Robotic prostatectomy is associated with increased patient travel and treatment delay

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Abstract

Introduction: New technologies may limit access to treatment. We investigated radical prostatectomy (RP) access over time since robotic introduction and the impact of robotic use on RP access relative to other approaches in the modern era.
Methods: Using the National Cancer Data Base, RPs performed during the eras of early (2004–2005) and late (2010–2011) robotic dissemination were identified. The primary endpoints, patient travel distance and treatment delay, were compared by era, and for 2010–2011, by surgical approach. Analyses included multivariable and multinomial logistic regression.
Results: 138 476 cases were identified, 32% from 2004–2005 and 68% from 2010–2011. In 2010–2011, 74%, 21%, and 4.3% of RPs were robotic, open, and laparoscopic, respectively. Treatment in 2010–2011 and robotic approach were independently associated with increased patient travel distance and longer treatment delay (p<0.001). Men treated robotically had 1.1–1.2 times higher odds of traveling medium-to-long-range distances and 1.2–1.3 higher odds of delays 90 days or greater compared to those treated open (p<0.001). Laparoscopic approach was associated with increased patient travel and treatment delay, but to a lesser extent than the robotic approach (p<0.001). In high-risk patients, treatment delays remained significantly longer for minimally invasive approaches (p<0.001). Other factors associated with the robotic approach included referral from an outside facility, treatment at an academic or high-volume hospital, higher income, and private insurance. Potential limitations include the retrospective observational design and lack of external validation of the primary outcomes.
Conclusions: The robotic approach is associated with increased travel burden and treatment delay, potentially limiting access to surgical care.

Introduction

Over the last 10 years, robotic-assisted radical prostatectomy (RARP) has become the most widely used surgical approach for prostate cancer (PCa) in the U.S.[1,2] Rapid adoption of robotic technology has caused increased RP use and centralization at high-volume centres.[3-5] These practice patterns have raised concerns about RP overuse on a population level and decreased access to care on a local-regional level. During early robotic dissemination, RARP was associated with sociodemographic disparities and increased patient travel distances.[6-8] In the modern era of widespread use, the influence of RARP on access to care has not been investigated.[2] We examine how RP access has changed over time since robotic introduction and how robotic use has impacted access relative to other approaches in modern times.

Methods

National Cancer Data Base (NCDB)

The NCDB is a joint project of the American Cancer Society and the Commission on Cancer (CoC) of the American College of Surgeons. It is a nationwide, hospital-based cancer registry that includes data from over 1500 CoC-accredited hospitals, effectively capturing 70% of cancers in the U.S.

Study population

After institutional review board approval, we identified patients with clinically localized PCa who underwent RP from 2004–2005 and 2010–2011, excluding patients managed initially with watchful waiting or active surveillance (AS). We selected these time periods to capture early robotic adoption (2004–2005) and widespread use (2010–2011) and to minimize the impact of AS on treatment delay.

In 2004–2005, RARP accounted for <10% of RPs.[7,8] In 2010–2011, <10% of eligible men underwent AS.[9] A surgical approach identifier, first coded in 2010, was used to differentiate open radical prostatectomy (ORP), laparoscopic radical prostatectomy (LRP), and RARP. Cases missing data on the timing of treatment (~5% of cases per year) were excluded (n=7667). Cases missing data on patient travel distance (~3% of cases per year) were excluded (n=4734). For the high-risk PCa subgroup analysis, cases with unknown approach were excluded (n=1400).

Study variables

Demographic factors included race/ethnicity (White or non-White), income level, insurance type (uninsured, social, and private), and county. Annual income quartiles were categorized as low (<$30 000), low-middle ($30 000–$35 000), middle ($35 000–$46 000), and upper-middle (>$46 000) based on 2000 U.S. census data. County was categorized as urban, metropolitan, or rural based on 2003 U.S. Department of Agriculture Research Service data.

Clinical factors included age (in years), Charlson comorbidity index (CCI), and D'Amico risk group. CCI was categorized as 0 (no comorbidities), 1, or >1. D'Amico risk groups were categorized as low (cT1/T2a, prostate-specific antigen [PSA] ≤10 ng/ml, and Gleason score ≤6), intermediate (T2b, and/or PSA 10–20 ng/mL, and/or Gleason score 7), and high (≥T2c, PSA >20 ng/mL, or Gleason score 8–10). A combined age-CCI variable (age <70 and CCI 0, 1, or >1; age >70 and CCI 0, 1, or >1) was created to account for collinearity.

Provider factors included hospital type, surgical volume, region, and referral status. Using CoC classifications, hospitals were categorized as academic, comprehensive community, and other. Hospitals were grouped into tertiles based on total RP volume (<164, 164–402, and >402). Regions included the Northeast, Midwest, South, and West.[10] Referral status (no or yes) indicated referral from another hospital for treatment.

Study endpoints

The primary endpoints were patient travel distance to the treating hospital and treatment delay. Travel distance was estimated using the great-circle distance, an established proxy for travel time, and classified by tertiles: short (<8.2 miles), medium (8.2–25 miles), and long (>25 miles). Treatment delay was categorized as <90, 90–180, or >180 days.

Statistical analyses

RPs in 2010–2011 were compared to RPs in 2004–2005, adjusting for age, CCI, race, income, insurance, county, risk group, hospital type, surgical volume, region, and referral status. For 2010–2011, surgical approaches (RARP vs. LRP vs. ORP) were compared to one another, adjusting for the same covariates. This analysis was repeated in the subgroup of men with high-risk PCa. The Chi-squared, Wilcoxon-Mann-Whitney, and Kruskal-Wallis tests were used for univariate analyses. Multivariable and multinomial logistic regression analyses were used to adjust for covariates. Statistical tests were performed using SAS® University Edition (SAS Institute Inc., Cary, NC, U.S.). P values <0.05 were considered statistically significant.

Results

The final cohort included 138 476 men with predominantly low- and intermediate-risk PCa, including 42 702 (31%) treated in 2004–2005 and 95 774 (69%) treated in 2010–2011. Most men were middle-aged, White, healthy, privately insured, upper-middle-income metropolitans. Median travel distance was 13.1 (interquartile range [IQR] 5.6–35.6) miles, and median treatment delay was two (IQR 1.2–2.9) months.

On univariate analysis (Table 1), patient travel distance and treatment delay differed significantly between the treatment periods (p<0.001). On multivariable analysis (Table 2), travel distance and treatment delay remained significant predictors of prostatectomy in 2010–2011 vs. 2004–2005. The odds of travelling medium or long distances were 1.2 and 1.1 times higher, respectively, for men treated in 2010–2011 (OR 1.17, 95% CI 1.13–1.20; OR 1.13, 95% CI 1.09–1.18; p<0.001). The odds of treatment delay 90–180 days or greater were 1.3 and 1.4 times higher, respectively, for men treated in 2010–2011 (OR 1.30, 95% CI 1.25–1.34; OR 1.35, 95% CI 1.26–1.45; p<0.001). Furthermore, the use of RP was up to 1.2–1.5-fold higher at high-volume, non-community hospitals in 2010–2011 compared to 2004–2005 (p<0.001).

Other factors independently associated with RP in 2010–2011 vs. 2004–2005 were age, CCI, race, insurance, and D'Amico risk group (Table 2). Specifically, RP was more common among older, comorbid, non-White, and socially insured men in 2010–2011 (p<0.001). Patients treated with RP in 2010–2011 also were more likely to have high-risk PCa (OR 1.06, 95% CI 1.03–1.10; p<0.001).

In 2010–2011, 70 096/94 374 (74.3%) men underwent RARP, 20 159/94 374 (21.4%) underwent ORP, and (4119/94 374) 4.4% underwent LRP. On univariate and multivariable analyses (Tables 3 and 4), patient travel distance and treatment delay differed significantly by approach. Compared to ORP, the odds of travelling medium-to-long distances were 1.1–1.2 times higher for RARP (medium vs. short distances, OR 1.11, 95% CI 1.06–1.16; long vs. short distances, OR 1.15, 95% CI 1.09–1.22; p<0.001) and 1.2

Table 1. Characteristics of men who underwent radical prostatectomy in the eras before (2004–2005) and after (2010–2011) widespread robotic adoption

	Total (N=138 476)		RP, 2004–2005 (n=42 702)		RP, 2010–2011 (n=95 774)		*p* value
Variables							
Age (years)							<0.001
Median (IQR)	61 (56–66)		61 (56–66)		61 (56–66)		
Mean (SD)	60.9 (7.1)		60.4 (7.2)		61.0 (7.1)		
	n	%	n	%	n	%	
Charlson score							<0.001
0	116 049	83.8	36 946	86.5	79 103	82.6	
1	19 973	14.4	5148	12.1	14 825	15.5	
>1	2454	1.8	608	1.4	1846	1.9	
Race							<0.001
White	111 284	80.4	34 657	81.2	76 627	80.0	
Non-White	23 035	16.6	6509	15.2	16 526	17.3	
Unknown	4157	3.0	1536	3.6	2621	2.7	
Income level							<0.001
Low	14 391	10.4	4322	10.1	10 069	10.5	
Low-middle	21 464	15.5	6485	15.2	14 979	15.6	
Middle	36 428	26.3	11 083	26.0	25 345	26.5	
Upper-middle	64 065	46.3	20 139	47.2	43 926	45.9	
Unknown	2128	1.5	673	1.6	1455	1.5	
Insurance							<0.001
Private	89 171	64.4	28 258	66.2	60 913	63.6	
Federal/social	44 976	32.5	12 657	29.6	32 319	33.7	
Uninsured	2074	1.5	565	1.3	1509	1.6	
Unknown	2255	1.6	1222	2.9	1033	1.1	
County							
Urban	21 260	15.4	6231	14.6	15 029	15.7	<0.001
Metropolitan	111 105	80.2	34 545	80.9	76 560	79.9	
Rural	3269	2.4	975	2.3	2294	2.4	
Unknown	2842	2.1	951	2.2	1891	2.0	
D'Amico risk group							<0.001
Low	44 813	32.4	14 518	34.0	30 295	31.6	
Intermediate	43 356	31.3	14 110	33.0	29 246	30.5	
High	32 623	23.6	10 113	23.7	22 510	23.5	
Unknown	17 684	12.8	3961	9.3	13 723	14.3	

IQR: interquartile range; RP: radical prostatectomy SD: standard deviation.

times higher for LRP (medium vs. short distances, OR 1.15, 95% CI 1.04–1.26; p<0.001). Treatment delays 90 days and longer were 1.2–1.3-fold higher for RARP (90–180 vs. <90 days, OR 1.28, 95% CI 1.22–1.34; >180 vs. <90 days, OR 1.17, 95% CI 1.06–1.29; p<0.001) and 1.2-fold higher for LRP (90–180 vs. <90 days, OR 1.16, 95% CI 1.06–1.26; p<0.001).

LRP and RARP were 13–27% less likely to be used to treat high-risk PCa on multivariable analysis (p<0.001). In order to further characterize the effect of risk group on treatment delay, we performed a subgroup analysis of high-risk PCa stratified by approach (Supplementary Table 1). In high-risk PCa, treatment delays remained significantly longer for LRP and RARP (p<0.001). High-risk PCa treated with LRP or RARP had 1.2-fold and 1.3-fold higher odds, respectively, of treatment delay 90–180 days compared to ORP (p<0.001). High-risk PCa managed with LRP or RARP also had 1.5-fold higher odds of being referred for treatment and 1.8–2.5-fold higher odds of treatment at a high-volume centre (p<0.001). Treatment delay >180 days and travel burden did not differ significantly by approach for high-risk disease.

Other factors independently associated with RP approach for all-risk PCa were referral status, income, hospital type, surgical volume, county, and region. Patients treated with RARP or LRP were 1.2 times and 1.5 times more likely to be referred from an outside facility for treatment than those

Table 1 (cont'd). Characteristics of men who underwent radical prostatectomy in the eras before (2004–2005) and after (2010–2011) widespread robotic adoption

	Total (N=138 476)		RP, 2004–2005 (n=42 702)		RP, 2010–2011 (n=95 774)		*p* value
Variables	**n**	**%**	**n**	**%**	**n**	**%**	
Hospital type							<0.001
Academic	59 094	42.7	18 193	42.6	40 901	42.7	
Comprehensive	70 814	51.1	21 061	49.3	49 753	51.9	
Community	7739	5.6	2982	7.0	4757	5.0	
Other	829	0.6	466	1.1	363	0.4	
Surgical volume							<0.001
Low	46 157	33.3	15 427	36.1	30 730	32.1	
Intermediate	46 300	33.4	12 932	30.3	33 368	34.8	
High	46 019	33.2	14 343	33.6	31 676	33.1	
Hospital region							<0.001
Northeast	28 682	20.7	9357	21.9	19 325	20.2	
Midwest	37 387	27.0	10 013	23.4	27 374	28.6	
South	47 905	34.6	14 725	34.5	33 180	34.6	
West	24 502	17.7	8607	20.2	15 895	16.6	
Referred for treatment							0.015
No	72 572	52.4	22 587	52.9	49 985	52.2	
Yes	65 904	47.6	20 115	47.1	45 789	47.8	
Distance travelled							<0.001
Short	46 377	33.5	15 188	35.6	31 189	32.6	
Medium	45 961	33.2	13 624	31.9	32 337	33.8	
Long	46 138	33.3	13 890	32.5	32 248	33.7	
Treatment delay							<0.001
<90 days	102 587	74.1	33 009	77.3	69 578	72.6	
90–180 days	30 677	22.2	8293	19.4	22 384	23.4	
>180 days	5212	3.8	1400	3.3	3812	4.0	

IQR: interquartile range; RP: radical prostatectomy SD: standard deviation.

treated with ORP (p<0.001). The odds of undergoing LRP or RARP vs. ORP were significantly higher for men within the highest income bracket and insured men (p<0.001). Both LRP and RARP were more common at academic and higher-volume hospitals (p<0.001).

Discussion

In order to assess the impact of widespread robotic adoption on practice patterns over time, we compared RPs performed in 2010–2011, when RARP accounted for the majority of cases, to those performed in 2004–2005, when RARP accounted for less than 10% of cases.[2,7,11] Consistent with the literature, RPs occurred increasingly at academic and high-volume hospitals over time.[4,6] This trend has been attributed to the ongoing centralization of complex cancer surgery at high-volume centres and to further technology-driven centralization at centres invested in robotic technology.[4-6,12,13]

While robot-driven centralization may improve the quality of surgical care overall, it also may pose a significant barrier to care for those without access to robotic centres. In a study of RP practice patterns in three Northeastern states from 2000–2009, Stitzenberg et al observed a link between RP centralization and longer patient travel distances.[6] Nationally, we observed significantly increased travel distances and treatment delays for men treated in 2010–2011 vs. 2004–2005. Since perioperative transportation costs have been shown to disproportionately impact low-income patients, we suspected that socioeconomic factors also might affect access to care.[14] Surprisingly, we did not detect a significant difference in RP use over time by income level. In fact, in 2010–2011, RP use was significantly more common among traditionally underserved groups, including non-White minorities, Medicare beneficiaries, uninsured men, and urbanites.[15] Likewise, the treatment of older, comorbid, and high-risk men was significantly higher in 2010–2011. These findings, while somewhat counterintuitive, may be explained by increased RP volume over time, which increased by 124% between 2004–2005 and 2010–2011 in our study, and by increased interest in the surgical treatment of high-risk PC.[3,16] Increased RP volume appears to have improved access to care for underserved men despite greater travel burden and longer treatment delays.

Table 2. Multivariable logistic regression analysis of predictors of radical prostatectomy by diagnosis year with 2004-2005 as the reference group

	2010–2011 vs. 2004–2005		
Variables	**OR**	**95% CI**	***p* value**
Age	1.01	1.01–1.01	**<0.001**
Charlson score			**<0.001**
0	1.00	(referent)	
1	1.27	1.22–1.32	
>1	1.27	1.15–1.41	
Race			**<0.001**
White	1.00	(referent)	
Non-White	1.22	1.18–1.27	
Income level			0.231
Low	1.00	(referent)	
Low-middle	1.01	0.95–1.06	
Middle	0.99	0.94–1.04	
Upper-middle	0.97	0.92–1.02	
Insurance			**<0.001**
Private	1.00	(referent)	
Federal/social	1.07	1.03–1.11	
Uninsured	1.19	1.06–1.33	
County			**<0.001**
Urban	1.00	(referent)	
Metropolitan	0.93	0.89–0.97	
Rural	0.91	0.83–1.00	
D'Amico risk group			**<0.001**
Low	1.00	(referent)	
Intermediate	0.96	0.93–0.99	
High	1.06	1.02–1.09	

CI: confidence interval; OR: odds ratio.

Table 2 (cont'd). Multivariable logistic regression analysis of predictors of radical prostatectomy by diagnosis year with 2004-2005 as the reference group

	2010–2011 vs. 2004–2005		
Variables	**OR**	**95% CI**	***p* value**
Hospital type			**<0.001**
Academic	1.00	(referent)	
Comprehensive	1.07	1.04–1.10	
Community	0.70	0.66–0.75	
Other	0.29	0.24–0.34	
Surgical volume			**<0.001**
Low	1.00	(referent)	
Intermediate	1.20	1.16–1.24	
High	1.16	1.11–1.20	
Hospital region			**<0.001**
Northeast	1.00	(referent)	
Midwest	1.41	1.35–1.46	
South	0.99	0.95–1.03	
West	0.83	0.80-0.87	
Referred for treatment			0.362
No	1.00	(referent)	
Yes	0.99	0.96–1.02	
Distance travelled			**<0.001**
Short	1.00	(referent)	
Medium	1.18	1.14–1.22	
Long	1.17	1.13–1.22	
Treatment delay			**<0.001**
<90 days		(referent)	
90–180 days	1.30	1.26–1.34	
>180 days	1.35	1.26–1.45	

CI: confidence interval; OR: odds ratio.

To further explore the impact of robotic use on access to care, we investigated RP practice patterns in 2010–2011 stratified by approach. In contrast to prior studies, which used hospital robot ownership as a proxy for robotic use, our study demonstrates the impact of actual robotic use on access to care.[4,6]

By 2010–2011, RARP accounted for 74% of RPs in the U.S., which is consistent with previously reported estimates.[2,5,17,18] LRP and RARP were more likely at academic and high-volume centres compared to ORP, likely due to centralization, which has occurred to a much greater extent for RARP and LRP than ORP.[5] This may explain why LRP and RARP were associated with increased patient travel and why RARP was less likely among rural dwellers. LRP and RARP also were performed less commonly in poor and socially insured men, possibly due to increased perioperative travel burden, which disproportionately limits access to care for the poor.[14] Altogether, these practice patterns suggest that technology-driven centralization may be limiting treatment access and reinforcing healthcare disparities.[4,8,19]

Patients managed with LRP or RARP in 2010–2011 were significantly more likely to experience treatment delays compared to patients who underwent ORP. We considered that delays may have been influenced by increasing use of, or at least, increasing time spent on the consideration of AS in men with low-risk PCa. However, based on prior research, we know that only 7.4% of men with D'Amico low-risk PCa were managed with AS in 2010–2011, and these patients were excluded from our study.[9] Moreover, to further adjust for AS as a confounder, we performed a subgroup analysis of men with high-risk PCa. Even men with high-risk PCa managed by LRP or RARP were more likely to have their surgeries delayed compared to ORP. Increased referral, which occurred preferentially among men undergoing minimally invasive RP, is one possible explanation for these delays. Although it is very unlikely that treatment delays compromise cancer control for low-risk PCa, for higher-risk disease, delays may have an unfavourable impact on oncologic outcomes.[20-22] Although the quality of the evidence on the association between treatment delay and oncologic outcomes is weak, treatment delay ideally should not exceed 90 days for men with intermediate- or high-risk disease.[23]

This study has some limitations. Due to its retrospective observational design, this study is susceptible to biases.

Table 3. Characteristics of men who underwent radical prostatectomy in 2010–2011 stratified by approach

	ORP (n=20 159)		LRP (n=4119)		RARP (n=70 096)		*p* value
Variables							
Age (years)							**<0.001**
Median (IQR)	62 (57–67)		61 (56–66)		61 (56–66)		
Mean (SD)	61.4 (7.2)		61.0 (7.2)		60.9 (7.1)		
	n	%	n	%	n	%	
Charlson score							**<0.001**
0	16 487	81.8	3392	82.4	57 978	82.7	
1	3205	15.9	647	15.7	10 842	15.5	
>1	467	2.3	80	1.9	1276	1.8	
Race							**<0.001**
White	15 911	78.9	3246	78.8	56 325	80.4	
Non-White	3833	19.0	761	18.5	11 702	16.7	
Unknown	415	2.1	112	2.7	2069	3.0	
Income level							**<0.001**
Low	2502	12.4	435	10.6	6971	9.9	
Low-middle	3606	17.9	630	15.3	10 499	15.0	
Middle	5801	28.8	1075	26.1	18 074	25.8	
Upper-middle	7905	39.2	1913	46.4	33 535	47.8	
Unknown	345	1.7	66	1.6	1017	1.5	
Insurance							**<0.001**
Private	12 069	59.9	2592	62.9	45 400	64.8	
Federal/social	7279	36.1	1424	34.6	23 130	33.0	
Uninsured	554	2.7	57	1.4	865	1.2	
Unknown	257	1.3	46	1.1	701	1.0	
County							
Urban	3603	17.9	627	15.2	10 537	15.0	**<0.001**
Metropolitan	15 571	77.2	3340	81.1	56 584	80.7	
Rural	614	3.0	88	2.1	1563	2.2	
Unknown	371	1.8	64	1.6	1412	2.0	
D'Amico risk group							**<0.001**
Low	5492	27.2	1239	30.1	23 324	33.3	
Intermediate	5406	26.8	1260	30.6	22 201	31.7	
High	5575	27.7	982	23.8	15 416	22.0	
Unknown	3686	18.3	638	15.5	9155	13.1	
Hospital type							<0.001
Academic	7657	38.0	2208	53.6	30 625	43.7	
Comprehensive	10 016	49.7	1726	41.9	37 225	53.1	
Community	2301	11.4	154	3.7	2102	3.0	
Other	185	0.9	31	0.8	144	0.2	
Surgical volume							<0.001
Low	9993	49.6	1263	30.7	18 655	26.6	
Intermediate	5581	27.7	1291	31.3	26 063	37.2	
High	4585	22.7	1565	38.0	25 378	36.2	

IQR: interquartile range; LRP: laparoscopic radical prostatectomy; ORP: open radical prostatectomy; RARP: robotic-assisted radical prostatectomy; SD: standard deviation.

Table 3 (cont'd). Characteristics of men who underwent radical prostatectomy in 2010–2011 stratified by approach

	ORP (n=20 159)		LRP (n=4119)		RARP (n=70 096)		*p* value
Variables	**n**	**%**	**n**	**%**	**n**	**%**	
Hospital region							<0.001
Northeast	3775	18.7	998	24.2	14 291	20.4	
Midwest	5656	28.1	870	21.1	20 436	29.2	
South	7119	35.3	1821	44.2	23 820	34.0	
West	3609	17.9	430	10.4	11 549	16.5	
Referred for treatment							0.015
No	12 149	60.3	1846	44.8	35 305	50.4	
Yes	8010	39.7	2273	55.2	34 791	49.6	
Distance travelled							<0.001
Short	7601	37.7	1245	30.2	21 765	31.1	
Medium	6544	32.5	1441	35.0	23 830	34.0	
Long	6014	29.8	1433	34.8	24 501	35.0	
Treatment delay							<0.001
<90 days	15 749	78.1	2978	72.3	49 817	71.1	
90–180 days	3717	18.4	976	23.7	17 381	24.8	
>180 days	693	3.4	165	4.0	2898	4.1	

IQR: interquartile range; LRP: laparoscopic radical prostatectomy; ORP: open radical prostatectomy; RARP: robotic-assisted radical prostatectomy; SD: standard deviation.

Table 4. Multinomial logistic regression analysis of predictors of radical prostatectomy stratified by approach with ORP as the reference group

	LRP vs. ORP		RARP vs. ORP		
Variables	**OR**	**95% CI**	**OR**	**95% CI**	***p* value**
Age	1.00	0.99–1.00	1.00	1.00–1.00	0.283
Charlson score					0.233
0	1.00	(referent)	1.00	(referent)	
1	0.99	0.89–1.10	1.00	0.95–1.05	
>1	0.97	0.74–1.26	0.86	0.76–0.98	
Race					0.794
White	1.00	(referent)	1.00	(referent)	
Non-White	0.97	0.88–1.08	1.01	0.96–1.06	
Income level					<0.001
Low	1.00	(referent)	1.00	(referent)	
Low-middle	0.93	0.80–1.09	0.94	0.87–1.01	
Middle	1.06	0.92–1.22	0.96	0.90–1.03	
Upper-middle	1.20	1.04–1.38	1.18	1.10–1.27	
Insurance					<0.001
Private	1.00	(referent)	1.00	(referent)	
Federal/social	1.10	1.00–1.21	0.98	0.93–1.02	
Uninsured	0.50	0.36–0.70	0.52	0.46–0.60	
Country					<0.001
Urban	1.00	(referent)	1.00	(referent)	
Metropolitan	1.04	0.91–1.18	1.13	1.06–1.20	
Rural	0.86	0.65–1.14	0.86	0.77–0.97	
D'Amico risk group					<0.001
Low	1.00	(referent)	1.00	(referent)	
Intermediate	1.04	0.95–1.14	0.98	0.94–1.03	
High	0.87	0.79–0.96	0.73	0.70–0.76	

CI: confidence interval; LRP: laparoscopic radical prostatectomy; OR: odds ratio; ORP: open radical prostatectomy; RARP: robotic-assisted radical prostatectomy.

Table 4 (cont'd). Multinomial logistic regression analysis of predictors of radical prostatectomy stratified by approach with ORP as the reference group

	LRP vs. ORP		RARP vs. ORP		
Variables	**OR**	**95% CI**	**OR**	**95% CI**	***p* value**
Hospital type					<0.001
Academic	1.00	(referent)	1.00	(referent)	
Comprehensive	0.81	0.74–0.89	1.46	1.40–1.53	
Community	0.38	0.31–0.48	0.56	0.52–0.61	
Other	1.25	0.80–1.94	0.43	0.33–0.57	
Surgical volume					<0.001
Low	1.00	(referent)	1.00	(referent)	
Intermediate	1.45	1.31–1.61	2.14	2.05–2.24	
High	1.78	1.59-1.98	2.36	2.24–2.49	
Hospital region					<0.001
Northeast	1.00	(referent)	1.00	(referent)	
Midwest	0.68	0.60–0.76	0.92	0.87–0.97	
South	1.20	1.08–1.33	0.85	0.81–0.90	
West	0.49	0.43–0.57	0.75	0.71–0.80	
Referred for treatment					<0.001
No	1.00	(referent)	1.00	(referent)	
Yes	1.49	1.36–1.62	1.19	1.14–1.24	
Distance travelled					<0.001
Short	1.00	(referent)	1.00	(referent)	
Medium	1.15	1.04–1.26	1.11	1.06–1.16	
Long	0.98	0.87–1.10	1.15	1.09–1.22	
Treatment delay					<0.001
<90 days	1.00	(referent)	1.00	(referent)	
90–180 days	1.16	1.06–1.28	1.28	1.22–1.34	
>180 days	1.03	0.85–1.26	1.17	1.06–1.29	

CI: confidence interval; LRP: laparoscopic radical prostatectomy; OR: odds ratio; ORP: open radical prostatectomy; RARP: robotic-assisted radical prostatectomy.

Supplementary Table 1. Multinomial logistic regression analysis of predictors of radical prostatectomy for high-risk disease stratified by approach with ORP as the reference group

	LRP vs. ORP		RARP vs. ORP		
Variables	**OR**	**95% CI**	**OR**	**95% CI**	***p* value**
Age	0.994	0.982–1.006	0.990	0.985-0.996	0.003
Charlson score					0.332
0	1.000	(referent)	1.000	(referent)	
1	0.934	0.770–1.132	0.961	0.879–1.050	
>1	1.139	0.740–1.754	0.849	0.688–1.048	
Race					0.651
White	1.000	(referent)	1.000	(referent)	
Non-White	1.068	0.888–1.285	0.986	0.903–1.076	
Income level					<0.001
Low	1.000	(referent)	1.000	(referent)	
Low-middle	1.036	0.786–1.367	1.036	0.915–1.173	
Middle	1.114	0.860–1.444	1.018	0.905–1.145	
Upper-middle	1.289	0.993–1.673	1.321	1.172–1.489	
Insurance					<0.001
Private	1.000	(referent)	1.000	(referent)	
Federal/social	1.006	0.843–1.201	1.009	0.929–1.096	
Uninsured	0.219	0.102–0.472	0.429	0.341–0.540	
Country					0.013
Urban	1.000	(referent)	1.000	(referent)	
Metropolitan	1.045	0.822–1.329	1.114	0.996–1.246	
Rural	0.633	0.354–1.133	0.769	0.618–0.958	
Hospital type					<0.001
Academic	1.000	(referent)	1.000	(referent)	
Comprehensive	0.698	0.593–0.820	1.269	1.174–1.372	
Community	0.326	0.221–0.480	0.528	0.457–0.610	
Other	0.972	0.372–2.537	0.418	0.235–0.742	
Surgical volume					<0.001
Low	1.000	(referent)	1.000	(referent)	
Intermediate	1.450	1.310–1.606	1.947	1.799–2.107	
High	1.776	1.592–1.981	2.543	2.306–2.804	
Hospital region					<0.001
Northeast	1.000	(referent)	1.000	(referent)	
Midwest	0.832	0.670–1.032	1.043	0.941–1.156	
South	1.108	0.906–1.354	0.881	0.796–0.974	
West	0.600	0.461–0.779	0.765	0.681–0.860	
Referred for treatment					<0.001
No	1.000	(referent)	1.000	(referent)	
Yes	1.543	1.326–1.795	1.462	1.362–1.569	
Distance travelled					0.210
Short	1.000	(referent)	1.000	(referent)	
Medium	1.156	0.969–1.378	1.033	0.954–1.119	
Long	1.144	0.920–1.422	1.108	0.999–1.229	
Treatment delay					<0.001
<90 days	1.000	(referent)	1.000	(referent)	
90–180 days	1.225	1.010–1.486	1.336	1.214–1.470	
>180 days	0.594	0.339–1.044	1.039	0.837–1.291	

CI: confidence interval; LRP: laparoscopic radical prostatectomy; OR: odds ratio; ORP: open radical prostatectomy; RARP: robotic-assisted radical prostatectomy.

Second, lack of data on robotic use in 2004–2005 prevented us from directly investigating its effect on RP practice patterns over time. However, to our knowledge, surgical approach data from this period does not exist in any other large registry or population-based database. Third, the outcomes in this study have not been externally validated; therefore, the clinical importance of these findings is unclear.

Conclusion

RARP is associated with increased patient travel and treatment delay, potentially limiting access to care. The clinical significance of these findings remains to be determined.

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