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ORIGINAL REPORT

Cost Implications of the Rapid Adoption of Newer Technologies for Treating Prostate Cancer

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ABSTRACT

Purpose
Intensity-modulated radiation therapy (IMRT) and laparoscopic or robotic minimally invasive radical prostatectomy (MIRP) are costlier alternatives to three-dimensional conformal radiation therapy (3D-CRT) and open radical prostatectomy for treating prostate cancer. We assessed temporal trends in their utilization and their impact on national health care spending.

Methods
Using Surveillance, Epidemiology, and End Results–Medicare linked data, we determined treatment patterns for 45,636 men age ≥ 65 years who received definitive surgery or radiation for localized prostate cancer diagnosed from 2002 to 2005. Costs attributable to prostate cancer care were the difference in Medicare payments in the year after versus the year before diagnosis.

Results
Patients received surgery (26%), external RT (38%), or brachytherapy with or without RT (36%). Among surgical patients, MIRP utilization increased substantially (1.5% among 2002 diagnoses *v* 28.7% among 2005 diagnoses, $P < .001$). For RT, IMRT utilization increased substantially (28.7% *v* 81.7%; $P < .001$) and for men receiving brachytherapy, supplemental IMRT increased significantly (8.5% *v* 31.1%; $P < .001$). The mean incremental cost of IMRT versus 3D-CRT was $10,986 (in 2008 dollars); of brachytherapy plus IMRT versus brachytherapy plus 3D-CRT was $10,789; of MIRP versus open RP was $293. Extrapolating these figures to the total US population results in excess spending of $282 million for IMRT, $59 million for brachytherapy plus IMRT, and $4 million for MIRP, compared to less costly alternatives for men diagnosed in 2005.

Conclusion
Costlier prostate cancer therapies were rapidly and widely adopted, resulting in additional national spending of more than $350 million among men diagnosed in 2005 and suggesting the need for comparative effectiveness research to weigh their costs against their benefits.

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INTRODUCTION

With approximately 180,000 new diagnoses per year,[1] prostate cancer has been cited as a litmus test for health care spending and reform due to its rising costs of care.[2] Over the past decade, newer and more expensive alternatives have been introduced for the treatment of prostate cancer. For men who choose surgery, minimally invasive radical prostatectomy (MIRP), which includes either laparoscopic or robotic-assisted surgery, is a costlier alternative to the traditional open RP due to the greater cost of disposables, equipment, and increased operating room time during a lengthy learning curve.[3] For men who choose radiation, intensity-modulated radiation therapy (IMRT) is a more expensive alternative to traditional three-dimensional conformal radiation therapy (3D-CRT) due to more intense physics planning and quality assurance time, as well as treatment delivery time and software and hardware costs.[4]

Despite interest from patients and providers in these newer technologies, and belief by advocates that they could improve outcomes, there was only limited comparative effectiveness data when they were introduced, and to date there have been no randomized trials testing their clinical efficacy compared to traditional, less expensive counterparts. The purpose of this study is to characterize the adoption of these more expensive therapies among Medicare beneficiaries and to estimate the excess health

Table 1. Baseline Patient Characteristics Stratified by Primary Curative Modality Chosen

Variable	Brachytherapy		External RT		Surgery		
	No.	%	No.	%	No.	%	*P*
Race							
White	13,247	80.44	13,326	77.14	9,498	79.86	< .001
Black	1,470	8.93	1,716	9.93	910	7.65	
Hispanic	842	5.11	1,058	6.12	904	7.60	
Asian	592	3.59	795	4.60	441	3.71	
Other/unknown	317	1.92	379	2.19	141	1.19	
Age at diagnosis, years							
65-69	5,591	33.95	3,969	22.98	7,435	62.51	< .0001
70-74	5,915	35.92	5,793	33.54	3,589	30.17	
75-79	4,962	30.13	7,512	43.49	870	7.31	
High school education in patient's census region, %							
< 75/unknown	3,453	20.97	3,906	22.61	2,377	19.98	< .0001
75-84	3,546	21.53	4,064	23.53	2,368	19.91	
85-89	3,118	18.93	3,255	18.84	2,213	18.61	
90+	6,351	38.57	6,049	35.02	4,936	41.50	
Median income, $							
< 35,000/unknown	5,244	31.85	6,686	38.70	3,590	30.18	< .0001
35,000-44,000	3,905	23.71	4,017	23.25	2,812	23.64	
45,000-59,000	3,921	23.81	3,634	21.04	2,736	23.00	
≥ 60,000	3,398	20.63	2,937	17.00	2,756	23.17	
Region*							
Northeast	4,936	29.97	4,362	25.25	1,414	11.89	< .0001
South	3,365	20.43	2,733	15.82	1,975	16.61	
Midwest	1,751	10.63	3,202	18.54	1,634	13.74	
West	6,416	38.96	6,977	40.39	6,871	57.77	
SEER registry							
San Francisco	605	3.67	592	3.43	488	4.10	< .0001
Michigan	1,137	6.90	2,029	11.75	916	7.70	
New Mexico/Georgia/Hawaii	1,526	9.27	1,145	6.63	770	6.47	
Iowa	614	3.73	1,173	6.79	718	6.04	
Seattle	1,092	6.63	745	4.31	909	7.64	
Utah	959	5.82	209	1.21	693	5.83	
Connecticut	978	5.94	1,552	8.98	448	3.77	
San Jose	433	2.63	375	2.17	246	2.07	
Los Angele	672	4.08	1,283	7.43	1,275	10.72	
Greater California	2,199	13.35	2,943	17.04	2,742	23.05	
Kentucky	1,178	7.15	1,261	7.30	684	5.75	
Louisiana	1,117	6.78	1,157	6.70	1,039	8.74	
New Jersey	3,958	24.03	2,810	16.27	966	8.12	
Population density							
Metropolitan	15,192	92.25	15,619	90.42	10,896	91.61	< .0001
Nonmetropolitan	1,276	7.75	1,655	9.58	998	8.39	
Marital status							
Not married	3,024	18.36	3,579	20.72	1,792	15.07	< .0001
Married	12,106	73.51	11,959	69.23	9,509	79.95	
Unknown	1,338	8.12	1,736	10.05	593	4.99	
Grade							
Well	224	1.36	224	1.30	158	1.33	< .001
Moderate	11,067	67.20	9,210	53.32	6,451	54.24	
Poorly/undifferentiated	4,849	29.44	7,530	43.59	5,211	43.81	
Unknown	328	1.99	310	1.79	74	0.62	
Clinical stage							
T1	7,880	47.85	7,246	41.95	5,149	43.29	< .001
T2	8,049	48.88	8,905	51.55	6,365	53.51	
T3	267	1.62	603	3.49	174	1.46	
T4	16	0.10	137	0.79	21	0.18	
Unknown	256	1.55	383	2.22	185	1.56	

(continued on following page)

Table 1. Baseline Patient Characteristics Stratified by Primary Curative Modality Chosen (continued)

	Brachytherapy		External RT		Surgery		
Variable	No.	%	No.	%	No.	%	*P*
Charlson score							
0	11,860	72.02	11,516	66.67	9,412	79.13	< .001
1	3,230	19.61	3,765	21.80	1,760	14.80	
2+	1,153	7.00	1,763	10.21	448	3.77	
Unknown	225	1.37	230	1.33	274	2.30	
Total	16,468	36	17,274	38	11,894	26	

NOTE. Education had 24 unknown, income had 26 unknown. For men diagnosed in 2002, well differentiated refers to a Gleason score of 2-4, moderately differentiated is Gleason 5-7, and poorly differentiated is Gleason 8-10, but for men diagnosed from January 1, 2003 onward, poorly differentiated was designated as Gleason 7. Region categorization: northeast: Connecticut and New Jersey; south, Atlanta, rural Georgia, Kentucky, and Louisiana; west: San Francisco, Hawaii, New Mexico, Seattle, Utah, San Jose, Los Angeles, and greater California; and midwest: Detroit and Iowa. Comorbidity is the Klabunde modification of the Charlson Index.[21]
Abbreviation: RT, radiation therapy.

care spending attributable to the increased utilization of these newer modalities.

METHODS

Data Source

Our study was approved by the Brigham and Women's institutional review board and a data-use agreement was in place with the Centers for Medicare and Medicaid Services; patient data were de-identified and the requirement for consent was waived. We used Surveillance, Epidemiology, and End Results (SEER) –Medicare data for analyses, composed of a linkage of population based cancer registry data from 16 SEER areas covering approximately 26% of the US population with Medicare administrative data. The Medicare program provides benefits to 97% of Americans age 65 years or older.[5]

Defining the Study Cohort and Exclusion Criteria

We identified 103,363 men age 65 years or older in the SEER registry with pathologically confirmed prostate cancer from 2002 to 2005, who had no history of other malignancies. We excluded men enrolled in a health maintenance organization or not enrolled in both Medicare Part A and Part B throughout the duration of the study because claims are not reliably submitted for such men. We also excluded men who were missing a date of diagnosis or had metastatic disease. This reduced the cohort to 71,674 men, of which 58,571 men underwent some form of treatment with follow-up through December 31, 2007. The focus of our study was men who underwent surgery or radiation, so we excluded 11,093 men who received primary androgen deprivation therapy and 1,205 who received cryotherapy. We also excluded 619 men who all received proton therapy at a single center because their trends results would not be generalizable. The final study cohort was 45,636 patients.

Determination of Surgery and Radiation Therapies

Treatment type was identified from Medicare inpatient, outpatient, and carrier component files (formerly physician/provider B files) based on the presence of Current Procedural Terminology, Fourth Edition (CPT-4) codes listed in Appendix Table A1 (online only). Brachytherapy and external RT were considered as part of a combination therapy if they were given within 6 months of each other.

Determination of Treatment Cost

To determine the cost of therapy, we summed the total amount paid by Medicare for inpatient, outpatient, and physician services within 12 months of prostate cancer diagnosis.[6] To ensure that we adequately captured the cost of treatment, we included in our cost analysis only men who began treatment within 6 months of the prostate cancer diagnosis. Using each subject as his own control, we subtracted health expenditures accrued in the 12 months before prostate cancer diagnosis, which we considered baseline annual health care costs, from 12-month expenditures after prostate cancer diagnosis.[7] This difference captures the cost of treatment and other services such as preoperative evaluation, imaging, laboratory tests, and treatment of complications within 1 year. The mean cost of each therapy was then tabulated and stratified by the year of diagnosis. All costs were adjusted to 2008 dollars using the 2007 Annual Report of the Boards of Trustees of the Federal Hospital Insurance and Federal Supplementary Medical Insurance Trust Fund Table 5.B.1 HI and SMI Average Per Beneficiary Costs (HI = Part A; SMI = Part B).

Determination of the Excess Direct Medical Spending on More Expensive Therapies at the National Level

To estimate the total amount spent nationwide on more expensive prostate cancer therapies for men of any age, we identified the total number of patients in the US diagnosed with nonmetastatic prostate cancer in 2005 from the SEER limited-use registry treated with surgery, external beam radiation, or brachytherapy plus external beam radiation.[8] We divided these figures by 0.26 to extrapolate national estimates of the number of people receiving each treatment since the SEER registry captures 26% of the US population. We multiplied the number in each treatment category (eg, surgery), by the proportion expected to receive the more expensive therapy to determine the expected number of people receiving the expensive therapy nationwide. The observed rates of utilization found in our cohort were adjusted for demographic differences between the cohort and the US population to develop expected utilization rates applicable to the US population. The number of people receiving each expensive therapy was then multiplied by the mean cost of each therapy to estimate national spending.[9]

Statistical Analyses

Temporal trends in use of the more expensive therapy were examined using the Mantel-Haenszel test for trend. The χ^2 test was used to determine the factors associated with the receipt of the more expensive therapy. A *P* value of lower than .05 was considered statistically significant. We developed directly standardized rates of utilization that would be expected in the general population by weighing each patient in our cohort by the ratio of patients in general population to SEER-Medicare for the strata of demographic characteristics to which each patient belongs.[10] All analyses were performed using SAS version 9.1.3 (SAS Institute Inc, Cary, NC).

RESULTS

Utilization Trends

The characteristics of the study cohort are listed in Table 1, stratified by treatment modality. Of the cohort, 11,894 (26%) received surgery, 17,274 (38%) received external radiation, and 16,468 (36%) received brachytherapy with or without external radiation as their primary therapy (year-by-year analysis in Appendix Table A2, online only). Figures 1A-C demonstrate rapidly increased utilization of the

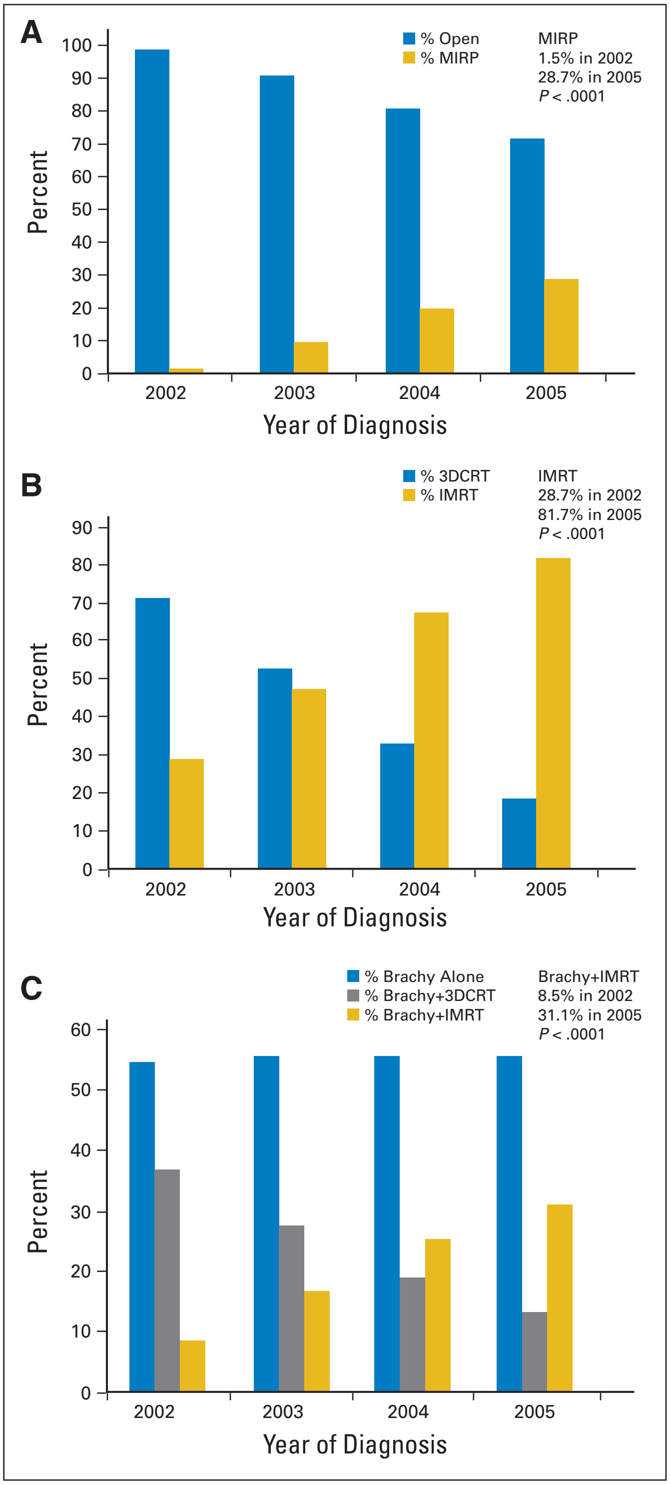

Fig 1. (A) Increasing use of minimally invasive radical prostatectomy (MIRP) among patients receiving surgery. (B) Increasing use of intensity-modulated radiation therapy (IMRT) among patients receiving external radiation. (C) Increasing use of supplemental IMRT among patients receiving brachytherapy (Brachy). 3D-CRT, three-dimensional conformal radiation therapy.

more expensive therapies over the study period. Among men undergoing surgery, MIRP was used by 1.5% of those diagnosed in 2002 versus 28.7% of those diagnosed in 2005 ($P < .001$), while IMRT was used by 28.7% in 2002 versus 81.7% in 2005 ($P < .001$) of those undergoing external radiation, and supplemental IMRT was used for 8.5% in 2002 versus 31.1% in 2005 ($P < .001$) among those receiving brachytherapy. Among just the subgroup of brachytherapy patients receiving supplemental external radiation, supplemental IMRT was used by 18.7% versus 70.2% ($P < .001$). Correspondingly, the use of each of the less expensive therapies (open RP, 3D conformal RT, and brachytherapy plus 3D conformal RT) decreased.

Predictors of Utilization

Table 2 presents a multivariable logistic regression of the factors associated with receiving more expensive therapy. Univariable analysis is listed in Appendix Table A3 (online only). The factors consistently associated with receiving the more expensive therapy regardless of whether they chose surgery or radiation were living in an area with median income ≥ $60,000, living in a metropolitan rather than rural area, having T1c disease, and being of Asian descent (all $P < .05$). The pattern of association with other demographic variables was less consistent. In our cohort of patients older than 65 years, the patients older than 75 years made up only 7% of those receiving MIRP, but were 33% of those receiving brachytherapy plus IMRT and 44% of those receiving IMRT. However, age was not a consistent significant predictor of utilization of more expensive therapies.

Cost of Therapy

Table 3 displays the mean cost of each primary therapy in 2008 dollars stratified by their year of diagnosis. Costs for each treatment declined significantly from 2002 to 2005 (all $P \leq .001$). For example, in constant 2008 dollars, IMRT costs fell by 15% from $37,125 to $31,574, brachytherapy plus IMRT costs fell by 16% from $43,723 to $36,795, and MIRP costs fell by 23% from $21,325 (in 2003 since the 2002 estimates are based on small numbers) to $16,469. Nevertheless, newer, more expensive treatments remained costlier than their less expensive alternatives over the study period. Specifically, among men diagnosed in 2005, the mean cost difference between IMRT and 3D-CRT was $10,986. Similarly, the cost difference between brachytherapy plus IMRT and brachytherapy plus 3D-CRT was $10,789, while the cost difference between MIRP and open RP was only $293. In Appendix Table A4 (online only), costs were alternatively estimated by matching controls from the Medicare 5% noncancer sample as outlined by Brown et al.[6]

Estimate of Excess Direct Medical Spending on Costlier Therapies at the National Level

Compared to the less costly alternative, the nationwide excess direct spending (Table 4) for the rapid adoption of more expensive therapies was $282 million for IMRT, $59 million for brachytherapy plus IMRT, and $4 million for MIRP for men diagnosed in 2005 (assuming that all treatments were reimbursed at Medicare rates).

DISCUSSION

Our study has several important findings. First, we found a rapid and substantial increase in the utilization of MIRP, IMRT, and brachytherapy plus IMRT, which are more expensive alternatives to traditional open RP, 3D-CRT, and brachytherapy plus 3D-CRT, respectively. Men who received the more expensive therapies tended to reside in wealthier areas, and in metropolitan as opposed to rural areas, possibly

Table 2. Multivariable Logistic Analysis of Factors Associated With More Expensive Therapy

Variable	MIRP *v* Open RP			IMRT *v* 3DCRT			Brachy/IMRT *v* Brachy/3DCRT		
	OR	95%CI	*P*	OR	95%CI	*P*	OR	95%CI	*P*
Outcome		MIRP			IMRT			Brachy/IMRT	
Age at diagnosis, years									
65-69	1.09	0.88 to 1.36	.4204	**1.18**	**1.09 to 1.28**	**< .001**	0.96	0.84 to 1.08	.4813
70-74	1.1	0.87 to 1.38	.4312	1.05	0.98 to 1.13	.1522	1.03	0.91 to 1.16	.6409
75+	1.00		ref	1.00		ref	1.00		ref
Comorbidity									
0	1.1	0.82 to 1.48	.5253	**1.14**	**1.03 to 1.26**	**.0135**	0.97	0.81 to 1.17	.7458
1	0.96	0.7 to 1.33	.8258	1.01	0.9 to 1.13	.876	0.99	0.81 to 1.21	.9107
2+	1.00		ref	1.00		ref	1.00		ref
Race									
White/Non-Hispanic	1.00		ref	1.00		ref	1.00		ref
Black/Non-Hispanic	0.91	0.71 to 1.15	.4284	**1.18**	**1.06 to 1.33**	**.0034**	1.17	0.99 to 1.38	.0608
Hispanic	**0.74**	**0.57 to 0.98**	**.0342**	**1.16**	**1 to 1.35**	**.0461**	**1.33**	**1.06 to 1.66**	**.0121**
Asian/Non-Hispanic	**1.51**	**1.18 to 1.93**	**.0011**	**1.49**	**1.27 to 1.76**	**< .001**	**1.43**	**1.11 to 1.86**	**.0062**
Other/unknown	1.03	0.65 to 1.66	.8868	1.21	0.97 to 1.51	.0894	1.27	0.84 to 1.93	.2561
High school education in patient's census region, %									
< 75	1.00		ref	1.00		ref	1.00		ref
75-84.99	0.99	0.8 to 1.22	.9448	**1.24**	**1.12 to 1.38**	**< .001**	1.06	0.9 to 1.25	.4966
85-89.99	**0.79**	**0.62 to 0.99**	**.0402**	**1.3**	**1.16 to 1.46**	**< .001**	**1.25**	**1.04 to 1.51**	**.0176**
90+	**0.74**	**0.58 to 0.93**	**.0111**	**1.52**	**1.35 to 1.73**	**< .001**	1.15	0.95 to 1.4	.1619
Median income, $									
< 35,000	1.00		ref	1.00		ref	1.00		ref
35,000-44,999	**1.49**	**1.24 to 1.79**	**< .001**	1.02	0.93 to 1.12	.6857	0.99	0.85 to 1.15	.8532
45,000-59,999	**1.91**	**1.57 to 2.33**	**< .001**	**1.13**	**1.02 to 1.26**	**.0228**	0.99	0.83 to 1.17	.8912
≥ 60,000	**3.1**	**2.49 to 3.85**	**< .001**	**1.47**	**1.29 to 1.67**	**< .001**	**1.31**	**1.07 to 1.59**	**.0075**
Region									
West	1.00		ref	1.00		ref	1.00		ref
Northeast	0.95	0.8 to 1.12	.5351	1.03	0.95 to 1.12	.4834	**2.17**	**1.91 to 2.47**	**< .001**
South	**0.73**	**0.61 to 0.88**	**.0009**	**0.74**	**0.67 to 0.82**	**< .001**	**1.65**	**1.43 to 1.91**	**< .001**
Midwest	**1.39**	**1.19 to 1.63**	**< .001**	**0.64**	**0.58 to 0.7**	**< .001**	**0.57**	**0.47 to 0.7**	**< .001**
Marital status									
Unmarried	1.00		ref	1.00		ref	1.00		ref
Married	0.99	0.84 to 1.16	.8818	1.04	0.96 to 1.12	.3355	1	0.88 to 1.13	.9599
Unknown	2.37	1.86 to 3.04	< .001	1.17	1.03 to 1.32	.0132	1.92	1.54 to 2.4	< .001
Population density									
Metropolitan	1.00		ref	1.00		ref	1.00		ref
Nonmetropolitan county	**0.75**	**0.58 to 0.97**	**.0307**	**0.76**	**0.67 to 0.85**	**< .001**	**0.52**	**0.41 to 0.66**	**< .001**
Grade/differentiation									
Well	1.00		ref	1.00		ref	1.00		ref
Moderately	1.09	0.62 to 1.93	.7538	1.13	0.86 to 1.49	.3752	0.86	0.5 to 1.46	.5726
Poorly	1.58	0.9 to 2.78	.1149	**1.73**	**1.32 to 2.28**	**< .001**	1.1	0.65 to 1.88	.7175
Unknown/missing	1.26	0.51 to 3.13	.6222	0.96	0.67 to 1.38	.8371	0.73	0.38 to 1.38	.3313
Clinical stage									
T1	1.00		ref	1.00		ref	1.00		ref
T2	**0.61**	**0.54 to 0.68**	**< .001**	**0.71**	**0.66 to 0.76**	**< .001**	**0.63**	**0.57 to 0.7**	**< .001**
T3	**0.53**	**0.33 to 0.86**	**.0104**	**0.67**	**0.57 to 0.8**	**< .001**	**0.71**	**0.53 to 0.94**	**.0169**
T4	0.36	0.08 to 1.62	.1853	**0.45**	**0.32 to 0.65**	**< .001**	0.71	0.23 to 2.23	.5637
Unknown/missing	0.29	0.15 to 0.56	.0002	0.72	0.58 to 0.9	.0038	0.8	0.51 to 1.25	.3183

NOTE. Boldface indicates statistical significance.
Abbreviations: MIRP, minimally invasive radical prostatectomy; Open RP, open radical prostatectomy; IMRT, intensity-modulated radiation therapy; 3DCRT, three-dimensional conformal radiation therapy; Brachy, brachytherapy; ref, referent.

due to the greater availability of newer technologies in these locations or greater marketing efforts directed toward their inhabitants. Of note, Asian race was consistently associated with 1.5-fold odds of receiving a more expensive therapy compared with white race, but the underlying reasons for this could not be determined from this study. Men undergoing the more expensive therapies also tended to have lower stage disease, which may reflect increased screening in more affluent populations, or perhaps a provider bias of offering these therapies to patients who will likely be cured of their prostate cancer and thereby have more time to benefit from any perceived reduction in long-term toxicity.

There are no randomized trials assessing whether newer treatments such as MIRP or IMRT have any clinical benefit over their less-expensive counterparts; the only available data currently come

Table 3. Mean Cost of Each Primary Therapy Among Medicare Enrollees, Stratified by Year of Diagnosis

Year	$ 3DCRT	IMRT	Brachy	Brachy+ 3DCRT	Brachy+ IMRT	Open RP	MIRP
2002	22,384	37,125	21,117	28,770	43,723	18,070	29,988
2003	23,542	37,418	19,476	27,320	43,364	17,423	21,325
2004	22,023	33,237	18,308	26,756	39,453	16,930	17,645
2005	20,588	31,574	17,076	26,006	36,795	16,469	16,762
P trend	< .001	< .001	< .001	< .001	< .001	< .001	.001

Abbreviations: 3DCRT, three-dimensional conformal radiation therapy; IMRT, intensity-modulated radiation therapy; Brachy, brachytherapy; Open RP, open radical prostatectomy; MIRP, minimally invasive radical prostatectomy.

from retrospective studies. For instance, an observational, population-based study comparing outcomes after MIRP versus open RP found that MIRP appeared to be associated with a shorter length of stay (2 *v* 3 days), fewer transfusions (2.7% *v* 20.8%), fewer postoperative respiratory complications (4.3% *v* 6.6%), and fewer anastomotic strictures (5.8% *v* 14.0%). However, MIRP was also associated with an increased risk of genitourinary complications (4.7% *v* 2.1%) and diagnoses of incontinence (15.9 per *v* 12.2 per 100 person-years) and erectile dysfunction (26.8 *v* 19.2 per 100 person-years).[11] For external radiation, retrospective studies seem to consistently suggest that IMRT is associated with a significant reduction in long-term rectal bleeding compared to 3D-CRT. Zelefsky et al demonstrated that men treated to 81 Gy with IMRT versus conformal radiation experienced a significantly lower risk of ≥ grade 2 rectal bleeding, (2% *v* 14%, respectively), and other retrospective series have had similar findings.[12-14]

However, even if there is some underlying clinical benefit to these newer more expensive therapies, it is still important to ask whether the marginal benefit of these therapies is large enough to justify their higher cost.

We found that the rapid shift to more expensive therapies versus less costly counterparts resulted in a national cost burden of more than $350 million among patients diagnosed in 2005. Specifically, Medicare expenditures for IMRT were nearly $11,000 greater per case compared to 3D-CRT and were also nearly $11,000 greater per case for brachytherapy plus IMRT compared to brachytherapy plus 3D-CRT. While the Medicare expenditures for MIRP appeared to be only $236 more per case than for open radical prostatectomy, this surgical amount only approximates the difference in Medicare reimbursed surgeon fees between MIRP and open RP, and does not nearly reflect the full extent of the underlying cost difference between the surgical procedures. For instance, the most widespread form of MIRP presently is

Table 4. Estimates of Additional Direct Costs As a Result of Newer Technologies

MIRP *v* Open RP

Year	Utilization of MIRP From Our Cohort	Weighted Estimated Utilization of MIRP in US	Total No. in SEER Who Underwent Surgery	Estimated Total No. in the US Who Underwent Surgery	Estimated No. of MIRP in the US	Mean Cost Difference Between MIRP and Open RP ($)	Total Cost Savings If All MIRP in US Changed to Open RP ($)
2002	1.49	1.14	15,368	59,108	674	11,918	8,030,720
2003	9.48	7.78	14,760	56,769	4,417	3,902	17,233,683
2004	19.59	18.17	15,360	59,077	10,734	715	7,675,018
2005	28.66	25.17	13,866	53,331	13,423	293	**3,933,060**

IMRT *v* 3D-CRT

Year	Utilization of IMRT From Our Cohort	Weighted Estimated Utilization of IMRT in US	Total No. in SEER Who Underwent RT	Estimated Total No. in the US Who Underwent RT	Estimated No. of IMRT in the US	Mean Cost Difference Between IMRT and 3DCRT ($)	Total Saving Cost If All IMRT in US Changed to 3DCRT ($)
2002	28.65	23.35	10,656	40,985	9,570	14,741	141,071,333
2003	47.20	39.62	10,148	39,031	15,464	13,876	214,579,605
2004	67.31	58.80	10,006	38,485	22,629	11,214	253,763,625
2005	81.66	74.18	8990	34,577	25,649	10,986	**281,782,316**

Brachy/IMRT *v* Brachy/3D-CRT

Year	Utilization of Brachy/IMRT From Our Cohort	Weighted Estimated Utilization of Brachy/IMRT in US	Total No. in SEER Who Underwent Brachy + RT	Estimated Total No. in the US Who Underwent Brachy + RT	Estimated No. of Brachy/IMRT in the US	Mean Cost Difference Between Brachy/IMRT and Brachy/EBRT ($)	Total Cost Savings If All Brachy/IMRT in US Changed to Brachy/EBRT ($)
2002	18.66	15.51	2,914	11,208	1,738	14,953	25,993,709
2003	37.54	36.49	2,136	8,215	2,998	16,044	48,094,353
2004	57.26	53.72	1,931	7,427	3,990	12,697	50,658,293
2005	70.19	71.27	2,000	7,692	5,482	10,789	**59,146,252**

Abbreviations: MIRP, minimally invasive radical prostatectomy; Open RP, open radical prostatectomy; SEER, Surveillance, Epidemiology, and End Results database; IMRT, intensity-modulated radiation therapy; Brachy, brachytherapy; 3DCRT, three-dimensional conformal radiation therapy.

robotic-assisted prostatectomy, which requires at least a $1.4 million upfront investment to purchase the robot and then a $140,000 annual maintenance for the robot.[3] Importantly, while private health plans may reimburse a facility fee, Medicare does not reimburse for the use of the robot. Therefore, this fixed component of the costs cannot be accounted for by a Medicare claims–based analysis, which makes the cost difference between open RP and MIRP seem artificially small. Moreover, our Medicare-based cost estimates likely underestimate the true expense of the rapid shift to newer, more costly technologies, as Medicare typically reimburses a lower amount compared to private health plans.

Just as the newer technologies have been widely adopted without rigorous efficacy trials, they have also been adopted without robust cost-effectiveness analysis. To our knowledge, there are no data on the cost-effectiveness of MIRP. As for the cost-effectiveness of IMRT, a study by Konski et al suggested that based on its likely reduction in rectal toxicity, IMRTs incremental cost per quality-adjusted life year was $40,101, which meets the typical requirement that treatments have an incremental cost/quality-adjusted life year lower than $50,000 to be considered cost-effective.[15] However, that article was not published until 2006, and this study suggests that by then, 81% of external radiation patients were already receiving IMRT, making it likely that even if IMRT were found to not be cost effective, it would have been nearly impossible to reverse the nationwide trend in its use.

This research has implications for predicting the patterns of use of other newer and more expensive technologies in health care, as these trends are likely not unique to prostate cancer. It suggests that when a newer expensive technology becomes available and is reimbursed by health plans, it is likely to be rapidly adopted even before there is adequate data on its clinical benefits and cost effectiveness. This study may also inform the debate about the use of proton therapy for prostate cancer. Proton therapy carries a significantly higher price tag than IMRT, with some estimates showing it is about twice as expensive.[16] There are also significant marketing efforts promoting protons for prostate cancer and growing patient interest in receiving it. While protons are likely less toxic for certain pediatric and CNS tumors,[17,18] it remains unknown whether protons for prostate cancer are superior to IMRT in terms of cancer control or toxicity, and there is great uncertainty about whether proton therapy for prostate cancer could be cost-effective.[16,19] Nevertheless, if protons become more widely available, the trends seen in the rapid uptake of IMRT for prostate cancer may well be repeated with proton therapy.

Proponents of allowing the widespread adoption of higher-cost therapies before they are proven may point out that as a technology becomes more widely used, its costs will decrease over time. This is in fact reflected in Table 3, which shows the mean cost of IMRT falling by 20% from 2002 to 2005, and of MIRP falling by 12% over the same time period. These drops in the inflation-adjusted cost of each prostate cancer therapy are corroborated by other reports.[7] As the prices of these newer technologies falls, the likelihood that they will become cost effective can theoretically increase. However, it should be noted that the costs of the less-expensive therapies were also falling over that same time period. If the cost of the less expensive therapy is also falling, then the more expensive therapy may remain equally cost-ineffective despite its lower absolute price tag.

This study has certain limitations. First, we may have overestimated the excess costs of the new therapies because we could only look at direct Medicare costs, and could not factor in the potential indirect cost benefits, such as MIRP potentially leading to fewer missed working days for patients. In addition, our 12-month cost methodology cannot capture potential long-term savings from toxicity reduction, such as IMRT potentially reducing the need for late interventions for rectal bleeding. We also could not account for any potential long-term savings that could be due to higher cure rates and lower need for salvage therapies. Also, as more surgeons performing MIRP overcome their learning curves, the cost differentials between MIRP and open RP may fall. Conversely, we may have underestimated the excess costs because to be consistent with other cost studies we only accounted for direct Medicare payments and excluded payments made by beneficiaries and supplemental insurance. Accounting for these additional payments would have increased our estimated excess expenditures by approximately 30%. Finally, as mentioned above, the cost estimates were entirely based on patients enrolled in Medicare, and applying the mean Medicare costs to younger patients who may have private insurance that reimburses at higher rates likely leads to an underestimate of the true nationwide expenditures on the more expensive therapies.

Despite limited comparative effectiveness research, newer and costlier prostate cancer therapies were rapidly and widely adopted, resulting in an excess national spending of more than $350 million among men diagnosed in 2005. This pattern of rapid adoption may provide some empirical evidence for why health care costs account for 17% of the US gross domestic product,[20] and suggests the need for increased comparative effectiveness research to accurately weigh costs and benefits.

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

The author(s) indicated no potential conflicts of interest.

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