Oral Oncology 96 (2019) 21–26

Contents lists available at ScienceDirect

Oral Oncology

journal homepage: www.elsevier.com/locate/oraloncology

Direct medical cost of oropharyngeal cancer among patients insured by Medicaid in Texas

Bo Zhao[a], Shuangshuang Fu[b,c], Chi-Fang Wu[d], Kristina R. Dahlstrom[c], Joël Fokom Domgue[e,f], Samantha Tam[c], Li Xu[c], Erich M. Sturgis[c,f], David R. Lairson[d,*]

[a] Department of Biostatistics, School of Public Health, The University of Texas Health Science Center at Houston, Houston, TX, United States
[b] Department of Epidemiology, Human Genetics & Environmental Sciences, School of Public Health, The University of Texas Health Science Center at Houston, Houston, TX, United States
[c] Department of Head and Neck Surgery, Division of Surgery, The University of Texas MD Anderson Cancer Center, Houston, TX, United States
[d] Department of Management, Policy, and Community Health, School of Public Health, The University of Texas Health Science Center at Houston, Houston, TX, United States
[e] Department of Gynecologic Oncology and Reproductive Medicine, The University of Texas MD Anderson Cancer Center. Houston, TX, United States
[f] Division of Cancer Prevention and Population Sciences, Department of Epidemiology, The University of Texas MD Anderson Cancer Center, Houston, TX, United States

ARTICLE INFO

Keywords:
Healthcare costs
Medicaid
Oropharyngeal cancer
Texas

ABSTRACT

Objectives: The aim of this study was to estimate the direct 2-year mean incremental medical care costs for incident oropharyngeal cancer (OPC) from the perspective of the Texas Medicaid program.
Methods: OPC patients treated from 2008 to 2012 were selected in the Texas Medicaid database. Using a two-step 1:1 propensity score matching method, we selected controls to determine the differential cost associated with OPC. Monthly and yearly direct costs were estimated for 2 years after the cancer diagnosis. For patients without 2-year complete follow-up, a generalized linear model with gamma distribution and log link function was applied to predict costs for the censored months.
Results: A total of 352 patients with OPC and the same number of controls were included in the study. Among OPC patients, 204 (58%) were covered by Medicaid and Medicare, and 148 patients (42%) were insured under Medicaid only. The adjusted first- and second-year mean differential costs were $45,102 and $11,684 for Medicaid-only enrollees and $5734 and $2162 for Medicaid-Medicare dual-eligible enrollees, respectively. Being male, Hispanic, Medicaid-only eligible, living in the Harlingen region, and having more comorbidities were positively associated with monthly cost. Lubbock residents experienced lower costs.
Conclusions: The direct incremental medical costs associated with OPCs among patients insured by Texas Medicaid were substantial in the first 2 years after cancer diagnosis and should be considered in assessing the economic consequences of increasing the investment in HPV vaccination in Texas.

Introduction

Anogenital and oropharyngeal cancers caused by human papillomavirus (HPV) are a significant health care burden in the United States, including Texas [1,2]. Almost 40,000 HPV-related cancers were diagnosed annually in the United States during 2008–2012, with 28,500 of these attributable to HPV types included in the 9-valent HPV vaccine [2]. Of these, 10,400 were oropharyngeal cancers (OPCs), which have now surpassed cervical cancer as the most common HPV-related cancer in the United States [2,3]. Seventy percent of OPCs are attributable to HPV, with the most common type being type 16 [2].The United States is experiencing a significant increase in incidence of OPCs, particularly among middle-aged men [3,4].

Fortunately, the HPV vaccine is expected to prevent the vast majority of HPV-related diseases, including OPCs [5]. Multiple studies have demonstrated a population-level impact on HPV-related disease in countries with HPV vaccination programs; however, the success of such programs relies on high coverage levels [6]. Although several studies have found the vaccine to be safe and cost effective [7–9], vaccination rates in the United States remain low [10]. Fifty-three percent of eligible girls and 44% of eligible boys have completed the vaccine series—with even lower rates in Texas, where just 40% of adolescents have

* Corresponding author at: Division of Management, Policy, and Community Health, School of Public Health, The University of Texas Health Science Center at Houston, 1200 Pressler St., Houston, TX 77030, United States.
E-mail address: David.R.Lairson@uth.tmc.edu (D.R. Lairson).

https://doi.org/10.1016/j.oraloncology.2019.06.033
Received 1 October 2018; Received in revised form 17 May 2019; Accepted 28 June 2019
Available online 04 July 2019
1368-8375/

completed the series [10].

Given the demonstrated success of vaccination programs [6], additional resources are warranted to increase vaccination rates in Texas. Justification for allocation of resources for such programs is supported by accurate and up-to-date estimates of the costs associated with treating HPV-related disease. We previously reported the health care costs associated with OPC among a privately insured population in Texas [11]. Medicaid is the largest health care payer covering low-income adults, elderly adults, pregnant women, individuals with disabilities, and children in the United States. Texas Medicaid is the state and federal cooperative program that provides health insurance to Texans with limited income and resources, and approximately 16% of the Texas population was covered by Medicaid in 2016 [12]. The aim of this study was to estimate the direct 2-year mean incremental medical care costs for incident OPC from the perspective of the Texas Medicaid program.

Methods

Data source

We used the Texas Medicaid database from 2008 to 2012 to select patients for the cost evaluation of OPCs in this study. During the study period, Texas Medicaid had 4.2–5.2 million enrollees annually. The database had information about demographics, enrollment, and claims for medical treatment and pharmacy use, along with associated payments.

Study population

OPC cohort

Newly diagnosed adult OPC patients were identified from the dataset. Patients were included in the cohort if they had at least one inpatient claim or two outpatient claims 30 days apart with an ICD-9 code of 141.0 (malignant neoplasm of base of tongue), 141.6 (malignant neoplasm of lingual tonsil), 145.3 (malignant neoplasm of soft palate), 145.4 (malignant neoplasm of uvula), 146 (malignant neoplasm of oropharynx), 149.0 (malignant neoplasm of pharynx, unspecified) and 149.1 (Malignant neoplasm of Waldeyer's ring) [11]. The first day of the OPC diagnosis was defined as the index diagnosis date.

Patients were then excluded from the cohort if they (1) were not continuously enrolled in Medicaid 6 months before or 6 months after the index diagnosis date, (2) were younger than 18 years on the index diagnosis date, or (3) had any other cancer diagnosis 6 months before the index diagnosis date.

Control group

We selected a 1:1 matched control group from the same Medicaid dataset. First, patients with no HPV-related conditions during the study period were identified as potential controls. Then, each index diagnosis date from the OPC cohort was randomly assigned to all potential controls (one-to-many match). After that, patients in the control group were excluded if they were not continuously enrolled in Medicaid 6 months before or 6 months after the index diagnosis date, or if they had any other cancer diagnosis 6 months before the index diagnosis date.

A two-step matching process was implemented. First, all eligible controls were matched with cancer patients if they had (1) age within 5 years of that of cancer patients, (2) the same index date, and (3) the same Medicaid only or Medicaid-Medicare dual-eligible status. In the second step, we applied a 1:1 propensity score matching with Mahalanobis distance. The variables included in the propensity score matching were sex, race, health services region, Charlson comorbidity score, number of psychiatric diagnostic groups [13] during the 6 months before the index date, and costs between the 6 months and 3 months before the index date. To avoid including costs related to cancer diagnosis, we did not include the costs for the 3 months immediately before the index date in the cost variable.

Statistical analysis

Baseline characteristics were compared between OPC patients and controls. Because the Medicaid data included no Medicare costs for Medicaid-Medicare dual-eligible patients, OPC patients, as well as controls, were separated into two subgroups: Medicaid only and those dual eligible for Medicaid and Medicare coverage. Since care for dual-eligible patients was partially covered by the federal Medicare program, it was important to document the differences between the two major subgroups of patients. The Pearson chi-square test was used to compare categorical baseline characteristics between groups, and the *t*-test was used for numerical variables; p-values < 0.05 were considered statistically significant.

Cost was measured from the Texas Medicaid program perspective. The first- and second-year costs after the index date were analyzed for all OPC patients and controls by Medicaid-only and dual-eligible status. Subgroup cost analysis was performed to show how coverage by the federal Medicare program affects the costs incurred by the state of Texas. The cost was converted to 2015 US dollars using the medical care category of the US Bureau of Labor Statistics Consumer Price Index.

For patients with less than 2 years of follow up, costs in the censored months were predicted using a generalized linear model with gamma distribution and log link function. To account for the nonlinear effect of time, both month and month-squared were included in the model. Observed total cost and predicted total cost were reported for both the first and second year. The observed total cost was also itemized to inpatient cost, outpatient cost, and pharmacy cost. Cost difference between OPC patients and controls was estimated and defined as the cost associated with cancer. Monthly cost was plotted using the combined observed and predicted costs; if patients were censored and observed cost was not available, predicted cost was used; otherwise, observed cost was used. All analyses were performed using SAS Enterprise Guide 7.1 (SAS institute, NC). All data were de-identified and therefore exempt from review by The University of Texas Health Science Center Committee for the Protection of Human Subjects.

Results

A total of 352 patients diagnosed with OPC during the 2008–2012 period were identified in the Texas Medicaid database. Of these, 148 patients (42%) were covered under Medicaid only and 204 (58%) were dual-eligible enrollees under Medicaid and Medicare (Table 1). The mean age of patients was 54.98 and 67.62 years for Medicaid-only and dual-eligible enrollees, respectively. Among OPC patients, there were more males (66.9% and 59.8% of the Medicaid-only and dual-eligible enrollees, respectively) than females, and nearly half (47.3% and 47.1% of the Medicaid-only and dual-eligible enrollees, respectively) were non-Hispanic whites. With 28.4% and 24.0%of patients in the Medicaid-only and dual-eligible groups, respectively, the health service region of Arlington had the highest rate of OPC patients. The demographic characteristics, Charlson comorbidity score, number of psychiatric diagnosis groups, and pre-diagnosis costs were not significantly different between OPC patients and controls among Medicaid-only and dual-eligible enrollees (Table 1).

The mean observed costs of OPC for Medicaid-only enrollees ($43,233 and $2165 for the first and second year, respectively) were higher than those for dual-eligible enrollees ($5392 and $1152 for the first and second year, respectively; Table 2). The highest costs were incurred for outpatient service in both groups.

Generalized linear model was applied to predict the censored monthly costs. After model adjustments, the cost differences between cases and controls among Medicaid-only beneficiaries were $45,102

Table 1
Baseline characteristics for oropharyngeal cancer patients and matched population controls.

Covariates	Medicaid-Medicare			Medicaid-only		
	Oropharyngeal cancer group (n = 204)	Control group (n = 204)	P Value	Oropharyngeal cancer group (n = 148)	Control group (n = 148)	*p*-value
Age, mean (SD), y	67.62 (10.98)	67.70 (11.14)	0.944	54.98 (6.09)	54.76 (6.13)	0.763
Sex			1.000			1.000
Female	82 (40.20%)	82 (40.20%)		49 (33.11%)	49 (33.11%)	
Male	122 (59.80%)	122 (59.80%)		99 (66.89%)	99 (66.89%)	
Race			0.722			0.795
White (not Hispanic)	96 (47.06%)	98 (48.04%)		70 (47.30%)	64 (43.24%)	
Black (not Hispanic)	44 (21.57%)	47 (23.04%)		47 (31.76%)	54 (36.49%)	
Hispanic	46 (22.55%)	47 (23.04%)		22 (14.86%)	23 (15.54%)	
Other	18 (8.82%)	12 (5.88%)		9 (6.08%)	7 (4.73%)	
Health service region			0.615			0.373
Public health region 1 - Lubbock	7 (3.43%)	8 (3.92%)		0 (0.00%)	3 (2.03%)	
Public health region 2/3 - Arlington	49 (24.02%)	55 (26.96%)		42 (28.38%)	45 (30.41%)	
Public health region 4/5 - Tyler	20 (9.80%)	24 (11.76%)		20 (13.51%)	13 (8.78%)	
Public health region 6/5 - Houston	43 (21.08%)	54 (26.47%)		40 (27.03%)	37 (25.00%)	
Public health region 7 - Temple	25 (12.25%)	18 (8.82%)		17 (11.49%)	19 (12.84%)	
Public health region 8 - San Antonio	24 (11.76%)	18 (8.82%)		18 (12.16%)	18 (12.16%)	
Public health region 9/10 - El Paso	9 (4.41%)	6 (2.94%)		7 (4.73%)	4 (2.70%)	
Public health region 11 - Harlingen	27 (13.24%)	21 (10.29%)		4 (2.70%)	9 (6.08%)	
Charlson comorbidity index score, mean (SD)[a]	1.90 (1.97)	1.80 (2.00)	0.636	1.66 (1.65)	1.69 (1.76)	0.865
No. of psychiatric diagnosis groups, mean (SD)[a]	0.17 (0.46)	0.25 (0.65)	0.137	0.20 (0.57)	0.25 (0.63)	0.498
Costs between 6 months and 3 months prior to diagnosis, mean (SD), $	559.0 (1344)	418.2 (806.4)	0.200	2141 (3391)	1990 (2946)	0.683

Abbreviation: SD, standard deviation.
[a] Charlson comorbidity index score and no. of psychiatric diagnosis groups were calculated for the 6 months prior to the index date.

and $11,684 for the first and second year, respectively (Table 2). For the dual-eligible enrollees, the cost differences between cases and controls were $5734 and $2162 for the first and second year, respectively. Higher Charlson Comorbidity index score, residing in the Harlingen health service region, being a female, being a case, higher costs between 6 months and 3 months prior to diagnosis, month-squared and interaction term between month-squared and case/control were significantly associated with higher monthly cost of OPC (Table 3). An example calculation of the model adjusted cost is provided in the Supplement. Costs for OPC cases in the first month ($4019) were higher than it in the second month ($3617). The highest cost for OPC cases was observed in the third month, then it gradually decreased until the tenth month (Fig. 1). After the tenth month, the costs remained steady (between $1000 and $2000 for cases and between $500 and $1000 for controls), until the end of the two-year follow-up period.

Table 2
Observed and adjusted cost differences between oropharyngeal cancer patients and controls by Medicare enrollment status.

Insurance	Year	Variable	Oropharyngeal cancer group		Control group		Differential cost		*p*-value
			Mean	SD	Mean	SD	Mean	SD	
Medicaid-only (n = 148)	**First year**	**All costs**	57,936	51,869	14,703	20,874	43,233	39,536	< 0.0001
		Inpatient service	15,918	23,214	4230	11,410	11,688	18,290	< 0.0001
		Outpatient service	37,983	36,892	6240	9385	31,743	26,918	< 0.0001
		Drug	4036	5470	4233	6143	−198	5816	0.7702
		Adjusted costs*	60,726	52,639	15,624	23,875	45,102	40,871	< 0.0001
	Second year	**All costs**	12,162	25,697	9997	21,943	2165	23,894	0.4364
		Inpatient service	2994	10,273	2946	13,046	47	11,741	0.9724
		Outpatient service	7626	17,216	5022	10,716	2604	14,339	0.1195
		Drug	1542	2955	2029	3549	−487	3266	0.2009
		Adjusted costs*	27,426	31,320	15,742	28,183	11,684	29,793	0.0008
Medicaid-Medicare (n = 204)	**First year**	**All costs**	7662	9341	2270	4370	5392	7292	< 0.0001
		Inpatient service	519	3242	85	486	435	2318	0.0596
		Outpatient service	7074	7551	2156	4302	4918	6145	< 0.0001
		Drug	69	253	29	104	40	193	0.0365
		Adjusted costs*	8102	9298	2368	4351	5734	7259	< 0.0001
	Second year	**All costs**	2341	4526	1189	2548	1152	3673	0.002
		Inpatient service	96	689	15	124	81	495	0.0989
		Outpatient service	2199	4230	1151	2512	1048	3479	0.0025
		Drug	46	169	23	124	23	148	0.1214
		Adjusted costs*	4004	4421	1842	2498	2162	3590	< 0.0001

Abbreviation: SD-standard deviation.
* The cost was adjusted so that the follow up period is the same for all enrollees after predicting the cost for the censored months using a generalized linear model with gamma distribution and log link function.

Table 3
Estimated coefficients for the generalized linear model, 2-year monthly cost estimate.

Parameter	Beta estimate	SE	95% confidence interval		Z	*p*-value
Intercept	6.9373	0.407	6.1396	7.7349	17.05	< 0.0001
Age	−0.0017	0.0057	−0.0128	0.0095	−0.29	0.7682
Charlson comorbidity index score[a]	0.1106	0.0305	0.0509	0.1703	3.63	0.0003
No. of psychiatric diagnosis groups[a]	0.1041	0.0718	−0.0367	0.2449	1.45	0.1474
Health service region						
Public health region 1 - Lubbock	−0.7952	0.2265	−1.2392	−0.3513	−3.51	0.0004
Public health region 4/5 - Tyler	−0.2514	0.1662	−0.5771	0.0742	−1.51	0.1302
Public health region 6/5 - Houston	0.1365	0.1539	−0.1652	0.4383	0.89	0.3751
Public health region 7 - Temple	−0.1534	0.1662	−0.4792	0.1723	−0.92	0.3559
Public health region 8 - San Antonio	0.0216	0.1651	−0.302	0.3452	0.13	0.896
Public health region 9/10 - El Paso	−0.2556	0.3967	−1.0331	0.522	−0.64	0.5194
Public health region 11 - Harlingen	0.5569	0.2096	0.1462	0.9676	2.66	0.0079
Public health region 2/3 - Arlington	Reference					
Gender						
Male	−0.2695	0.1078	−0.4808	−0.0582	−2.5	0.0124
Female	Reference					
Race						
Black (non-Hispanic)	0.0185	0.1314	−0.2391	0.276	0.14	0.8883
Hispanic	−0.3205	0.1419	−0.5987	−0.0424	−2.26	0.0239
Other	0.1786	0.1555	−0.1262	0.4833	1.15	0.2508
White (non-Hispanic)	Reference					
Medicare						
Yes	−1.7381	0.1448	−2.022	−1.4543	−12	< 0.0001
No	Reference					
Case/Control status						
Case	2.2119	0.154	1.91	2.5137	14.36	< 0.0001
Control	Reference					
Costs between 6 months and 3 months prior to diagnosis	0.0001	0	0.0001	0.0002	7.77	< 0.0001
Censor status						
Not censored	−0.0131	0.1014	−0.2118	0.1857	−0.13	0.8974
Censored	Reference					
Month						
Month	−0.0548	0.0256	−0.105	−0.0046	−2.14	0.0324
Month-squared	0.0025	0.0012	0.0002	0.0047	2.15	0.0314
Interaction between month and case status						
Month * case	−0.1372	0.0317	−0.1993	−0.0752	−4.33	< 0.0001
Month * control	Reference					
Month-square * case	0.003	0.0014	0.0002	0.0057	2.1	0.036
Month-square * control	Reference					

Abbreviation: SE-standard error.
*Sample interpretation:
Age: As age increase by 1 year-old, the 2-year monthly cost is exp(−0.0017) = 0.998 times lower, after adjusting for other covariates in the model. As age increase by 10 years-old, the 2-year monthly cost is exp(−0.0017 * 810) = 0.983 times lower, after adjusting for other covariates in the model.
Charlson comorbidity index score: As Charlson comorbidity index score increase by 1 point, the 2-year monthly cost is exp(0.1106) = 1.117 times higher, after adjusting for other covariates in the model.
Health service region: Compared with patients living in Arlington, the 2-year monthly cost for patients living in Houston is exp(0.1365) = 1.146 times higher, after adjusting for other covariates in the model.
[a] Charlson comorbidity index score and no. of psychiatric diagnosis groups were calculated during the six months prior to index date.

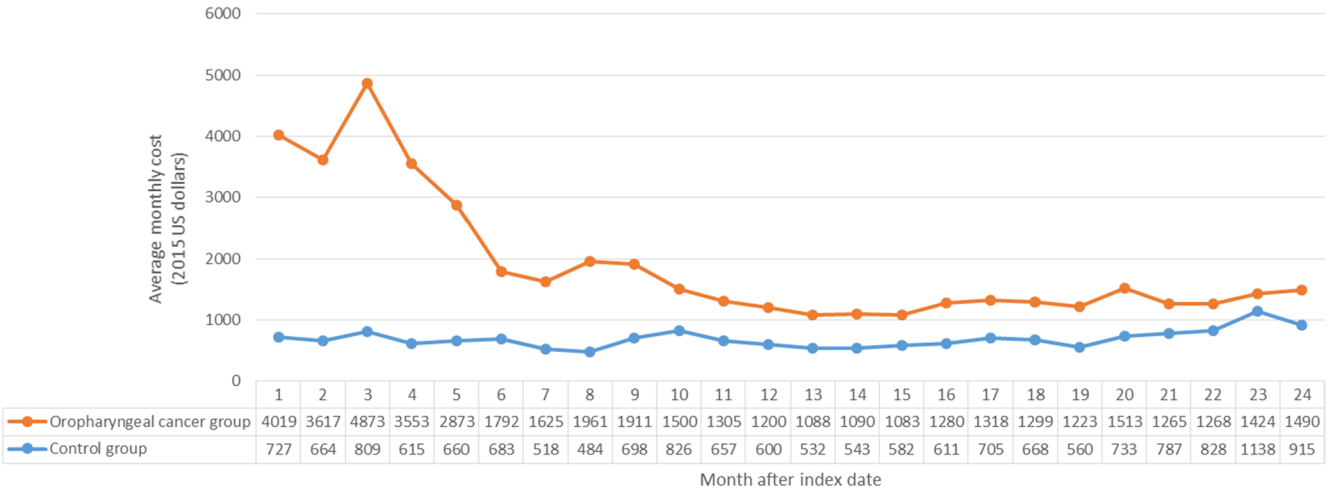

Fig. 1. Variation of the cost of oropharyngeal cancer in patients insured by Texas Medicaid from the date of cancer diagnosis to the 24th month of follow-up.

Discussion

In this study, the mean differential health care costs to the Texas Medicaid program for the first 2 years following OPC diagnosis were substantially higher for Texas residents enrolled in Medicaid only ($56,786) than for those enrolled in both Medicare and Medicaid ($7896). The main explanation for this difference is that, for the Medicaid-only enrollees, the cost reported represents the total cost of OPC treatment from the Medicaid program perspective, while for the dual-eligible enrollees, our estimates represent only the Medicaid portion of cost of OPC treatment, as Medicare cost was not available for analysis in the study. Patients who were male, had more comorbidities, were Hispanic, had Medicaid only, or lived in the Harlingen region were more likely to have a greater monthly cost in the first 2 years of treatment. To our knowledge, this is the first population-based study on the cost associated with management of OPC in patients enrolled in Texas Medicaid.

The incidence of OPCs in the United States has been rising in the past decade [3], probably reflecting the substantial increase in the incidence of HPV-related OPCs. Since there currently exists no validated screening option for this malignancy, HPV vaccination offers the only opportunity for prevention of OPCs. Because vaccination policy is decided at a state level in the United States, state-wide assessment of direct costs incurred by OPC patients is essential to determine the potential economic consequences of HPV vaccination for the state. Since safety net programs are budgeted by the state government, cost of care for patients insured by Medicaid may be of utmost importance.

Ten years ago, Epstein et al. investigated the cost of treatment for oral and pharyngeal cancers using a cohort of patients insured by Medi-Cal, the California Medicaid program [14]. The authors found that treatment costs were $33,358 (2015 USD) in the first year after diagnosis, lower than the costs observed in our study. However, the Medi-Cal patients represented a heterogeneous group of cancers. Treatment of OPC differs widely from oral cavity cancer and other cancers of the pharynx (e.g. hypopharyngeal and nasopharyngeal carcinomas) [15]. OPC is now mainly attributable to HPV, in contrast to cancers at other head and neck sites which rarely are [16], and are recognized to be a subset of head and neck cancers with distinct epidemiological, pathological, and clinical characteristics [17]. Patients with HPV-related OPC are less likely to have a history of alcohol and tobacco use than those with cancers at other head and neck [17], and typically present with a small tumor burden with neck nodal metastases [18]. Treatment of OPC often incudes radiation and those with HPV-related disease have an improved prognosis compared to those with HPV-unrelated disease [19]. Mainly due to different treatment strategies in oral cavity versus OPCs, health care cost of OPC may be underestimated when OPC is combined with oral cavity cancer [20,21]. Cost estimates derived from SEER-Medicare data by Hollenbeak et al. [22] ($48,544 [2015 USD]) and Hu and Goldie [23] ($42,534 [2015 USD]) were closer to the findings in our study. Although these studies included OPC with oral cavity cancer, Medicare generally pays more for services than Medicaid. These offsetting effects resulted in mean cost estimates similar to our findings for Medicaid OPC cases.

Our estimate ($88,152) for overall cost during the first 2 years after diagnosis of OPC in Texas Medicaid-insured patients is lower than that in our previous study, in which the overall first-2-year cost for Texas commercially insured OPC patients was $160,639 [11]. Part of the reason why Medicaid-insured OPC patients had lower cost may be because on average, Medicaid generally has lower payment rates than private insurance for the same services. A study of 2005 Medical Expenditure Panel Survey data found that—after adjusting for health status, socioeconomic status, and other factors—if an average adult were covered by Medicaid instead of private insurance, inpatient hospital, outpatient hospital, and physician expenditures would be 33%, 40%, and 34% lower, respectively [24]. A recent survey of Medicaid physician fees revealed that in 2016 in Texas, Medicaid fees were 65% of the Medicare fees, and for primary care the Medicaid-to-Medicare ratio was only 58% [25]. Studies have demonstrated disparities in access to health care related to health insurance status, such as hospital utilization (nonteaching vs. teaching hospitals) [26] and coverage of medications and procedures [27,28]. These also likely contributed to the cost difference between Medicaid and private insurance in OPC treatment.

This study has some limitations. Our study may be underpowered to detect significant cost differences due to a relatively small sample size. We used propensity score matching to balance observable risk factors related to medical care cost but could not correct for unobservable factors that may affect costs. Although Texas Medicaid database provides excellent medical claim data, disease-specific variables were limited, and we were unable to analyze the variation in cost based on stage at diagnosis, HPV status or end of life care. This lack of disease-specific variables, along with retrospective data confined to Texas, limits the generalizability of our findings. In addition, adults may be more likely to enroll in Medicaid when they are ill; so the differential cost may be underestimated.

The strengths of this study include up-to-date comprehensive longitudinal medical claims data and a robust methodology to assess the differential cost due to OPC, adjusting for the unrelated cost, right censoring, and not normally distributed data. We estimated medical cost of OPC by demographic and health characteristics such as age, race, dual-eligible status, and comorbid conditions. By incorporating these characteristics into our model and including only HPV-related OPCs (well-defined ICD-9-CM site codes), we can address questions regarding health care costs of these HPV-related cancers and risk factors that affect cost in the Texas Medicaid population.

In conclusion, after diagnosis of OPC, mean incremental medical cost for Medicaid was about $45,100 in the first year and 11,700 in the second year in Texas Medicaid-only patients, and about $5700 in the first year and $2200 in the second year in dual-eligible patients, indicating a significant cost burden of OPC. As costs for running Medicaid continue to grow, this study provides important parameters for future decision-analytic models of the cost-effectiveness of investments to increase HPV vaccination in Texas.

Funding

This study was supported by the Christopher and Susan Damico Chair in Viral Associated Malignancies, the Stiefel Oropharyngeal Research Fund, a Cancer Prevention Fellowship supported by the Cancer Prevention and Research Institute of Texas (CPRIT) grant award, RP170259 (J.F.D), and the contribution from the Lyda Hill Foundation to the Moon Shots Program of The University of Texas MD Anderson Cancer Center. The study sponsors provided financial resources to support the research but had no role in the design, conduct, or interpretation of the study.

Declaration of Competing Interest

None declared.

Acknowledgement

We acknowledge the editing services provided by the Department of Scientific Publications at MD Anderson Cancer Center.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.oraloncology.2019.06.033.

References

[1] Jemal A, Simard EP, Dorell C, Noone AM, Markowitz LE, Kohler B, et al. Annual Report to the Nation on the Status of Cancer, 1975–2009, featuring the burden and trends in human papillomavirus(HPV)-associated cancers and HPV vaccination coverage levels. J Natl Cancer Inst 2013;105(3):175–201.

[2] Viens LJ, Henley SJ, Watson M, Markowitz LE, Thomas CC, Thompson TD, et al. Human papillomavirus-associated cancers - United States, 2008–2012. MMWR Morb Mortal Wkly Rep 2016;65(26):661–6.

[3] Chaturvedi AK, Engels EA, Pfeiffer RM, Hernandez BY, Xiao W, Kim E, et al. Human papillomavirus and rising oropharyngeal cancer incidence in the United States. J Clin Oncol 2011;29(32):4294–301.

[4] Gillison ML, Chaturvedi AK, Anderson WF, Fakhry C. Epidemiology of human papillomavirus-positive head and neck squamous cell carcinoma. J Clin Oncol 2015;33(29):3235–42.

[5] Saraiya M, Unger ER, Thompson TD, Lynch CF, Hernandez BY, Lyu CW, et al. US assessment of HPV types in cancers: implications for current and 9-valent HPV vaccines. J Natl Cancer Inst 2015;107(6):djv086.

[6] Drolet M, Benard E, Boily MC, Ali H, Baandrup L, Bauer H, et al. Population-level impact and herd effects following human papillomavirus vaccination programmes: a systematic review and meta-analysis. Lancet Infect Dis 2015;15(5):565–80.

[7] Elbasha EH, Dasbach EJ. Impact of vaccinating boys and men against HPV in the United States. Vaccine 2010;28(42):6858–67.

[8] Brisson M, Laprise JF, Chesson HW, Drolet M, Malagon T, Boily MC, et al. Health and economic impact of switching from a 4-valent to a 9-valent HPV vaccination program in the United States. J Natl Cancer Inst 2016;108(1).

[9] Boiron L, Joura E, Largeron N, Prager B, Uhart M. Estimating the cost-effectiveness profile of a universal vaccination programme with a nine-valent HPV vaccine in Austria. BMC Infect Dis 2016;16:153.

[10] Walker TY, Elam-Evans LD, Yankey D, Markowitz LE, Williams CL, Mbaeyi SA, et al. National, regional, state, and selected local area vaccination coverage among adolescents aged 13–17 Years - United States, 2017. MMWR Morb Mortal Wkly Rep 2018;67(33):909–17.

[11] Lairson DR, Wu CF, Chan W, Dahlstrom KR, Tam S, Sturgis EM. Medical care cost of oropharyngeal cancer among texas patients. Cancer Epidemiol Biomarkers Prev 2017;26(9):1443–9.

[12] Bulsara VM, Worthington HV, Glenny AM, Clarkson JE, Conway DI, Macluskey M. Interventions for the treatment of oral and oropharyngeal cancers: surgical treatment. Cochrane Database Syst Rev 2018;12:CD006205.

[13] Ashcraft ML, Fries BE, Nerenz DR, Falcon SP, Srivastava SV, Lee CZ, et al. A psychiatric patient classification system. An alternative to diagnosis-related groups. Med Care 1989;27(5):543–57.

[14] Epstein JD, Knight TK, Epstein JB, Bride MA, Nichol MB. Cost of care for early- and late-stage oral and pharyngeal cancer in the California Medicaid population. Head Neck 2008;30(2):178–86.

[15] Razfar A, Mundi J, Grogan T, Lee S, Elashoff D, Abemayor E, et al. IMRT for head and neck cancer: cost implications. Am J Otolaryngol 2016;37(6):479–83.

[16] Castellsague X, Alemany L, Quer M, Halec G, Quiros B, Tous S, et al. HPV involvement in head and neck cancers: comprehensive assessment of biomarkers in 3680 patients. Jnci-J Natl Cancer I 2016;108(6).

[17] Gillison ML, D'Souza G, Westra W, Sugar E, Xiao W, Begum S, et al. Distinct risk factor profiles for human papillomavirus type 16-positive and human papillomavirus type 16-negative head and neck cancers. J Natl Cancer Inst 2008;100(6):407–20.

[18] Gillison ML, Alemany L, Snijders PJF, Chaturvedi A, Steinberg BM, Schwartz S, et al. Human papillomavirus and diseases of the upper airway: head and neck cancer and respiratory papillomatosis. Vaccine 2012;30:F34–54.

[19] Ang KK, Harris J, Wheeler R, Weber R, Rosenthal DI, Nguyen-Tan PF, et al. Human papillomavirus and survival of patients with oropharyngeal cancer. N Engl J Med 2010;363(1):24–35.

[20] Dahlstrom KR, Calzada G, Hanby JD, Garden AS, Glisson BS, Li G, et al. An evolution in demographics, treatment, and outcomes of oropharyngeal cancer at a major cancer center: a staging system in need of repair. Cancer 2013;119(1):81–9.

[21] Borggreven PA, Aaronson NK, Verdonck-de Leeuw IM, Muller MJ, Heiligers ML, Bree R, et al. Quality of life after surgical treatment for oral and oropharyngeal cancer: a prospective longitudinal assessment of patients reconstructed by a microvascular flap. Oral Oncol 2007;43(10):1034–42.

[22] Hollenbeak CS, Kulaylat AN, Mackley H, Koch W, Schaefer EW, Goldenberg D. Determinants of medicare costs for elderly patients with oral cavity and pharyngeal cancers. JAMA Otolaryngol Head Neck Surg 2015;141(7):628–35.

[23] Hu D, Goldie S. The economic burden of noncervical human papillomavirus disease in the United States. Am J Obstet Gynecol 2008;198(5). 500 e1–7.

[24] Ku L. Medical and dental care utilization and expenditures under Medicaid and private health insurance. Med Care Res Rev 2009;66(4):456–71.

[25] Zuckerman S, Skopec L, Epstein M. Medicaid physician fees after the ACA primary care fee bump. Washington, DC: Urban Institute; 2017.

[26] Bhattacharyya N, Abemayor E. Patterns of hospital utilization for head and neck cancer care: changing demographics. JAMA Otolaryngol Head Neck Surg. 2015;141(4):307–12. quiz 400.

[27] Lieberman DA, Polinski JM, Choudhry NK, Avorn J, Fischer MA. Medicaid prescription limits: policy trends and comparative impact on utilization. BMC Health Serv Res 2016;16:15.

[28] Giladi AM, Aliu O, Chung KC. The effect of medicaid expansion in New York state on use of subspecialty surgical procedures by medicaid beneficiaries and the uninsured. J Am Coll Surg. 2014;218(5):889–97.