# Surgeon and Hospital Level Variation in the Costs of Robot-Assisted Radical Prostatectomy

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**Abbreviations and Acronyms**

CCI = Charlson comorbidity index

MVA = multivariate analysis

PCa = prostate cancer

RARP = robot-assisted radical prostatectomy

RP = radical prostatectomy

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**Purpose:** We assessed surgeon and hospital level variation in robot-assisted radical prostatectomy costs and predictors of high and low cost surgery.

**Materials and Methods:** The study population consisted of a weighted sample of 291,015 men who underwent robot-assisted radical prostatectomy for prostate cancer by 667 surgeons at 197 U.S. hospitals from 2003 to 2013. We evaluated 90-day direct hospital costs (2014 USD) in the Premier Hospital Database. High costs per robot-assisted radical prostatectomy were those above the 90th percentile and low costs were those below the 10th percentile.

**Results:** Mean hospital cost per robot-assisted radical prostatectomy was $11,878 (95% CI $11,804–$11,952). Mean cost was $2,837 (95% CI $2,805–$2,869) in the low cost group vs $25,906 (95% CI $24,702–$25,490) in the high cost group. Nearly a third of the variation in robot-assisted radical prostatectomy cost was attributable to hospital characteristics and more than a fifth was attributable to surgeon characteristics (R-squared 30.43% and 21.25%, respectively). High volume surgeons and hospitals (90th percentile or greater) had decreased odds of high cost surgery (surgeons: OR 0.24, 95% CI 0.11–0.54; hospitals: OR 0.105, 95% CI 0.02–0.46). The performance of robot-assisted radical prostatectomy at a high volume hospital was associated with increased odds of low cost robot-assisted radical prostatectomy (OR 839, 95% CI 122–greater than 999).

**Conclusions:** This study provides insight into the role of surgeons and hospitals in robot-assisted radical prostatectomy costs. Given the substantial variability, identifying and remedying the root cause of outlier costs may yield substantial benefits.

**Key Words:** prostatic neoplasms, prostatectomy, robotic surgical procedures, health care costs, health services

It is acknowledged that health care costs in the United States are unsustainable. Mean costs have increased from just above $1,000 per capita in 1980 to nearly $8,000 in 2009.[1] Prostate cancer is a common and costly disease with expensive and high-tech treatment modalities,[2–4] and substantial variation in management.[5] Total costs were $11.85



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billion in 2010 and are expected to reach $19 billion by 2020.[6] One driver of costs is radical prostatectomy. Recently there has been increased adoption of RARP, a costlier but now predominant approach.

Prior studies have compared costs, demonstrating that the cost of RARP is higher than open RP but lower than certain other modalities such as intensity modulated radiation therapy.[7,8] There is also considerable geographic variation and volume related cost variation in RP.[5,9] Less well studied is individual surgeon variation in costs, especially in the era of robotic surgery. Specifically, given access to the same basic equipment and a fairly standardized technique, how much do surgeons vary in their average costs of RARP?

Given data showing that variations in costs do not generally correlate with better outcomes in PCa care,[10,11] there is strong motivation to account for cost discrepancies. In an effort to identify lost value, we designed a study to assess surgeon level variation using a nationally representative data set. We chose to limit our analysis to RARP as that is the most commonly performed approach in the U.S.[12–14] At the same time, overall fixed and variable costs of RARP are high. We hypothesized that there would be variation in costs of performing RARP between individual surgeons and hospitals, and that high volume surgeons and hospitals would be less likely to incur high cost RARP.

## MATERIALS AND METHODS

### Data Source

We analyzed data from the Premier Hospital Database (Premier, Inc., Charlotte, North Carolina), a nationally representative all-payer data set capturing more than 45 million hospital inpatient discharges, representing 20% of all hospitalizations at more than 600 hospitals in the United States. Premier's database contains comprehensive data on all billed items, date-stamped medications, and laboratory, diagnostic and therapeutic services.[7] Premier's data have been validated and used in previous landmark studies.[15–17] We received institutional review board exemption for this study.

Hospital specific projection weights are applied to each discharge to project the sample to a national estimate of inpatient discharges. The projection methodology was developed by Premier and validated by the Food and Drug Administration in 2001. It is based on a stratified comparison of Premier's inpatient database to all U.S. hospitals responding to the American Hospital Association Annual Survey and validated through a comparison to projections using the National Hospital Discharge Survey. Numbers reported in this study are projected estimates.

### Study Population

Using ICD-9 codes we extracted data for all men diagnosed with PCa (185) discharged after RP (60.5) between January 1, 2003 and December 31, 2013. We excluded men with metastatic disease (196.x, 197.x, 198.x) and other malignancies (140.x to 209.79). Of those remaining, the patients with a code for robotic assistance (ICD-9 17.42 or 17.44 introduced in October 2008, Healthcare Common Procedure Coding System CPT code S2900 introduced in July 2005) or a recorded charge code for robotic instrumentation were classified as RARP. This methodology is more accurate and reliable than relying on ICD-9 codes alone.[18,19]

In our weighted cohort of 323,411 men we identified 1,638 surgeons who performed the surgery at 262 unique hospitals. As our goal was to define the scale of cost variation, we excluded surgeons whose surgical volume was less than 10 procedures annually as we believed that very low volume surgeons might artificially increase variability in mean costs simply as a result of much smaller denominators. This resulted in a final cohort of 667 unique surgeons performing RARP in 291,015 men at 197 hospitals across the United States. While only 40% of surgeons performed RARP, they performed 90% of all RARP in the United States.

### Outcomes

Our main outcome of interest was 90-day direct hospital costs. These included the cost of the robotic procedure and associated inpatient costs up to 90 days after the procedure but not acquisition or maintenance of the surgical robot. Costs include variable direct costs and fixed (overhead) costs. All costs were adjusted to 2014 U.S. dollars using the medical component of the Consumer Price Index. Payments to hospitals and hospital charges were not assessed.

### Study Variables

Patient characteristics included age, race, marital status, insurance and CCI. Hospital characteristics included teaching status (teaching vs nonteaching), hospital size (less than 400, 400 to 600, more than 600 beds), location (urban vs rural), geographical region (Midwest, Northeast, West, South) and prostatectomy volume. We defined high volume prostatectomy hospitals as greater than the 90th percentile for volume (more than 760 robot-assisted radical prostatectomies per year). Surgeon characteristics included surgical volume. We defined high surgeon volume as greater than the 90th percentile (more than 386 robot-assisted radical prostatectomies per year). Sensitivity analysis using a cutoff of 75% was also performed. Volume was defined for the year of surgery in question.

### Statistical Analyses

We identified the scale of variation in nonadjusted direct hospital costs for all attending surgeons who performed at least 10 robot-assisted radical prostatectomies annually. We generated a ranked list of the 667 surgeons in our cohort ordered by total direct hospital costs for 90 days following all RARP. To calculate each surgeon's mean cost per RARP we divided the sum of 90-day direct hospital costs by the total number of robot-assisted radical prostatectomies performed during the study period. This yielded a mean total cost per RARP for that surgeon. Standard deviations were used to generate 95% CIs. We then plotted costs along with 95% CI ranked from least to