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Recent Trends in the Diagnostic and Surgical Management of Benign Prostatic Hyperplasia in the U.S. from 2004 to 2017: Annual Changes in the Selection of Treatment Options and Medical Costs

Francesco Del Giudice [1,2,†], Jin Kyu Oh [3,*,†], Satvir Basran [2], Edouard Nicaise [4], Phil Hyun Song [5], Wansuk Kim [6], Sang Youn Kim [7], Gyeong Eun Min [8], Koo Han Yoo [8], Hyuk Jin Cho [9], Sinyeong Lee [10], Alessandro Sciarra [1], Stefano Salciccia [1], Ettore De Berardinis [1], Vincenzo Asero [1], Carlo Maria Scornajenghi [1], Benjamin Pradere [11], Wojciech Krajewski [12], Andrea Gallioli [13], Matteo Ferro [14], Felice Crocetto [15], Savio Domenico Pandolfo [15,16], Riccardo Autorino [16], Federico Belladelli [2,17], Andrea Mari [18], Gian Maria Busetto [19], Shufeng Li [2,20], Simone Crivellaro [21] and Benjamin Inbeh Chung [2]

1 Department of Maternal Infant and Urologic Sciences, Sapienza University of Rome, Policlinico Umberto I Hospital, 00161 Rome, Italy
2 Department of Urology, Stanford University School of Medicine, Stanford, CA 94305, USA
3 Department of Urology, Gachon University Gil Medical Center, Gachon University College of Medicine, Incheon 21565, Korea
4 Department of Urology, Massachusetts General Hospital, Boston, MA 02114, USA
5 Department of Urology, College of Medicine, Yeungnam University, Daegu 42415, Korea
6 Department of Urology, College of Medicine, Inje University, Busan Paik Hospital, Busan 47392, Korea
7 Department of Radiology, Seoul National University Hospital, Seoul 03080, Korea
8 Department of Urology, Kyung Hee University School of Medicine, Kyung Hee University Hospital at Gangdong, Seoul 02447, Korea
9 Department of Urology, College of Medicine, Catholic University, Seoul 06591, Korea
10 Department of Urology, Seoul Medical Center, Seoul 03080, Korea
11 Department of Urology, Comprehensive Cancer Center, Medical University of Vienna, 1090 Vienna, Austria
12 Department of Minimally Invasive and Robotic Urology, University Center of Excellence in Urology, Wrocław Medical University, 50-367 Wrocław, Poland
13 Department of Urology, Fundació Puigvert, 08025 Barcelona, Spain
14 Department of Urology, European Institute of Oncology, IRCCS, 20141 Milan, Italy
15 Department of Neurosciences, Reproductive Sciences and Odontostomatology, University of Naples "Federico II", 80125 Naples, Italy
16 Division of Urology, VCU Health, Richmond, VA 23219, USA
17 Division of Experimental Oncology, Unit of Urology, Urologicl Research Institute (URI), IRCCS, Ospedale San Raffaele, 20132 Milan, Italy
18 Oncologic Minimally Invasive Urology and Andrology Unit, Department of Experimental and Clinical Medicine, University of Florence, Careggi Hospital, 50134 Florence, Italy
19 Department of Urology and Organ Transplantation, University of Foggia, 71122 Foggia, Italy
20 Department of Dermatology, Stanford University School of Medicine, Stanford, CA 94305, USA
21 Department of Urology, College of Medicine, University of Illinois, Chicago, IL 60612, USA
* Correspondence: shaq21@empas.com; Tel.: +82-32-460-3334; Fax: +82-32-460-8340
† These authors contributed equally to this work.

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Abstract: Background: Transurethral resection of the prostate (TURP) is the gold-standard treatment for benign prostatic hyperplasia (BPH). However, laser surgery techniques (e.g., photoselective vaporization of the prostate (PVP), holmium laser, thulium laser enucleation of the prostate (HoLEP or ThuLEP)), and minimally invasive treatment options (e.g., UroLift) are increasingly replacing TURP. This study seeks to report the annual incidence, management trends, and costs of BPH procedures in the U.S. Methods: Data analyses of U.S. health insurance claims from 2004 to 2017, collected from the de-identified Optum Clinformatics Claims Database, were performed to determine the number of BPH patients and the treatment selected. Results: A total of 51,448 patients underwent BPH procedures from 2004 to 2017. There was a significant increase in the annual rate from 770 in 2004 to 6571 in 2017. The mean patient age (±SD) increased from 67.6 years old (±8.4) in 2004 to

73.4 years old (±8.4) in 2017. More than 60% of patients underwent cystourethroscopy and a post-void residual urine check for workup prior to surgical management. TURP was the most-common, and PVP was the second-most-common BPH procedure. Medical and total treatment costs increased, while the detection rate of prostate cancer after BPH surgery gradually decreased from 19.87% in 2004 to 5.78% in 2017. Conclusions: Our study demonstrates a recent trend in BPH management that replaces the traditional TURP technique with alternative methods. Due to rising costs, future studies should assess whether these newer methods are cost effective over the long term.

Keywords: benign prostatic hyperplasia; surgery; trends

1. Introduction

Benign prostatic hyperplasia (BPH) is a common condition afflicting male patients, who may suffer from related lower urinary tract symptoms (LUTS), such as frequency, nocturia, and urgency. Several mechanisms have been reported to affect and aggravate LUTS in BPH patients, including age-related impairment of blood flow in pelvic organs and aggravation in bladder dysfunction [1]. If LUTS are medically uncorrectable, surgical treatment should be considered for otherwise healthy male patients, who suffer from moderate-to-severe outlet-obstructive symptoms.

Transurethral resection of the prostate (TURP) is the gold standard for surgical treatment of BPH [2]. However, technological advancements in medical device development have provided many alternative surgical options, including photoselective vaporization of the prostate (PVP), holmium laser enucleation of the prostate (HoLEP), thulium laser enucleation of the prostate (ThuLEP), and UroLift. Furthermore, some studies have shown that there are favorable outcomes for using these new BPH surgical techniques instead of TURP [3–6].

In more detail, HoLEP and ThuLEP have demonstrated similar disobstruction outcomes with a comparable International Prostate Symptom Score (IPSS) improvement at both mid- and long-term follow-up, while similarly improving the overall quality of life (QoL) outcomes [7]. Despite these surgical options, which are still considered as possible alternatives (if the equipment and surgical expertise are available) according to international guidelines, the information regarding the safety profile resulting from the short- and long-term follow-up is in favor of laser-assisted enucleating or vaporesection techniques, making these a possible game changer in case of fragile patients or for those receiving anticoagulant or antiplatelet therapy [8]. Moreover, Salciccia et al. [9] have recently demonstrated how these new available endoscopic surgical techniques, including PVP, can be valid for an outpatient setting, thus, expanding the potentiality of application and the wide distribution of the techniques when compared to TURP.

However, these newer modalities, in many cases, may be far more expensive than traditional TURP, and there are few contemporary studies that analyze and compare these costs [10]. Moreover, we have few data regarding the total overall costs incurred from the BPH workup utilized to confirm the need for surgical treatment. Therefore, the aim of our study is to present the annual rates of BPH surgery and to analyze recent trends in the utilization of newer surgical modalities and any changes in medical costs related to these treatments over a 15-year period in the U.S.

2. Materials and Methods

The current study was performed with approval from the Center for Population Health Science at Stanford University in the U.S. Patient data collected from the Optum Clinformatics Data Mart Claims Database were derived from commercial and Medicare Advantage health insurance claims. Optum Clinformatics Data Mart is a database comprised of administrative health claims submitted for payment by providers and pharmacies. These claims are verified, adjudicated, adjusted, and de-identified. Data are included for only those covered lives, roughly 70 million over a 14-year period, with both medical and prescription drug coverage. Costs are standardized to create standard prices across all provider services. International Classification of Disease Ninth and Tenth Revisions, Clinical Modification (ICD-9-CM, ICD-10-CM) codes, and Current Procedural Terminology (CPT) codes were used to identify the study cohort, treatments, and comorbidities. A comprehensive list of ICD-9/10 and CPT codes summarizing the analytical steps for the data analysis and inclusion/exclusion criteria are presented in Supplementary File S1. This method has been used in other studies [11–14], and, given de-identified information, this study was deemed exempt from informed consent requirements by the Stanford University Medical Center Institutional Review Board.

Patients who had undergone BPH surgery (index date) between 2004 and 2017 in the U.S. were reviewed. As per primary aim, only those patients with an associated code for specific BPH surgical procedure were included (i.e., TURP, HoLEP, ThuLEP, UroLift). Trends and distribution over the years of enrolment were analyzed and reported for each single procedure over the time of database enrolment across the U.S. Moreover, as per inclusion criteria, subjects at least 50 years old, with at least 6 months enrolment time before, and 1 month after the index date were further assessed leading to the final of n = 82,458 men. Additionally, patients were considered eligible per final enrolment, only if they had a least one urodynamic, cystourethroscopy, USG, biopsy, uroflowmetry, or surgical urological procedure treatment code. Overall, this led to the final cohort composition of n = 51,448 men.

Per the secondary aim of the study, we reviewed the trends in adoption of various diagnostic methods for BPH including urodynamic studies, cystourethroscopy, transrectal ultrasound, prostatic biopsy, uroflowmetry, and the measurement of post-void residual urine volume (PVR). The collected data included patient age, race, household income, educational status, and co-morbidities. In addition, the annual costs of BPH diagnostic and treatment modalities were reviewed from the database for both diagnostic and therapeutic BPH-related procedures. All costs were standardized based on Medicare Relative Value Units and other pricing methods, adjusting for inflation. Finally, incidental diagnoses of prostate cancer (PCa) detected during BPH procedures were recorded over the years to depict the trends in cancer detection and the median prostate specific antigen (PSA) values associated with BPH patients ultimately addressed to surgical disobstruction.

Statistical Analysis

Patient demographics and the socio-economic and clinical characteristics for those who received diagnostic and/or therapeutic BPH-related procedures were summarized by mean values (standard deviation (SD)), or median values (inter-quartile range (IQR)). Temporal trends with descriptive statistics on the adoption of each explored diagnostic procedure for BPH were presented to assess the number of cases by year and the relative percentages of each adopted procedure. Additionally, temporal trends in median cost per diagnosis and/or treatment were presented and plotted to show the yearly trajectory of the different procedures reviewed. Incidental PCa findings and associated PSA values were recorded and compared by temporal trends.

3. Results

The overall number of subjects reviewed included 51,448 patients. Table 1 shows the patients' characteristics of age, race, household incomes, and educational status by BPH surgery year.

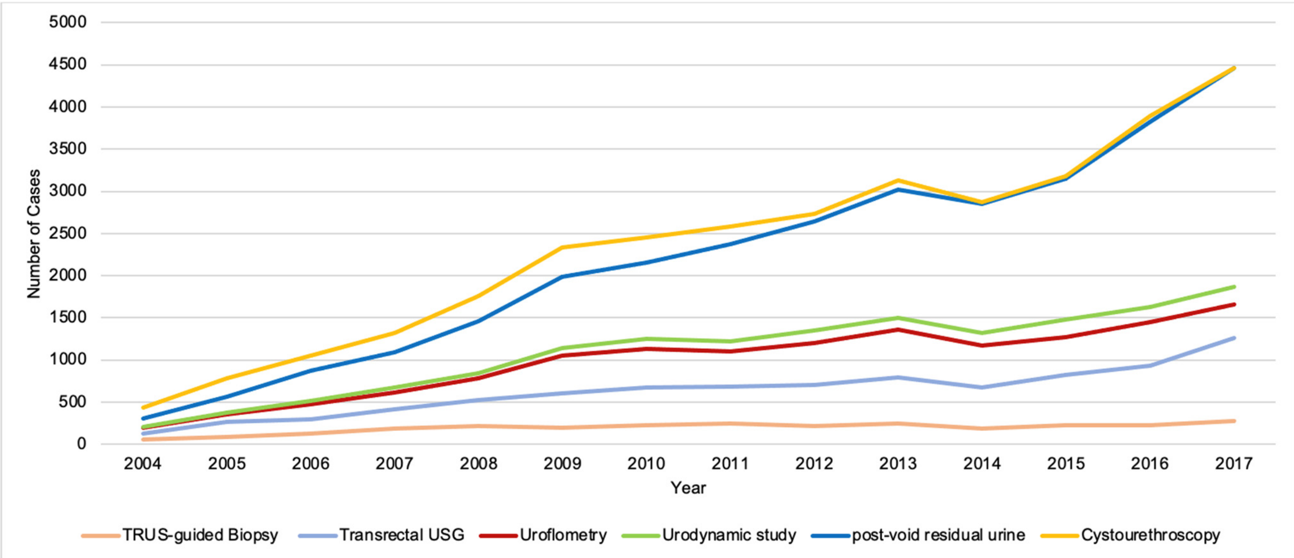
Table 1. Annual characteristics of patients undergoing benign prostatic hyperplasia surgery.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Number (n)	770	1306	1762	2212	2942	3741	3920	4057	4305	4818	4344	4873	5827	6571
Age (years), mean (std)	67.6 (8.4)	68.4 (8.2)	69.3 (8.4)	69.7 (8.5)	70.4 (8.8)	71 (8.7)	71.3 (8.7)	71.7 (8.6)	71.9 (8.7)	72 (8.6)	72.6 (8.5)	72.7 (8.6)	72.9 (8.6)	73.4 (8.4)
Race, n (%)														
Asian	18 (2.34)	25 (1.91)	27 (1.53)	34 (1.54)	63 (2.14)	79 (2.11)	80 (2.04)	101 (2.49)	115 (2.67)	139 (2.89)	132 (3.04)	146 (3)	170 (2.92)	190 (2.89)
Black, non-Hispanic	76 (9.87)	97 (7.43)	162 (9.19)	149 (6.74)	242 (8.23)	305 (8.15)	353 (9.01)	332 (8.18)	344 (7.99)	357 (7.41)	279 (6.42)	342 (7.02)	487 (8.36)	579 (8.81)
Hispanic	46 (5.97)	86 (6.68)	124 (7.04)	144 (6.51)	254 (8.63)	391 (10.45)	365 (9.31)	373 (9.19)	432 (10.03)	470 (9.76)	471 (10.84)	500 (10.26)	637 (10.93)	704 (10.71)
White	630 (81.82)	1098 (84.07)	1449 (82.24)	1885 (85.22)	2383 (81.00)	2966 (79.28)	3122 (79.64)	3251 (80.13)	3414 (79.3)	3852 (79.95)	3462 (79.7)	3885 (79.73)	4533 (77.79)	5098 (77.58)
Household Incomes, n (%)														
<USD 40K	212 (27.53)	342 (26.19)	483 (27.41)	616 (27.85)	795 (27.02)	1054 (28.18)	1083 (27.63)	1023 (25.22)	1054 (24.48)	1096 (22.75)	963 (22.17)	995 (20.42)	1235 (21.19)	1298 (19.75)
USD 40K–USD 49K	66 (8.57)	124 (9.49)	150 (8.51)	223 (10.08)	263 (8.94)	326 (8.72)	343 (8.75)	372 (9.17)	397 (9.22)	420 (8.72)	336 (7.73)	365 (7.49)	476 (8.17)	488 (7.43)
USD 50K–USD 59K	61 (7.92)	117 (8.96)	162 (9.19)	211 (9.54)	289 (9.82)	318 (8.5)	364 (9.29)	418 (10.3)	397 (9.22)	456 (9.46)	379 (8.72)	442 (9.07)	518 (8.89)	611 (9.3)
USD 60K–USD 74K	93 (12.08)	149 (11.41)	213 (12.09)	261 (11.8)	341 (11.59)	481 (12.86)	508 (12.96)	524 (12.92)	520 (12.08)	590 (12.25)	573 (13.19)	622 (12.76)	783 (13.44)	864 (13.15)
USD 75K–USD 99K	128 (16.62)	222 (17)	284 (16.12)	361 (16.32)	479 (16.28)	622 (16.63)	632 (16.12)	679 (16.74)	757 (17.58)	877 (18.2)	802 (18.46)	957 (19.64)	1103 (18.93)	1317 (20.04)
USD 100K+	210 (27.27)	352 (26.95)	470 (26.67)	540 (24.41)	775 (26.34)	939 (25.11)	990 (25.26)	1041 (25.66)	1180 (27.41)	1379 (28.62)	1291 (29.72)	1492 (30.62)	1712 (29.38)	1993 (30.33)
Education														
Less than 12th grade	<11	<11	<11	<11	26 (0.88)	29 (0.78)	35 (0.89)	18 (0.44)	24 (0.56)	26 (0.54)	35 (0.81)	32 (0.66)	60 (1.03)	35 (0.53)
High school diploma	195 (25.32)	293 (22.43)	433 (24.57)	578 (26.13)	824 (28.01)	1063 (28.42)	1109 (28.29)	1164 (28.69)	1258 (29.45)	1318 (27.36)	1125 (25.9)	1210 (24.83)	1569 (26.93)	1794 (27.3)
Less than bachelor's degree	444 (57.66)	779 (59.65)	1019 (57.83)	1291 (58.36)	1598 (54.32)	2093 (55.96)	2201 (56.15)	2261 (55.73)	2357 (54.75)	2720 (56.45)	2464 (56.72)	2771 (56.86)	3230 (55.43)	3716 (56.55)
Bachelor's degree plus	100+	200+	200+	300+	494 (16.79)	555 (14.84)	575 (14.67)	614 (15.13)	656 (15.24)	754 (15.65)	720 (16.57)	860 (17.65)	968 (16.61)	1026 (15.61)
Co-morbidity, n (%)														
Hypertension	667 (86.62)	1153 (88.28)	1554 (88.2)	1943 (87.84)	2570 (87.36)	3286 (87.84)	3398 (86.68)	3544 (87.36)	3776 (87.71)	4180 (86.76)	3753 (86.4)	4171 (85.59)	4960 (85.12)	5506 (83.79)
Heart disease	480 (62.34)	844 (64.62)	1144 (64.93)	1442 (65.19)	1842 (62.61)	2364 (63.19)	2444 (62.35)	2549 (62.83)	2647 (61.49)	2857 (59.3)	2584 (59.48)	2857 (58.63)	3381 (58.02)	3604 (54.85)
Diabetes	299 (38.83)	504 (38.59)	697 (39.56)	898 (40.6)	1176 (39.97)	1567 (41.89)	1689 (43.09)	1708 (42.1)	1791 (41.6)	2052 (42.59)	1794 (41.3)	2018 (41.41)	2363 (40.55)	2578 (39.23)
Circulatory system diseases	411 (53.38)	712 (54.52)	939 (53.29)	1179 (53.3)	1474 (50.1)	1898 (50.74)	1933 (49.31)	2007 (49.47)	2105 (48.9)	2263 (46.97)	2030 (46.73)	2128 (43.67)	2536 (43.52)	2674 (40.69)
Prostate cancer	153 (19.87)	227 (17.38)	344 (19.52)	357 (16.14)	464 (15.77)	499 (13.34)	480 (12.24)	475 (11.71)	443 (10.29)	498 (10.34)	458 (10.54)	453 (9.3)	468 (8.03)	380 (5.78)

The majority of patients were White. Interestingly, both the lowest and highest household incomes each carried a high proportion of all BPH patients. The mean age for BPH surgical patients gradually increased annually from 67.6 years in 2004 to 73.4 in 2017.

Table 2 indicates a slight increase in the cost of BPH diagnostic tools.

Apart from the stationary cost of diagnosis, the total number of diagnostic approaches for determining BPH surgery has increased steadily (Figure 1).



Year	TRUS-guided Biopsy	Transrectal USG	Uroflowmetry	Urodynamic study	Post-void residual urine	Cystourethroscopy
2004	57	129	197	209	304	436
2005	90	261	354	378	561	779
2006	123	295	479	509	871	1054
2007	189	418	618	675	1094	1318
2008	215	525	781	844	1458	1760
2009	195	604	1052	1140	1983	2332
2010	227	672	1131	1248	2159	2449
2011	250	680	1105	1219	2370	2583
2012	218	701	1199	1347	2638	2736
2013	246	797	1358	1502	3017	3130
2014	183	673	1175	1318	2855	2872
2015	223	823	1273	1475	3151	3184
2016	222	927	1446	1629	3827	3899
2017	277	1258	1653	1870	4466	4461

Figure 1. Graph of annual numbers of diagnostic procedures.

Post-void residual urine and cystourethroscopy were among the diagnostic tools with the greatest increases over the study period, with post-void residual measurements increasing from 304 cases in 2004 to 4466 in 2007 and cystourethroscopy increasing from 436 cases in 2004 to 4461 in 2007. On the contrary, TRUS-guided biopsy was the procedure with the smallest amount of increase, going from 57 cases in 2004 to 277 in 2007.

In Table 3, recent changes in the surgical modalities for treating BPH have been identified.

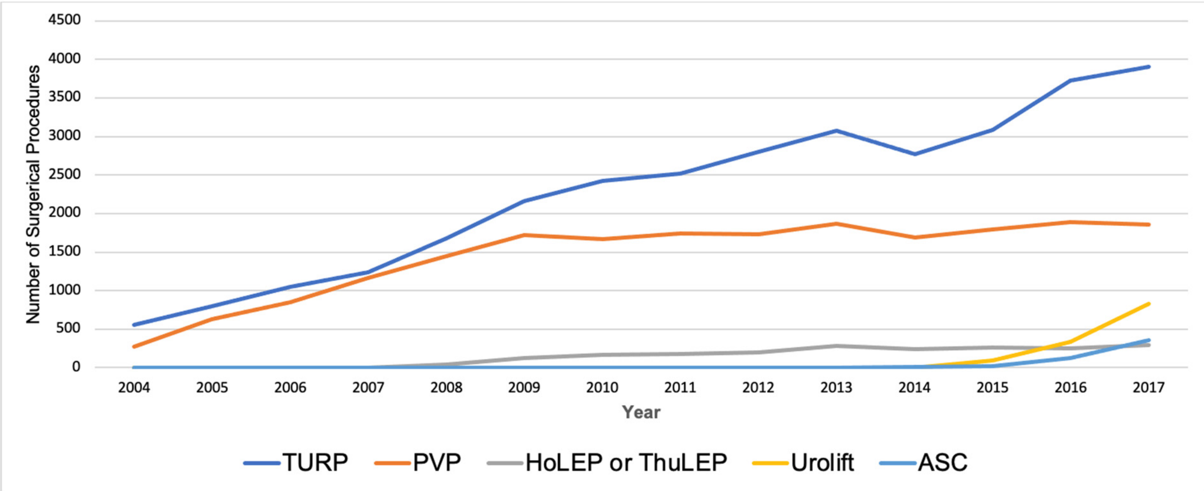
Table 2. Annual numbers and costs of diagnostic procedures.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Urodynamic study														
number	209	378	509	675	844	1140	1248	1219	1347	1502	1318	1475	1629	1870
Cost (USD), median (IQR)	24 (12–147)	24 (13–147)	24 (24–275)	27 (24–318)	26 (24–331)	49 (24–331)	65 (24–839)	61 (24–856)	79 (24–962)	107 (24–1146)	99 (14–1121)	299 (19–1242)	180 (14–1261)	132 (14–1233)
Cystourethroscopy														
number	436	779	1054	1318	1760	2332	2449	2583	2736	3130	2872	3184	3899	4461
Cost (USD), median (IQR)	287 (287–305)	287 (287–364)	287 (287–364)	287 (287–365)	287 (287–364)	287 (287–388)	287 (287–384)	287 (287–388)	287 (287–384)	324 (287–417)	324 (324–409)	324 (324–437)	324 (324–437)	324 (324–403)
Transrectal USG														
number	129	261	295	418	525	604	672	680	701	797	673	823	927	1258
Cost (USD), median (IQR)	152 (120–272)	152 (120–272)	152 (120–272)	152 (120–272)	152 (120–272)	152 (120–272)	152 (120–272)	152 (120–272)	152 (120–272)	160 (152–263)	160 (149–227)	160 (148–193)	160 (153–191)	160 (160–171)
TRUS-guided biopsy														
number	57	90	123	189	215	195	227	250	218	246	183	223	222	277
Cost (USD), median (IQR)	338 (223–338)	338 (338–338)	338 (338–338)	338 (338–338)	338 (338–338)	338 (338–338)	338 (338–338)	338 (278–338)	338 (338–338)	343 (338–343)	343 (205–343)	343 (343–343)	343 (298–343)	343 (177–343)
Uroflowmetry														
number	197	354	479	618	781	1052	1131	1105	1199	1358	1175	1273	1446	1653
Cost (USD), median (IQR)	35 (24–73)	37 (24–61)	46 (24–73)	37 (24–73)	48 (24–73)	49 (24–97)	49 (24–97)	49 (24–97)	49 (24–97)	54 (28–97)	55 (28–97)	44 (28–84)	47 (28–83)	55 (28–94)
Post-void residual urine														
number	304	561	871	1094	1458	1983	2159	2370	2638	3017	2855	3151	3827	4466
Cost (USD), median (IQR)	29 (29–58)	29 (29–58)	29 (29–58)	29 (29–58)	29 (29–58)	34 (29–58)	44 (29–58)	44 (29–66)	44 (29–73)	49 (32–81)	49 (32–81)	49 (32–81)	49 (32–81)	49 (32–81)
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017

Table 3. Annual numbers and costs of surgical treatment.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TURP														
number	557	798	1053	1239	1678	2165	2428	2519	2800	3072	2770	3088	3725	3909
Cost (USD), median (IQR)	1321 (1321–1321)	1321 (1321–1321)	1321 (1321–1321)	1321 (1321–1321)	1321 (1321–1321)	1321 (1321–1321)	1321 (1321–1638)	1321 (1321–2403)	1321 (1321–2710)	1321 (1321–3332)	1459 (1321–3332)	1459 (1252–3783)	1459 (1459–3708)	1459 (1459–4260)
PVP														
number	273	624	849	1161	1449	1717	1668	1747	1728	1870	1687	1799	1888	1853
Cost (USD), median (IQR)	1351 (1351–5999)	1351 (1314–6382)	1351 (1314–6412)	1351 (1314–5742)	1351 (1314–5694)	1434 (1314–4763)	1743 (1314–5318)	2031 (1314–5318)	2048 (1314–4921)	2210 (1286–5335)	2084 (1286–5335)	2000 (1286–4862)	2261 (1286–4692)	2194 (1286–4988)
HoLEP or ThuLEP														
number	<11	<11	<11	<11	45	124	172	181	199	281	236	258	248	297
Cost (USD), median (IQR)					1393 (1393–6901)	1393 (1393–6689)	1404 (1393–6689)	1410 (1393–5072)	1419 (1393–5660)	1419 (1419–5680)	1419 (1419–5680)	1419 (1419–4082)	1419 (1419–5742)	1419 (1419–6465)
Urolift														
number	0	0	<11	<11	0	<11	<11	<11	<11	<11	<11	98	339	825
Cost (USD), median (IQR)												2867 (1642–4569)	3284 (2193–4959)	3284 (2517–5313)

The total number of treated cases was 31,801, 20,313, 2061, 1280, and 507 for TURP, PVP, HOLEP/ThULEP, Urolift, and ASC, respectively. Although there is still an annual increasing trend in the total number of cases for which TURP is the method of BPH treatment, the proportion of those undergoing TURP demonstrates an annually decreasing trend. Among BPH laser surgeries, PVP has been the most-common modality since 2017 (Figure 2).



Year	TURP	PVP	HoLEP or ThuLEP	Urolift	ASC
2004	557	273	<11	0	0
2005	798	624	<11	0	0
2006	1053	849	<11	<11	0
2007	1239	1161	<11	<11	0
2008	1678	1449	45	0	0
2009	2165	1717	124	<11	0
2010	2428	1668	172	<11	<11
2011	2519	1747	181	<11	<11
2012	2800	1728	199	<11	0
2013	3072	1870	281	<11	0
2014	2770	1687	236	<11	11
2015	3088	1799	258	98	19
2016	3725	1888	248	339	120
2017	3909	1853	297	825	355

Figure 2. Graph of annual numbers of surgical procedures.

The total number of BPH diagnosis was 44,820, and the median cost for each procedure was USD 1459, USD 1875, USD 1419, USD 3284, and USD 3590 for TURP, PVP, HOLEP/ThULEP, Urolift, and ASC, respectively. The median overall cost was USD 2471. With regard to the costs of treating BPH surgically, the diagnostic and treatment costs demonstrate annual increases, as shown in Table 4, with the slope of costs becoming steeper in the last 4 years (Figure 3).

Between 2007 and 2012, the number of incidentally detected prostate cancer diagnoses during BPH surgery for which PSA data was available was very low; therefore, the rate of cancer detection between 2007 and 2012 could not be estimated. However, in comparing the outcomes of cancer detection in 2004 to those in 2017, the probability of incidentally detected prostate cancer during surgery demonstrated an annual decrease, as shown in Table 5.

Table 4. Annual overall medical costs related to surgery.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Number of patients (n)	770	1306	1762	2212	2942	3741	3920	4057	4305	4818	4344	4873	5827	6571
Total cost, median (IQR)	1668 (1350–2982)	1743 (1379–4615)	1794 (1380–4616)	1889 (1459–4636)	1887 (1457–4411)	1895 (1416–4383)	2082 (1490–4819)	2337 (1589–5405)	2445 (1576–5446)	2763 (1609–6107)	2735 (1610–6032)	2885 (1643–6073)	3118 (1738–6145)	3523 (1799–6898)
Cost of treatment, median (IQR)	1321 (1321–2635)	1321 (1321–3267)	1321 (1321–3895)	1321 (1321–3812)	1321 (1321–3507)	1321 (1321–3542)	1321 (1321–3678)	1321 (1321–4283)	1321 (1321–4372)	1459 (1285–4879)	1459 (1286–4929)	1607 (1286–4861)	1966 (1286–4994)	2575 (1459–5665)
Cost of diagnosis, median (IQR)	302 (88–484)	336 (239–592)	331 (224–630)	345 (259–617)	360 (268–651)	345 (224–640)	364 (242–846)	364 (259–864)	360 (220–902)	394 (227–1013)	403 (228–959)	405 (244–1034)	409 (279–962)	407 (266–936)
Number of diagnoses	615	1071	1468	1851	2397	3155	3334	3506	3769	4270	3893	4360	5192	5939

Table 5. Analysis of incidentally detected prostate cancer.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Number of patients (n)	57	92	91	16	<11	12	20	26	29	191	239	263	310	341
PSA (ng/mL), median (IQR)	2.5 (1.1–5.2)	1.8 (0.9–4.4)	2.4 (1–5.1)	3 (1.3–6)	3.5 (1.1–5.8)	3.2 (2.3–7)	2.9 (1.5–5.5)	1.6 (0.7–3.9)	2.9 (1.7–5.6)	2.4 (1.2–5)	2.6 (1.4–5.5)	2.6 (1.1–5.4)	2.5 (1.2–4.9)	2.7 (1.3–5.4)
Number of cancer detections	16	14	18	<11	<11	0	<11	<11	<11	21	34	21	30	15
Percentage of cancer detection	28.07	15.22	19.78			0				10.99	14.23	7.98	9.68	4.4

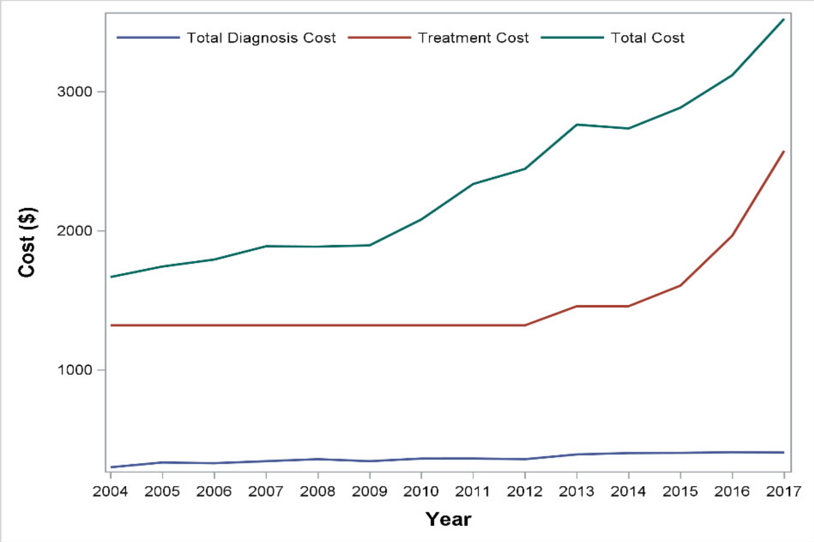


Figure 3. Graph of annual medical costs related to surgery.

4. Discussion

The increase in average life expectancy results in a greater occurrence of functional disorders in aging male patients, with BPH representing one of the most-common and bothersome diseases of aging males, creating an adverse effect on patients' quality of life. Moreover, lower urinary tract symptoms are strongly associated with aging. This was clearly demonstrated in different series and countries, including the Florey Adelaide Male Ageing Study from Australia, where there was a marked effect of age, with 31.5% of men aged 70–80 years reported some degree of bothersome LUTS, compared to 13.4% of the youngest-aged men in the cohort [15]. While some functional decline of the lower urinary tract undoubtedly occurs, with aging being an independent predictor, some other risk factors indirectly correlated with aging processes, such as abdominal fat mass, plasma glucose, obstructive sleep apnea, HDL cholesterol, and energy intake may produce an incremental effect on the intensity of the symptoms, thus potentially shortening the time to the need for surgical management [16]. Additionally, Stroup et al. investigated the adverse events related to BPH in the U.S. from 1998 to 2008 and reported significant sequelae, including acute renal failure, bladder stones, and urinary retention [17].

For BPH treatment, there are several options—medical, surgical, and procedural management [18,19]. In general, surgical treatment is utilized in medically refractory BPH and TURP and has been the traditional gold standard of surgical treatment [20,21]. However, newer procedures have recently come to the forefront, with some suggesting that HoLEP is potentially a new gold standard of BPH surgery, as it can also treat obstruction caused by high-intensity focused ultrasound (HIFU) treatment for prostate cancer [22,23]. Recently, UroLift was introduced as a minimally invasive, office-based treatment for BPH, which has shown favorable surgical outcomes [24,25]. Although we demonstrate that TURP is still the most-common surgery to treat BPH in the U.S. (Figure 2), the number of UroLift procedures has increased remarkably in recent years. The total medical costs related to BPH surgery demonstrate an annual increase, likely from increasing costs of non-TURP options, and it remains to be seen if this trend continues, as other alternative procedures continue with more widespread adoption.

There are some interesting trends worth mentioning during the study period. With regards to age, the mean age of those who underwent BPH surgery demonstrated a gradual increase from 67.4 years old in 2004 to 73.4 years old in 2017 (Table 1). In terms of racial differences, we find no disparity among races, which supports the results from a previous study [26]. The increasing age of patients undergoing procedural intervention may reflect increasing safety in BPH treatments and greater efficacy of medical treatments, with the decision of clinicians to delay the need for surgical intervention until later in the disease course.

The diagnostic workup prior to BPH procedural management and the studies used are not standardized, so controversy exists regarding what is necessary. These studies include post-void residual measurement, urodynamics, cystourethroscopy, and transrectal ultrasound [27]. We find that cystourethroscopy is the most-common diagnostic tool prior to surgery. The second-most-common diagnostic tool is a PVR, and two-thirds of patients in our study underwent both cystourethroscopy and a PVR. These studies showed consistency throughout the study period and as such, costs of this workup remained low and stable.

Our study also demonstrates a steady decrease in the detection of incidental prostate cancer. Several studies have also reported a decrease in incidentally detected prostate cancer due to earlier PSA screening [18,28]. In terms of incidentally detected prostate cancer during BPH surgery, the detection rate reported by a selection of studies ranges from 21% to 4.8% [18]. The reasons for the decrease in incidental diagnoses are not clear, but there are a couple of possible reasons. It may be that the more-frequent use of an MRI to detect occult prostate cancer prior to BPH procedures has resulted in more upfront prostate cancer diagnoses, requiring more radical treatment. Moreover, the higher utilization of procedures that do not submit tissue for pathologic diagnosis such as PVP or Urolift could also lower the incidental detection rate.

Several limitations of the present study warrant mention. As the dataset is administrative in nature, relying on accurate coding of diagnoses and procedures, there is a possibility of misclassification. Additionally, procedures done prior to access to insurance and entry into the database may not have been captured. In addition, in keeping with the administrative nature of the dataset, no staging or information regarding BPH including prostate volume, catheterization time, and/or indolent vs. non-indolent incidental PCa diagnosis were available, which could limit our ability to assess the indication for surgical excision and related oncological outcomes. Despite the limitations, our study provides an analysis of population-based data previously not studied, revealing important clinical information about changing trends in the surgical management of BPH in the U.S. To the best of our knowledge, this unique insight contributes to the comprehensive understanding of overall recent U.S. trends in the surgical treatment of BPH in real clinical practice across the country.

5. Conclusions

Our study demonstrates that TURP is still the most-common surgical treatment of BPH in the U.S. However, there is a rising trend in the number of BPH cases that are treated with alternative surgical methods in place of TURP. Furthermore, the total medical costs related to surgical treatment are also increasing. Future studies with long-term follow-up should assess whether these newer options are indeed cost-effective.

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