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Postoperative radiation performed at the same surgical facility associated with improved overall survival in oral cavity squamous cell carcinoma

Arya Amini, MD^{1,2}, William A. Stokes, MD¹, Bernard L. Jones, PhD¹, Sagus Sampath, MD¹, Robert S. Kang, MD, PhD³, Thomas J. Gernon, MD³, Ellie G. Maghami, MD³, Erminia Massarelli, MD, PhD, MS⁴, Cathy J. Bradley, PhD⁵, Sana D. Karam, MD, PhD²

¹Department of Radiation Oncology, City of Hope National Cancer Center, Duarte, California

²Department of Radiation Oncology, University of Colorado School of Medicine, Aurora, Colorado

³Division of Head and Neck Surgery, City of Hope National Cancer Center, Duarte, California

⁴Department of Medical Oncology & Therapeutics Research, City of Hope National Cancer Center, Duarte, California

⁵Department of Health Systems Management and Policy, Colorado Comprehensive Cancer Center, University of Colorado, Aurora, Colorado

Abstract

Background: The purpose of this analysis is to evaluate whether postoperative radiotherapy (PORT) at the same facility as surgery portends to better survival outcomes compared to PORT given at a different facility.

Methods: Patients underwent upfront surgery at the National Cancer Database reporting facility followed by PORT. PORT was coded as performed at either the same facility or at a different facility as surgery.

Results: A total of 10 832 patients were selected. Five-year overall survival (OS) was higher in patients undergoing PORT at the same facility: 52.5% vs 48.4% ($P < 0.001$). PORT performed at the same facility was associated with improved OS under multivariate (HR, 0.92; $P = 0.01$) and propensity score matched (hazard ratio, 0.90; $P = 0.004$) analyses.

Conclusions: OS was better among patients with head and neck cancer who received PORT at the same facility as surgery.

Correspondence Arya Amini, Department of Radiation Oncology, City of Hope National Cancer Center, 1500 E. Duarte Road, Duarte, CA 91010. aamini@coh.org.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

CONFLICT OF INTEREST

The authors have no conflicts of interest to report.

Keywords

facility location; National Cancer Database (NCDB); oral cavity cancer; outcomes; postoperative radiation therapy (PORT)

1 | INTRODUCTION

Management of most locally advanced head and neck cancers (HNCs) requires multimodality therapy, which typically includes surgery and radiation therapy (RT), with or without concurrent chemotherapy.¹ Coordination of care between the specialty services can be complex. For patients requiring postoperative radiation (PORT), communication among the surgical, medical, and radiation teams is critical in properly timing adjuvant treatment and guiding the appropriate therapies indicated based on individual risk factors. Furthermore, RT fields are more complicated in the postoperative setting given the alteration in normal anatomy after surgery. For this reason, direct communication between the surgeon and radiation oncologists plays an important role in delineating areas at higher risk of recurrence such as areas of the resection bed where margins are questionable and may require a higher dose of RT or potential nerve tracking that may also necessitate changes in RT planning.

Because of the extensive time commitment for patients undergoing PORT or additional factors out of patients' control including insurance authorization, many receive RT closer to home, at a different facility than where their surgery was performed. Given the relative rarity of HNCs with respect to other malignancies, there is growing evidence that higher volume and more specialized centers that focus on HNCs both in surgery and radiation oncology are associated with better overall survival (OS).²⁻⁴ There are, however, limited data demonstrating whether outcomes in patients requiring multimodality therapy (surgery followed by RT with or without chemotherapy) for HNCs are improved when performed all at the same institution. The objective of this study was to evaluate the impact of receiving PORT at the same facility as surgery vs receiving PORT at a different facility from surgery.

2 | PATIENTS AND METHODS

2.1 | Data source and patient selection

The National Cancer Database (NCDB) is a joint project of the Commission on Cancer of the American College of Surgeons and the American Cancer Society. It is a hospital-based registry that represents 70% of all cancer cases in the United States, drawing data from more than 1500 commission-accredited cancer programs. The NCDB contains detailed information on disease stage, risk-factors specific to HNC, and receipt of treatment including surgery, radiation, and chemotherapy delivered during the first course of treatment. The data used in the study are derived from a de-identified NCDB file. The American College of Surgeons and the Commission on Cancer have not verified and are not responsible for the analytic or statistical methodology employed, or the conclusions drawn from these data by the investigator. The NCDB has established criteria to ensure the data

submitted meet specific quality benchmarks. The following NCDB analysis was performed with the approval of our local institutional review board.

We initially queried patients with oral cavity, oropharynx, nasopharynx, larynx, hypopharynx, nasal cavity, and salivary gland carcinomas (all histologies) diagnosed between 2004 and 2013 (Figure 1). Patients included in the primary query received upfront surgery (site-specific surgery code “30 or higher”) at the reporting facility and had known follow up; biopsy only (site specific surgery code “0”), local tumor destruction (site specific surgery code “20”), and local tumor excision (site specific surgery code “20”) were excluded. Patients receiving neoadjuvant chemotherapy and/or RT were excluded. The cohort was next limited to patients with nonmetastatic disease who received PORT. The group was subsequently limited to only patients diagnosed with squamous cell carcinoma of the oral cavity; all other head and neck disease sites and histologies were excluded. The final group selected had known location of RT, either at the same site of the reporting facility where upfront surgery was performed or at a different site than surgery (<http://ncdbpuf.facs.org/content/location-radiation-treatment>).

2.2 | Patient demographics and treatment variables

Potentially relevant patient and treatment characteristics were included. Age was analyzed as a continuous variable. Race was categorized as white, African-American, and all others. Insurance status was defined by the NCDB and included not insured, private insurance/managed care, government (Medicaid, Medicare, other government), and unknown. Metropolitan, urban, and rural residence was coded based on published files by the US Department of Agriculture Economic Research Service. Median household income in the patient zip code was assessed as quartiles relative to the US population. Patient comorbidities were categorized as 0, 1, or 2 according to Charlson-Deyo (CD) comorbidity scores.⁵ Institution type was classified as community cancer program, comprehensive community cancer program, integrated network cancer program, and academic/research program including National Cancer Institute (NCI)-designated comprehensive cancer centers. Each patient stage was based on the edition corresponding to their year of diagnosis (American Joint Committee on Cancer [AJCC] 5th, 6th, or 7th edition). Time from diagnosis to surgery and time from diagnosis to start of RT were subtracted from one another to define the time between surgery and RT; the study defined PORT delay using a cutoff of 42 days (6 weeks) based on the National Comprehensive Cancer Network (NCCN) guideline recommendations suggesting PORT start within 5–6 weeks after surgery.¹ The NCDB records the elapsed days of RT from start of RT to finish, and the cutoff of 48 days (median) was selected. Concurrent chemotherapy with RT was defined as starting within 14 days of RT start.

The primary end point was OS.

2.3 | Statistical analysis

All statistical analyses were performed using SPSS V24.0 (SPSS Inc., Chicago, Illinois). Pearson chi-square tests were used to assess associations between categorical variables and RT treatment facility.

OS interval was calculated from the date of diagnosis to the date of death. OS was first examined using the Kaplan-Meier method. Univariate survival analysis was performed with the log-rank test and unadjusted Cox proportional hazards models to estimate hazard ratios (HR); HR > 1 corresponded to worse OS. Patient and clinical variables were selected a priori. Variables included location of RT relative to surgery, age, sex, race, insurance, residence, median household income, CD-comorbidity score, facility type, facility location, year of diagnosis, tumor site, AJCC stage, margin status, extracapsular extension (ECE), lymph node dissection, time between surgery and RT, duration of RT, and receipt of adjuvant chemotherapy. Multivariate Cox regression analysis (MVA) was performed using OS as outcomes. The proportional hazards assumption was assessed using a test of Schoenfeld residuals for covariates in all final models and returned no significant results.⁶

Subgroup analysis of those with known margin status and ECE in order to confirm the results remained consistent with the overall study findings.

Multivariate logistic regression models were used to identify predictors of receipt of RT at the same facility or different facility as their initial surgery. The Hosmer-Lemeshow test was used to check for the goodness-of-fit of the regression models.

To further account for confounding variables, propensity score matching (PSM) was performed to compare OS outcomes between patients receiving RT at the same facility vs different facility; the same variables used in the multivariate model were included. One-to-one propensity matching without replacement was performed using caliper match algorithm described by Coca-Perraillon,⁷ with the caliper width set to 0.05 times the SD of the logit of the propensity score.⁸ Survival outcomes were assessed using a log-rank test, and the HR was determined by univariate Cox regression.

3 | RESULTS

3.1 | Patient characteristics

A total of 10 832 patients were included in the study: 6781 (63%) received PORT at the same facility as surgery and 4051 (37%) received RT at a different facility (Figure 1, Table 1). Median age of the entire cohort was 60 years (18–90 years). The majority of patients with oral cavity cancer underwent a lymph node dissection (93%). Most patients initiated PORT after 42 days (6 weeks) of their surgery (65%) and most completed RT within 48 days (Table 1).

Under multivariate logistic regression adjusting for patient characteristics (Table 2), receipt of PORT at the same facility was more common at larger institutions including comprehensive community cancer programs (odds ratio [OR], 1.79), academic/research (including NCI) facilities (OR, 1.54), or an integrated network cancer program (OR, 1.64). Patients with HNC undergoing PORT at the same facility were also more likely to receive concurrent chemotherapy (OR, 1.27). Patients receiving PORT at the same facility were less likely to undergo lymph node dissections (OR, 0.81), have treatment delays (>6 weeks) between surgery and start of PORT (OR, 0.79), or complete RT longer than a period of 48 days (OR, 0.62).

3.2 | Overall survival

The median follow-up for the entire cohort was 30 months (range, 1–141 months). Two- and 5-year OS rates were 69.2% and 51.0%, respectively. Five-year OS rates were higher in patients undergoing PORT at the same facility compared to a different facility: 52.5% vs 48.4% respectively (HR, 0.86; 95% confidence interval [CI], 0.81–0.91; $P < 0.001$) (Figure 2A).

Under MVA, patients with HNC undergoing PORT performed at the same facility as surgery had longer OS compared to those receiving PORT at an outside facility (HR, 0.92; 95% CI, 0.87–0.98; $P = 0.01$). Additional variables associated with improved OS under MVA included surgery at an academic/research institution and receipt of chemotherapy. Factors associated with worse OS under MVA were older age, government insurance or uninsured status, higher CD-comorbidity score, treatment in the South, higher T- and N-classification, positive margins, presence of ECE, and RT duration of treatment >48 days (Table 3).

On subgroup analysis of those undergoing both a primary and neck node dissection with known margin status and ECE (7602 patients included with 4763 treated at the same facility and 2839 treated at a different facility), RT at the same facility remained associated with improved OS under MVA (HR, 0.91; 95% CI, 0.84–0.98; $P = 0.02$) (Supplementary Table 1).

3.3 | Propensity score matching

PSM for all patients combined resulted in a cohort consisting of 3546 patients, well-matched and divided evenly between RT at the same facility and different facility. Consistent with the MVA, HNCs receiving PORT at the same facility had longer 5-year OS (59.4% vs 56.7%) (HR, 0.90; 95% CI, 0.84–0.97; $P = 0.004$) (Figure 2B).

4 | DISCUSSION

The main finding from this study suggesting better OS when PORT is conducted at the same facility as surgery may be indicative of the complexity of HNC treatment. Additional variables including surgical facility type, known socioeconomic factors including median household income, and insurance status, and RT durations extending beyond 48 days also appeared to contribute to OS in this analysis. Approximately one-third of all patients in this study experienced RT durations extending beyond 48 days suggesting breaks in treatment; additionally, two-thirds of all patients with oral cavity cancer in this national database did not initiate PORT within the recommended 6 weeks of their surgery which current NCCN guidelines suggest, although this was not a significant predictor of OS in our analysis.

Our study directly shows a correlation of improved survival in patients receiving surgery and RT at the same facility. There are currently other studies as well, which suggest indirectly that this may be the case as patients with HNC treated at higher volume or specialized cancer centers appear to have improved outcomes.^{3,4,9,10} Chen et al. utilized the NCDB to evaluate survival outcomes by facility volume for locally advanced laryngeal cancer and confirmed that high-volume centers were associated with improved OS.⁹ A similar study using the Surveillance Epidemiology, and End Results-Medicare database also found

patients with locally advanced head and neck squamous cell cancer had improved outcomes at high-volume centers suggesting this may be due to multiple factors, including increased likelihood of multidisciplinary involvement.¹⁰ Both these studies perhaps indirectly support our findings that larger centers which have multidisciplinary care allow for better communication and patient care between the services. In our study, even after accounting for facility type, OS did remain independently associated with PORT at the same facility. Under logistic regression, however, there did appear to be a relationship between facility type/volume and receipt of RT at the same facility, as our analysis demonstrated a greater likelihood of receiving PORT at the same facility if the facility was a comprehensive cancer, integrated network cancer program, or academic cancer program. Patients treated at community cancer programs were less likely to receive PORT at the same facility.¹¹

There may be several other factors contributing to the survival improvement when PORT is performed at the same facility as surgery. For example, patients undergoing RT at the same facility as their surgery were less likely to start PORT greater than 6 weeks after surgery, a known prognostic factor in head and neck.^{1,12} Although the interval between surgery and PORT is a known predictor of outcomes, our study does not appear to suggest this as a major factor in OS; perhaps more surprising and in need of further exploration is the finding that nearly two-thirds of the population with oral cavity cancer in this national data set had surgery and PORT interval delays greater than the recommended 6 weeks. Next, total RT duration was less than 48 days when RT was performed at the same facility as surgery, suggesting less breaks in RT; this may again be due to more comprehensive care available to patients at a larger cancer center. Like many cancer sites, HNC requires a multidisciplinary approach involving medical, surgical, and radiation oncologists, in addition to supportive services to provide optimal treatment and close monitoring of toxicities that may cause treatment interruptions and potential unnecessary hospitalizations. Variables that could not accurately be assessed in the NCDB and which may also play a role in improved survival outcomes for those undergoing PORT at the same facility as their surgery include more direct communication between surgeons and radiation oncologists during tumor board discussion. Given the complex anatomy in the postoperative setting, clear communication between the surgeon and radiation oncologist plays perhaps an even more important role in the treatment of HNCs. RT volumes and dosing in the postoperative setting are largely based on areas at highest risk for recurrence; a multidisciplinary tumor board discussion in the presence of medical, surgical, and radiation oncology, in addition to pathology and radiology, provides an important venue for the radiation oncologist to define and refine his or her RT fields based on high-risk areas. In the era of intensity-modulated RT, the complexity of contouring and treatment planning are critical, as a minor deviation from the standard of care or an oversight of a high-risk area (close or positive margin, major perineural invasion requiring nerve tracking to the base of skull) could make the difference in disease control, as studies in HNC have demonstrated.³

The NCDB confers several benefits over other population databases, including a large sample size. However, the NCDB is limited by its retrospective nature and the potential for miscoding. Next, there may be an inherent selection bias for those receiving RT at the same facility, not accounted for with the variables available in the NCDB. However, our results hold under PSM analysis, which attempts to account for this bias, although the impact by

facility type became relatively smaller after adjusting for imbalances in the cohorts. Details of RT, including total dose and treatment site (primary and nodal levels) recorded, are incompletely coded with errors in the NCDB and therefore not utilized in this analysis. Other limitations include the lack of documentation of type of chemotherapy used or inclusion of additional prognostic information including depth of invasion, perineural invasion, lymphovascular invasion, or performance status before or after surgery. Although receipt and timing of chemotherapy were known, the specific chemotherapy agent, dose, and number of cycles administered were unknown. Furthermore, facility type in this study is the NCDB reporting facility which is where the upfront surgery was performed; that same facility type is applicable to the RT site only for those treated at the same facility as surgery. The NCDB does not provide facility type information for patients treated at a different facility. Outcome measurements are limited to OS in this study and overall follow-up was short.

In summary, PORT at the same facility as surgery appears to be associated with improved OS in patients with HNC, although the observed differences became relatively smaller (absolute benefit of 4%) in both cohorts and may not appear clinically meaningful to all practitioners. These results may reflect decreased RT breaks during treatment, overall physician experience (surgical, radiation, and medical oncologists), improved communication between providers, and delivery of higher quality, guideline-concordant RT. Although logistically challenging and impractical for all patients to receive adjuvant therapy at the same institution as their surgery, physicians may want to consider adjuvant treatment at the same facility in more complicated scenarios where clear communication between services are needed. Given the rarity of HNC and complexity of RT design and planning inherent in the postoperative setting, the importance of receiving PORT at the same facility is perhaps even more pronounced, and we suspect this may impact survival in other less common malignancies with technically difficult RT treatment planning and delivery.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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FIGURE 1.
Flowchart illustrating patient selection for the final analysis and exclusion criteria

FIGURE 2.

Kaplan-Meier curves illustrate overall survival, unadjusted (A) and adjusted by propensity score matching (B), between patients receiving postoperative radiation therapy (PORT) at the same facility or different facility as surgery

TABLE 1

Patient and treatment characteristics

Characteristic	All patients		RT at same facility		RT at different facility		P
	No. of patients	%	No. of patients	%	No. of patients	%	
Age							
<65 years	6930	64.0	4446	65.6	2484	61.3	<0.001
65 years	3902	36.0	2335	34.4	1567	38.7	
Sex							0.38
Male	7017	64.8	4414	65.1	2603	64.3	
Female	3815	35.2	2367	35.2	1448	35.7	
Race							<0.001
White	9389	86.7	5744	84.7	3645	90.0	
African-American	904	8.3	661	9.7	243	6.0	
Others	446	4.10	324	4.8	122	3.0	
Missing	93	0.9	52	0.8	41	1.0	
Insurance status							<0.001
Private insurance/managed care	4827	44.6	3091	45.6	1736	42.9	
Government	5268	48.6	3172	46.8	2096	51.7	
Uninsured	607	5.6	415	6.1	192	4.7	
Missing	130	1.2	103	1.5	27	0.7	
Residence							<0.001
Metropolitan	8603	79.4	5608	82.7	2995	73.9	
Urban	1699	15.7	861	12.7	838	20.7	
Rural	185	1.7	95	1.4	90	2.2	
Missing	345	3.2	217	3.2	128	3.2	
Median household income (USD)							<0.001
<30 000	1954	18.0	1209	17.8	745	18.4	
30 000–34 999	2736	25.3	1543	22.8	1193	29.4	
35 000–45 999	2827	26.1	1767	26.1	1060	26.2	
46 000	3169	29.3	2168	32.0	1001	24.7	
Missing	146	1.3	94	1.4	52	1.3	

Characteristic	All patients		RT at same facility		RT at different facility		P
	No. of patients	%	No. of patients	%	No. of patients	%	
Charlson-Deyo comorbidity score							0.36
0	8106	74.8	5097	75.2	3009	74.3	
1	2146	19.8	1336	19.7	810	20.0	
2+	580	5.4	348	5.1	232	5.7	
Facility type							<0.001
Community Cancer Program	266	2.5	139	2.0	127	3.1	
Comprehensive Community Cancer Program	1886	17.4	1224	18.1	662	16.3	
Academic/Research (includes NCI)	7116	65.7	4425	65.3	2691	66.4	
Integrated Network Cancer Program	991	9.1	619	9.1	372	9.2	
Other	573	5.3	374	5.5	199	4.9	
Facility location							0.001
West	1451	13.4	890	13.1	561	13.8	
Midwest	3223	29.8	2096	30.9	1127	27.8	
South	3547	32.7	2065	30.5	1482	36.6	
East	2038	18.8	1356	20.0	682	16.8	
NOS	573	5.3	374	5.5	199	4.9	
Year of diagnosis							0.15
2004–2006	1861	17.2	1199	17.7	662	16.3	
2007–2009	2930	27.0	1806	26.6	1124	27.7	
2010–2013	6041	55.8	3776	55.7	2265	55.9	
T classification							<0.001
T1	2261	20.9	1461	21.5	800	19.7	
T2	3495	32.3	2271	33.5	1224	30.2	
T3	1346	12.4	874	12.9	472	11.7	
T4 NOS	168	1.6	99	1.5	69	1.7	
T4a	3393	31.3	1979	29.2	1414	34.9	
T4b	169	1.6	97	1.4	72	1.8	
N classification							0.18
N0	4054	37.4	2523	37.2	1531	37.8	
N1	2125	19.6	1345	19.8	780	19.3	

Characteristic	All patients		RT at same facility		RT at different facility		P
	No. of patients	%	No. of patients	%	No. of patients	%	
N2 NOS	241	2.2	156	2.3	85	2.1	
N2a	308	2.8	210	3.1	98	2.4	
N2b	3109	28.7	1945	28.7	1164	28.7	
N2c	896	8.3	536	7.9	360	8.9	
N3	99	0.9	66	1.0	33	0.8	
Lymph node neck dissection							0.002
No	787	7.3	535	7.9	252	6.2	
Yes	10 037	92.7	6239	92.0	3798	93.8	
Unknown	8	0.1	7	0.1	1	0.0	
Margin status							0.02
Negative	8620	79.6	5351	79.6	3269	80.7	
Positive	2021	18.7	1295	19.1	726	17.9	
Unknown	191	1.8	135	2.0	56	1.4	
Extracapsular Extension							0.34
No	3996	36.9	2466	36.9	1530	37.8	
Yes	1669	15.4	1052	15.5	617	15.2	
Unknown	5167	47.7	3263	48.1	1904	47.0	
Time between surgery and RT days							<.001
42	3146	29.0	2147	21.7	999	24.7	
>42	7066	65.2	4421	65.2	2645	65.3	
Missing	620	5.7	213	3.1	407	10.0	
Duration of RT treatment days							<.001
48	6096	56.3	4232	62.4	1864	46.0	
>48	3864	35.7	2305	34.0	1559	38.5	
Missing	872	8.1	244	3.6	628	15.5	
Chemotherapy							<.001
No	5790	53.5	3520	51.9	2270	56.0	
Yes	4850	44.8	3166	46.7	1684	41.6	
Missing	192	1.8	95	1.4	97	2.4	

Abbreviations: AJCC, American Joint Committee on Cancer; NCI, National Cancer Institute; NOS, not otherwise specified; RT, radiation therapy.

TABLE 2

Logistic regression analysis of predictors for postoperative radiation at the same surgical facility

Variable	Multivariate analysis		
	OR	95% CI	P
Age			
<65 years	1		
65 years	0.87	0.78–0.96	0.007
Sex			
Male	1		
Female	0.96	0.88–1.05	0.41
Race			
White	1		
African-American	1.86	1.57–2.20	<0.001
Others	1.73	1.38–2.18	<0.001
Missing	0.83	0.53–1.29	0.40
Insurance status			
Private insurance/managed care	1		
Government	1.04	0.94–1.16	0.42
Uninsured	1.45	1.19–1.75	<0.001
Missing	2.90	1.84–4.57	<0.001
Residence			
Metropolitan	1		
Urban	0.59	0.53–0.67	<0.001
Rural	0.63	0.46–0.86	0.004
Missing	0.98	0.74–1.31	0.91
Median household income (USD)			
<30 000	1		
30 000–34 999	0.82	0.72–0.93	0.002
35 000–45 999	0.93	0.81–1.06	0.26
46 000	1.14	0.99–1.31	0.06
Missing	0.97	0.62–1.51	0.89
Charlson-Deyo comorbidity score			
0	1		
1	1.00	0.89–1.11	0.95
2+	0.97	0.81–1.17	0.76
Facility type			
Community Cancer Program	1		
Comprehensive Community Cancer Program	1.79	1.36–2.35	<0.001
Academic/Research (includes NCI)	1.54	1.18–2.00	0.001
Integrated Network Cancer Program	1.64	1.22–2.20	0.001
Other	1.59	1.14–2.21	0.006
Facility location			

Variable	Multivariate analysis		
	OR	95% CI	P
West	1		
Midwest	1.16	1.01–1.34	0.04
South	0.79	0.69–0.91	0.001
East	1.14	0.98–1.33	0.10
NOS	1.14	0.98–1.33	0.10
Year of diagnosis			
2004–2006	1		
2007–2009	0.83	0.73–0.94	0.004
2010–2013	0.85	0.70–1.02	0.09
T classification			
T1	1		
T2	1.04	0.93–1.17	0.47
T3	1.03	0.88–1.19	0.75
T4 NOS	0.99	0.70–1.40	0.94
T4a	0.81	0.71–0.91	<0.001
T4b	0.75	0.54–1.06	0.102
N Classification			
N0	1		
N1	0.99	0.87–1.11	0.80
N2 NOS	0.96	0.72–1.28	0.78
N2a	1.10	0.85–1.44	0.47
N2b	0.93	0.82–1.04	0.20
N2c	0.83	0.70–0.99	0.03
N3	1.14	0.72–1.80	0.58
Lymph node neck dissection			
No	1		
Yes	0.81	0.67–0.97	0.02
Unknown	5.56	0.49–63.0	0.17
Margin status			
Negative	1		
Positive	1.17	1.05–1.31	0.004
Unknown	1.52	1.09–2.12	0.01
Extracapsular extension			
No	1		
Yes	1.03	0.90–1.19	0.64
Unknown	1.06	0.88–1.27	0.53
Time between surgery and RT (days)			
42	1		
>42	0.79	0.72–0.87	<0.001
Missing	0.47	0.38–0.58	<0.001
Duration of RT treatment (days)			

Variable	Multivariate analysis		
	OR	95% CI	P
48	1		
>48	0.62	0.57–0.67	<0.001
Missing	0.19	0.16–0.23	<0.001
Chemotherapy			
No	1		
Yes	1.27	1.15–1.39	<0.001
Missing	0.71	0.52–0.97	0.03

Abbreviations: AJCC, American Joint Committee on Cancer; CI, confidence interval; NCI, National Cancer Institute; NOS, not otherwise specified; OR, odds ratio; RT, radiation therapy.

TABLE 3
Univariate and multivariate analysis of predictors of overall survival for postoperative head and neck cancer

Variable	Univariate			Multivariate		
	HR	95% CI	P	HR	95% CI	P
RT at same facility as surgery						
No	1			1		
Yes	0.86	0.81–0.91	<0.001	0.92	0.87–0.98	0.01
Age						
<65 years	1			1		
65 years	1.48	1.40–1.56	<0.001	1.19	1.11–1.28	<0.001
Sex						
Male	1			1		
Female	0.97	0.92–1.03	0.32	1.00	0.94–1.06	0.99
Race						
White	1			1		
African-American	1.11	1.00–1.22	0.04	0.95	0.86–1.06	0.34
Others	0.94	0.81–1.09	0.38	1.00	0.86–1.16	0.98
Missing	0.95	0.70–1.29	0.74	0.88	0.65–1.19	0.93
Insurance status						
Private insurance/managed care	1			1		
Government	1.71	1.61–1.82	<0.001	1.44	1.34–1.54	<0.001
Uninsured	1.32	1.16–1.51	<0.001	1.23	1.08–1.41	0.002
Missing	1.59	1.25–2.04	<0.001	1.65	1.29–2.12	<0.001
Residence						
Metropolitan	1			1		
Urban	1.09	1.01–1.18	0.03	0.99	0.91–1.07	0.80
Rural	0.97	0.78–1.21	0.81	0.92	0.74–1.15	0.46
Missing	1.46	1.26–1.68	<0.001	1.11	0.92–1.33	0.29
Median household income (USD)						
<30 000	1			1		
30 000–34 999	0.92	0.85–1.00	0.06	0.96	0.88–1.04	0.33

Variable	Univariate			Multivariate		
	HR	95% CI	P	HR	95% CI	P
35 000–45 999	0.84	0.77–0.92	<0.001	0.93	0.85–1.02	0.13
46 000	0.79	0.73–0.86	<0.001	0.96	0.88–1.06	0.42
Missing	1.19	1.46–2.19	<0.001	1.80	1.39–2.34	<0.001
Charlson-Deyo comorbidity score						
0	1			1		
1	1.21	1.13–1.29	<0.001	1.09	1.02–1.17	0.01
2+	1.85	1.66–2.06	<0.001	1.67	1.50–1.87	<0.001
Facility type						
Community Cancer Program	1			1		
Comprehensive Community Cancer Program	0.97	0.81–1.16	0.74	0.87	0.73–1.04	0.13
Academic/Research (includes NCI)	0.88	0.75–1.05	0.15	0.74	0.62–0.88	0.001
Integrated Network Cancer Program	0.98	0.81–1.19	0.84	0.86	0.71–1.04	0.12
Other	0.60	0.49–0.75	<0.001	0.71	0.57–0.90	0.004
Facility location						
West	1			1		
Midwest	0.96	0.87–1.05	0.36	0.98	0.89–1.08	0.63
South	1.13	1.03–1.24	0.008	1.15	1.04–1.26	0.005
East	0.97	0.87–1.07	0.48	1.06	0.95–1.17	0.31
NOS	0.68	0.58–0.79	<0.001	...	...	...
Year of diagnosis						
2004–2006	1			1		
2007–2009	0.96	0.89–1.04	0.31	0.94	0.87–1.02	0.14
2010–2013	0.90	0.84–0.97	0.007	0.90	0.78–1.02	0.11
T classification						
T1	1			1		
T2	1.44	1.32–1.58	<0.001	1.39	1.27–1.52	<0.001
T3	2.10	1.89–2.33	<0.001	1.99	1.79–2.22	<0.001
T4 NOS	1.72	1.38–2.14	<0.001	1.69	1.35–2.11	<0.001
T4a	2.06	1.89–2.25	<0.001	1.96	1.79–2.14	<0.001
T4b	2.02	1.61–2.53	<0.001	2.04	1.62–2.56	<0.001

Variable	Univariate			Multivariate		
	HR	95% CI	P	HR	95% CI	P
N classification						
N0	1			1		
N1	1.24	1.15–1.35	<0.001	1.39	1.28–1.52	<0.001
N2 NOS	1.52	1.26–1.84	<0.001	1.65	1.36–2.01	<0.001
N2a	0.89	0.72–1.10	0.28	1.14	0.92–1.42	0.22
N2b	1.83	1.71–1.96	<0.001	2.01	1.85–2.18	<0.001
N2c	2.55	2.32–2.81	<0.001	2.51	2.25–2.80	<0.001
N3	2.00	1.52–2.65	<0.001	2.24	1.68–2.98	<0.001
Lymph node neck dissection						
No	1			1		
Yes	1.20	1.08–1.34	0.001	0.93	0.82–1.05	0.26
Unknown	1.63	0.61–4.37	0.33	1.61	0.60–4.32	0.35
Margin status						
Negative	1			1		
Positive	1.34	1.26–1.44	<0.001	1.24	1.15–1.33	<0.001
Unknown	0.97	0.77–1.20	0.75	0.88	0.70–1.10	0.25
Extracapsular extension						
No	1			1		
Yes	1.78	1.63–1.95	<0.001	1.33	1.21–1.47	<0.001
Unknown	1.30	1.22–1.40	<0.001	1.13	0.99–1.28	0.08
Time between surgery and RT (days)						
42	1			1		
>42	1.17	1.10–1.25	<0.001	1.06	1.00–1.14	0.06
Missing	1.22	1.08–1.39	0.002	1.11	0.96–1.28	0.18
Duration of RT treatment (days)						
48	1			1		
>48	1.20	1.13–1.27	<0.001	1.07	1.00–1.13	0.04
Missing	1.22	1.10–1.36	<0.001	1.12	0.99–1.26	0.08
Chemotherapy						
No	1			1		

Variable	Univariate			Multivariate		
	HR	95% CI	P	HR	95% CI	P
Yes	1.17	1.10–1.24	<0.001	0.90	0.85–0.96	0.002
Missing	0.90	0.72–1.12	0.35	0.86	0.69–1.07	0.18

Abbreviations: AJCC, American Joint Committee on Cancer; CI, confidence interval; HR, hazard ratio; NCI, National Cancer Institute; NOS, not otherwise specified; RT, radiation therapy.