re-operations, and prolonged LOS. Although our results suggest that it may be possible to reduce costs without harming patient outcomes, prior evidence of the direction of association between health care cost and quality is inconsistent. Most studies have found that the association between cost and quality is small to moderate, regardless of whether the direction is positive or negative [42].

Limitations to the present analysis must be considered. The present study used administrative data for the index hospitalization only, and thus lacked detailed clinical data such as stage, survival, and receipt of neoadjuvant chemotherapy. Additionally, we were unable to measure disease severity across patients in our cohort, so facilities with the most severely ill patients could have had higher average costs and complications. Furthermore, the analysis was limited to a small number of quality indicators, and our risk-adjusted measures of hospital quality may not have sufficiently accounted for more complex patients at some hospitals. Differences among hospitals in the selected quality measures could be attributed to unmeasured confounders (e.g., specialty of the primary surgeon) and selection bias. Lastly, in analyses of quality, we used 2007–2010 hospital costs as a proxy for 2011–2014 hospital costs. This implicitly assumed hospital costs have remained largely the same over the two periods. Nevertheless, risk-adjusted hospital costs for the two periods were strongly correlated (0.7).

In conclusion, we identified significant variation in standardized costs for ovarian cancer surgery among hospitals, and OR and supply costs were the largest drivers of variation. These findings suggest some opportunities to improve resource utilization in high-cost facilities. In addition, we observed that efforts to decrease reoperations and post-operative complications might have a significant impact on cost reduction. Quality of care initiatives could be used to target care deficiencies in lower-performing facilities to improve the efficiency of care and ultimately potentially decrease costs. Finally, a better understanding of the source of the increasing OR costs could provide an effective target to try to contain the cost of care in this population.

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Disclosure of interests

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Author contribution

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