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## Racial disparities in the choice of definitive treatment for squamous cell carcinoma of the oral cavity

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### Abstract

**Background:** Definitive surgery is recommended for oral cavity squamous cell carcinoma (SCC). The purpose of this study was to present our assessment of the disparities in treatment selection for oral cavity SCC.

**Methods:** Non-Hispanic white and non-Hispanic black patients with oral cavity SCC were identified in the National Cancer Database (NCDB). Regression models were used to estimate relative risk (RR) of receiving surgery and absolute difference between non-Hispanic white and non-Hispanic black patients.

**Results:** There were 82.3% of non-Hispanic white patients who received surgery, compared to 64.2% of non-Hispanic black patients ( $P < .001$ ). The non-Hispanic black patients were less likely to receive surgery than non-Hispanic white patients (RR 0.87) with an absolute difference of 10.9%. The non-Hispanic black patients were significantly more likely to not be offered surgery (RR 1.42) and to refuse recommended surgery (RR 1.38) but not have a contraindication to surgery (RR 1.17).

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**Conclusion:** The non-Hispanic black patients are less likely to receive or be recommended surgery for oral cavity SCC and are more likely to refuse surgery. Further study is needed to identify strategies to close this disparity.

### Keywords

oral cavity carcinoma; racial disparity; reason for no surgery; surgery; treatment selection

## 1 | INTRODUCTION

Squamous cell carcinomas (SCCs) of the head and neck are a relatively heterogeneous group of malignancies with multiple subsites that can be treated with either definitive surgery or radiation, with or without chemotherapy. Non-Hispanic black patients, when compared with non-Hispanic white patients, present with more advanced disease, are less likely to receive definitive cancer treatment, and experience poorer survival.<sup>1–3</sup> The non-Hispanic black patients are less likely to have up-front surgery recommended for oral cavity and oropharyngeal cancers<sup>4</sup> and are less likely to actually receive surgery for oropharyngeal cancers.<sup>5,6</sup>

Whereas surgery and nonoperative management are first-line standard of care therapies for oropharyngeal tumors<sup>7</sup> with equivalent survival when controlling for other factors,<sup>6</sup> the National Comprehensive Cancer Network guidelines clearly recommend surgery over definitive radiotherapy as the primary treatment for oral cavity cancers.<sup>7</sup> Up-front surgery for oral cavity cancer has a substantial survival benefit compared to radiation-based treatment in a small randomized trial<sup>8</sup> and a single-institution retrospective study.<sup>9</sup>

Despite known racial disparities in survival and the likelihood of being recommended surgery for oral cavity cancer specifically,<sup>2–4</sup> no studies, to our knowledge, have examined whether racial disparities exist in actual treatment received. The purpose of this study was to evaluate contemporary racial disparities in both management recommendations for surgery and actual treatment received for oral cavity SCCs alone in the context of overall survival (OS) using the National Cancer Database (NCDB).

## 2 | MATERIALS AND METHODS

### 2.1 | Data source

The NCDB is a nationwide facility-based dataset operated by both the American Cancer Society and the American College of Surgeon's Commission on Cancer, capturing an estimated 70% of newly diagnosed cancer cases within the United States, including approximately 80% of oral cavity and pharyngeal cancers, from approximately 1500 Commission on Cancer-accredited cancer programs around the country.<sup>10</sup> Institutional review board approval was not necessary for this study because no patient, provider, or hospital identifiers were examined.

## 2.2 | Study population

The study cohort included non-Hispanic white and non-Hispanic black patients diagnosed with oral cavity SCC between 2004 and 2013 from the following sites (with corresponding International Classification of Diseases for Oncology-3 site codes): oral tongue (C02.0–02.3 and 02.8–02.9), alveolar ridge (C03.0–03.1 and 03.9), floor of mouth (C04.0–04.1, 04.8–04.9, and 06.1, 06.9), hard palate (C05.0 and 05.8–05.9), buccal mucosa (C06.0), retromolar trigone (C06.2), and other oral cavity (C06.8). We excluded patients with a history of malignancy or synchronous malignancies who were not treated and diagnosed at the same facility, who underwent local tumor destruction or an excisional biopsy, who received chemotherapy alone (indicating palliative intent), and whose treatment or clinical staging information was unknown. Patients with distant metastatic or clinical T4b disease were also excluded, because surgery is not the recommended primary treatment for these patients.<sup>7</sup>

## 2.3 | Clinical variables

Our 2 main outcomes were recommended management and actual treatment received. Recommended management was categorized as: (1) surgery was not offered to the patient or the patient was offered surgical and nonsurgical management and chose nonsurgical; (2) surgery was recommended but not received, which included surgery refusal by the patient documented in the chart or surgery refusal reason not known; and (3) surgery was contraindicated due to patient factors. Actual treatment received was defined as up-front surgery (with or without adjuvant treatment) or definitive radiotherapy (with or without chemotherapy [CRT]). Use of this approach to evaluate reasons for not receiving surgery have been documented previously.<sup>11,12</sup>

We considered several relevant patient, tumor, and facility characteristics as predictor variables; race (non-Hispanic white or non-Hispanic black) was considered the primary predictor variable. Patient characteristics comprising other covariates included age at diagnosis (assessed as a continuous variable), sex, socioeconomic status (SES), insurance, and comorbidity. The NCDB contains zip code level of median household income, and percent not graduating high school, with patients categorized into quartiles for each. Using an approach similar to that used in studies of a similar database (Surveillance, Epidemiology, and End Results Program),<sup>13,14</sup> we computed an average income/education quartile for where each patient lived and then created a composite SES variable of 3 roughly equal quantiles from this average. Insurance was categorized as private, Medicare, Medicaid, other government, uninsured, and unknown. Comorbidity was assessed using the Deyo modification of the Charlson index<sup>15</sup> and categorized as 0, 1, or 2.

Tumor factors included year of diagnosis, stage, and primary site. Tumor staging included clinical classification (T and N) and grouped clinical stage (I–IV) per the American Joint Committee on Cancer seventh edition (for cases diagnosed 2010–2013)<sup>16</sup> or the sixth edition (for cases diagnosed 2004–2009)<sup>17</sup> guidelines; of note, there were no major changes between the sixth and seventh editions for oral cavity SCC. Oral cavity subsites were grouped as described earlier into oral tongue, alveolar ridge, floor of mouth, hard palate, buccal mucosa, retromolar trigone, and other (subsite not specified). Treatment facility type

was categorized as community cancer center, comprehensive community cancer center, academic/research facility, and other.

## 2.4 | Statistical analysis

Differences in sociodemographic and clinical characteristics were analyzed between non-Hispanic white patients and non-Hispanic black patients using the t tests for continuous variables and the chi-square tests for categorical variables. The OS from diagnosis was assessed across primary treatment received (surgery or CRT), race (non-Hispanic white or non-Hispanic black), and a race-treatment composite variable, using Kaplan-Meier analysis with log-rank tests.

This was restricted to cases diagnosed from 2004–2012, as survival data was unavailable for patients diagnosed in 2013.

We estimated relative risks (RRs) of receiving surgery between racial groups directly using Poisson regression with robust error variance,<sup>18,19</sup> adjusting for patient age, sex, SES, insurance, comorbidity, stage, primary site, treatment facility type, and diagnosis year. We used the Poisson regression model instead of logistic regression as it allows estimation of the RR directly. Because Poisson regression will overestimate the error for the RR for binomial data, we used a robust error variance procedure to rectify the standard error estimation.<sup>18,19</sup> Absolute differences in the likelihood of surgery were also estimated using predicted marginal differences and presented alongside adjusted RRs, as recommended in health disparities research.<sup>20</sup> We then fit separate Poisson models for each year studied (2004–2013) to evaluate temporal trends in receipt of surgery. Separate Poisson models were fit to evaluate disparities in reasons for not receiving surgery (not offered, recommended but not received, and contraindicated). Finally, to further evaluate the degree to which the racial disparity persisted after accounting for socioeconomic factors, we also used composite race/SES and race/insurance variables to compare differences in receipt of surgery and reasons for not receiving surgery. Statistical analysis was performed using Stata version 14.2.<sup>21</sup> All tests were 2-sided, and P values < .05 were considered statistically significant.

## 3 | RESULTS

### 3.1 | Cohort characteristics

We identified 25 357 patients meeting inclusion criteria. Patient and tumor characteristics are presented by racial group in Table 1. Overall, 80.9% of patients received primary surgery; however, this rate was substantially lower among non-Hispanic black patients compared with non-Hispanic white patients (64.2% vs 82.3%;  $P < .001$ ). The crude absolute difference between races for up-front surgery was, therefore, 18.1%. Compared with non-Hispanic white patients, non-Hispanic black patients tended to be younger (mean age 59.3 years vs. 62.5 years;  $P < .001$ ), more likely to be of a low SES (71.2% vs 33.2%;  $P < .001$ ), have Medicaid (23.0% vs 7.8%;  $P < .001$ ), and present with more advanced disease (eg, 58.2% of non-Hispanic black patients were stage IV vs 32.1% of non-Hispanic white patients;  $P < .001$ ).

### 3.2 | Survival rates by treatment and race

Patients undergoing surgery had substantially greater survival compared to those receiving CRT (Figure 1A). The 1-year and 5-year survival rates for the surgical group were 87% and 60%, respectively, compared with 64% and 27% among those treated with CRT (log-rank  $P < .001$ ).

The non-Hispanic black patients experienced poorer OS compared with non-Hispanic white patients (log-rank  $P < .001$ ; Figure 1A). At 1 year, the difference was 7% (76% vs 83%) but increased to 14% at 5 years (40% vs 54%). The racial disparities in OS were attenuated when comparing survival stratified by both race and treatment (Figure 1B). Among patients who underwent CRT, OS was similar between non-Hispanic black patients and non-Hispanic white patients (log-rank  $P = .11$ ). Among surgically treated patients, non-Hispanic black patients exhibited a significantly poorer survival than non-Hispanic white patients (log-rank  $P < .001$ ; Figure 1B). For 1-year survival, this difference between non-Hispanic black patients and non-Hispanic white surgery patients was 3% (84% vs 87%) and for 5-year survival, it was 10% (50% vs 60%).

### 3.3 | Receipt of up-front surgery

Table 2 details the association between the likelihood of up-front surgery and patient, tumor, and facility factors. The non-Hispanic black patients were 13% less likely than non-Hispanic white patients to receive surgery (adjusted RR [aRR] 0.87; 95% confidence interval [CI] 0.84–0.89), corresponding to an adjusted absolute difference of –10.9% (95% CI –13.1 to –8.7). Patients of a lower SES also were less likely to receive surgery than those of a higher SES (aRR for high vs low SES 1.02; 95% CI 1.00–1.03; absolute difference 1.4%; 95% CI 0.3–2.5). In comparison with patients with private insurance, those with other forms of insurance were less likely to receive surgery, such as patients with Medicaid (aRR vs private insurance 0.92; 95% CI 0.90–0.94; absolute difference –6.5%; 95% CI –8.4 to –4.6) or uninsured patients (aRR 0.93; 95% CI 0.90–0.95; absolute difference –5.9%; 95% CI –8.1 to –3.8).

The likelihood of surgery decreased with increasing age (absolute difference –0.4% per 1-year increase in age; 95% CI –0.4 to –0.3), increasing T classification (absolute difference –13.6% for T3–T4 vs T1–T2; 95% CI 214.8 to 212.3), and increasing N classification (absolute difference –52.2% for N3 vs N0; 95% CI –58.7 to –45.8). The likelihood of surgery increased over the study time period (2004–2013) at 1.7% per year (95% CI 1.6–1.9).

### 3.4 | Temporal trends in likelihood of receiving surgery

In 2004, non-Hispanic black patients were 22.5% less likely than non-Hispanic white patients to receive surgery ( $P < .001$ ). The absolute difference reached a nadir of 6.0% in 2010 ( $P = .061$ ), and remained stable through 2013 (6.1%;  $P = .032$ ; data not shown).

### 3.5 | Reported reasons for not receiving surgery

The majority of patients who underwent CRT (79.8%) were documented as not having surgery recommended; with smaller percentages not receiving the recommended

surgery (8.2%; of which 80.8% had documented patient refusals in their chart) or having contraindications to surgery (6.1%). The reason for not receiving surgery was unknown in the remaining 5.9% of patients who received CRT.

In a multivariable Poisson regression model, non-Hispanic black patients were, relative to non-Hispanic white patients, more likely to not have surgery recommended in their treatment plan (aRR 1.42; 95% CI 1.31–1.54) and also more likely not to undergo recommended surgery (aRR 1.38; 95% CI 1.02–1.87; Table 3). In contrast, we did not find non-Hispanic black patients to be significantly more likely to have contraindications to surgery (aRR 1.17; 95% CI 0.80–1.70).

### 3.6 | Treatment groups according to race and socioeconomic factors

Finally, we assessed the magnitude of differences in treatment group (received surgery, not offered surgery, refused surgery, and surgery contraindicated) according to composites of race/SES (Figure 2) and race/insurance (Figure 3). This allowed for more direct comparisons between non-Hispanic white and non-Hispanic black patients of a similar socioeconomic background.

The non-Hispanic black patients were less likely than non-Hispanic white patients to receive surgery within each SES group, and non-Hispanic white patients of low SES were still more likely than non-Hispanic black patients of high SES to receive surgery (80.6% vs 72.9%; Figure 2A). There was also only a minimal increase in likelihood of receiving surgery with increasing SES, regardless of race. Within each SES group, non-Hispanic black patients were also more likely than non-Hispanic white patients to not be offered surgery (absolute difference 5.5–6.8%; Figure 2B). The non-Hispanic black patients were also more likely than non-Hispanic white patients to refuse recommended surgery (absolute difference 0.4%–1%; Figure 2C) and to have a contraindication to surgery (absolute difference 0.1%–0.9%; Figure 2D), although these differences were small.

The non-Hispanic white patients were also more likely than non-Hispanic black patients to receive surgery regardless of insurance status (Figure 3A). Although insurance rates were lower for patients with Medicaid compared to those with private or Medicare insurance, regardless of race, non-Hispanic white Medicaid patients were slightly more likely than non-Hispanic black patients with private insurance to receive surgery (76.4% vs 73.3%). The non-Hispanic white patients were also less likely to not be offered surgery, regardless of insurance status (absolute difference 3.3%–8.3%; Figure 3B). Differences in likelihood of refusing surgery were relatively small but within each insurance group non-Hispanic black patients were more likely to refuse surgery (absolute difference 0.3%–1.4%; Figure 3C). There were no clear patterns between race and likelihood of having surgery contraindicated within insurance groups (absolute difference 20.4% to 0.4%; Figure 3D).

## 4 | DISCUSSION

The National Comprehensive Cancer Network guidelines recommend surgery over CRT as the preferred definitive treatment for oral cavity SCC.<sup>7</sup> Supporting these recommendations, we found that patients receiving surgery have a statistically significantly better survival



compared with those receiving CRT. We also show a significant disparity in oral cavity SCC survival between non-Hispanic white patients and non-Hispanic black patients, which corroborates the findings of previous studies.<sup>2,3</sup> This difference is partially explained by differences between non-Hispanic black patients and non-Hispanic white patients in actual treatment received; non-Hispanic black patients were 11% less likely than non-Hispanic white patients to receive surgery when controlling for potential confounders. Although there is substantial literature demonstrating barriers in access to care for patients of lower SES, those lacking insurance, and racial minorities, the focus of our analysis is on racial disparities in the receipt of a guideline-indicated treatment with clear superiority in survival. Moreover, studies that do include treatment as part of their analyses combine results with nonoral cavity subsites.<sup>4</sup> Many patients with nonoral cavity subsites do not see a similar survival benefit with primary surgery as seen in the oral cavity; therefore, combining the subsites may confound results on treatment recommendations. This is the first study to specifically evaluate in depth the extent of this racial disparity in the oral cavity alone—both in an absolute sense, which shows that approximately 1 in 6 non-Hispanic black patients in excess of non-Hispanic white patients do not receive surgery—and in terms of factors that may be underlying this difference.

These results are consistent with previous studies showing non-Hispanic black patients to be less likely to receive cancer-directed surgery in multiple solid tumor sites.<sup>11,12,22–29</sup> For example, in their study of the treatment of early-stage nonsmall cell lung cancer in 1999, Bach et al<sup>22</sup> found that non-Hispanic black patients were significantly less likely than non-Hispanic white patients to receive surgery. Our crude absolute difference of 18% for rates of surgery received between non-Hispanic black patients and non-Hispanic white patients is comparable to results documented for other primary cancers, which have shown crude absolute differences in surgery rates between non-Hispanic white patients and non-Hispanic black patients of 4%–18%.<sup>11,12,22–25,27–29</sup>

Racial disparities in the receipt of surgical treatment for oral cavity SCC persisted after controlling for tumor classification, both clinical T or N classifications and grouped TNM classification, suggesting that racial differences in disease severity were unlikely to account for differences in treatment type. These disparities are unlikely to be driven substantially by racial differences in tumor classification and, therefore, presumed resectability.

Although significant racial disparities in likelihood of surgery persisted when controlling for SES and insurance, we also found that surgery rates were higher among patients of higher SES and among those with private insurance or Medicare. In our cohort, most non-Hispanic black patients were of low SES (71.2% vs 33.2% of non-Hispanic white patients) and a smaller proportion had private insurance (26.3% vs 41.8% of non-Hispanic white patients). This suggests that socioeconomic and insurance-related barriers related to receipt of surgery might also disproportionately impact non-Hispanic black patients. After the passage of the Affordable Care Act in 2010, it is possible that these barriers will decrease with increased insurance and healthcare access. Notably, rates of surgery for colorectal cancer increased in Massachusetts after statewide healthcare reform in 2006 (a reform that ultimately became the model for the Affordable Care Act), although there was no such increase in control states.<sup>30</sup> However, our analysis further shows that among patients with the same insurance or

the same SES, there remain significant racial disparities. Thus, these findings do not seem to be explained by access issues alone.

The non-Hispanic black patients were also more likely not to have surgery as recommended, consistent with prior literature about surgical resection for oral cavity SCC.<sup>4</sup> Fujiwara et al<sup>31</sup> reported on treatment patterns in oral cavity carcinoma using the NCDB as well and found non-Hispanic black patients were less likely to receive surgery compared with non-Hispanic white patients. However, his group used an older dataset that completed in 2011. Our analysis included data up to 2013 and demonstrated the racial disparity in treatment selection persisted.<sup>31</sup> In addition, our finding that non-Hispanic black patients were more likely not to receive a recommended surgery than non-Hispanic white patients (aRR 1.38; 95% CI 1.02–1.87), presumably due to patient refusals (the majority of this cohort had some documentation of patient refusal of surgery in the charts), may indicate patient preference as a factor contributing to racial disparities in the treatment for oral cavity SCC. Notably, these results remained consistent after creating composite variables that included insurance status and SES. Taken together, these results imply that race is the key driver associated with receipt of recommended treatment. Our results are consistent with a Surveillance, Epidemiology, and End Results study of nonsmall cell lung cancer, which found that, among patients not receiving surgery, non-Hispanic black patients were more likely than non-Hispanic white patients to have refused a recommended surgery.<sup>12</sup> Racial differences in trust of physicians are well-documented,<sup>32,33</sup> and it is certainly possible that such feelings manifest in refusing to receive a recommended surgery. Investigation into patient perceptions of physician recommendations using focus groups and individual interviews of patients with lung cancer have found that non-Hispanic black patients, in comparison with non-Hispanic white patients, tended to feel that physicians perform unnecessary surgeries and believe that traditional remedies are an appropriate alternative to medical treatment for cancer.<sup>32,34</sup> Importantly, such studies have not, to our knowledge, been conducted in patients with head and neck cancer, and further study is indicated.

Last, we demonstrated that non-Hispanic black patients were less likely to have up-front surgery recommended (aRR 1.42; 95% CI 1.31–1.54), and this difference persisted when combining race with insurance status and SES. There is evidence in other solid tumor sites demonstrating racial bias in provider likelihood to recommend or refer for surgery due to concerns about a patient's likelihood to adhere to recommended perioperative regimens.<sup>35</sup> The origin of this physician bias is less clear and requires further study to identify means of closing this disparity gap.

There are some limitations to this work. As a retrospective observational study, it is difficult to draw any causal conclusions about observed associations, and analyses are prone to residual confounding and selection bias. The NCDB is also a facility-based dataset that only captures cancers diagnosed at Commission on Cancer-accredited facilities, which may not reflect trends in treatment utilization for non-Commission on Cancer-accredited facilities. However, non-Commission on Cancer facilities are less likely to have the ability to treat oral cavity SCC nonsurgically due to reduced availability of radiation services.<sup>36</sup> Moreover, Commission on Cancer-facilities capture approximately 70% of all oral cavity SCC cases



and there is not a significant difference between the percentages of non-Hispanic black and non-Hispanic white populations captured compared to the United States Cancer Statistics.<sup>37</sup>

In addition, our SES variables, income and education, were only available at the zip code level. Controlling for these factors more precisely at the patient level may diminish some of the observed racial disparity. Finally, our measure of why a patient did not receive surgery may have some mis-classification, as a portion of those in the surgery nonrecommended group may have had contraindications to surgery or refused surgery without these being accurately documented in their medical records.

## 5 | CONCLUSION

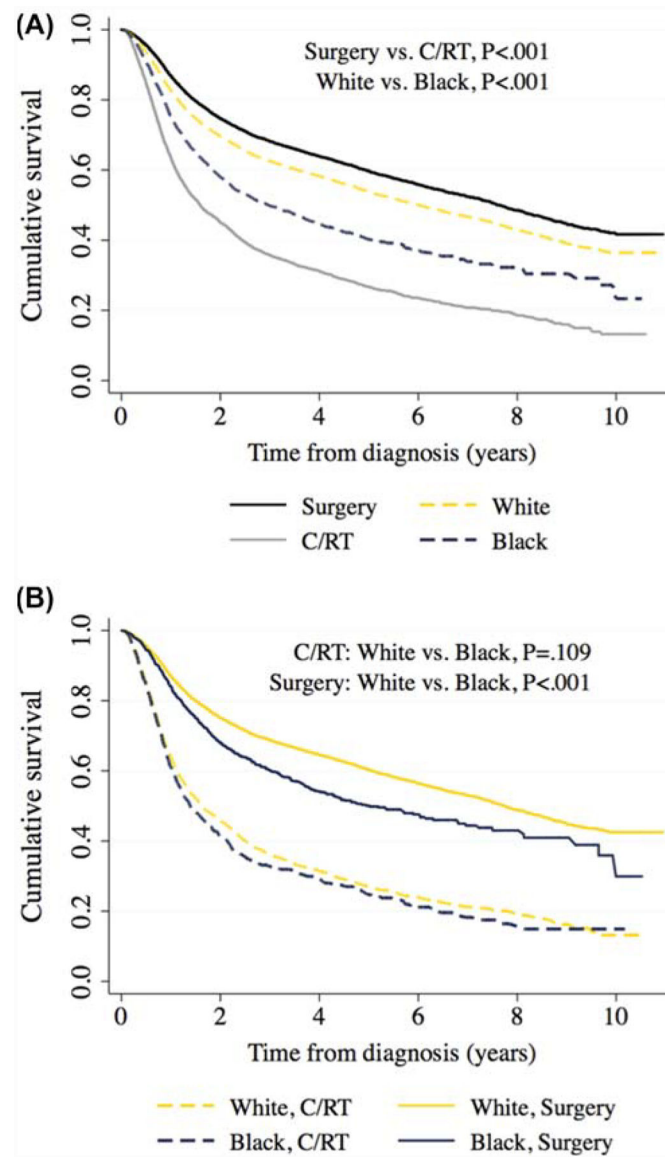
In conclusion, we found that despite statistically significant better OS when oral cavity SCC is treated with up-front surgery instead of CRT, non-Hispanic black patients are significantly less likely than non-Hispanic white patients to receive surgery for oral cavity SCC, independent of age, sex, SES, insurance status, tumor stage, and comorbidity. Our findings suggest that biases exist on the provider side (surgery was less likely to be recommended to non-Hispanic black patients vs non-Hispanic white patients) and on the patient side (non-Hispanic black patients were less likely to undergo recommended surgery than non-Hispanic white patients). Although reasons for the observed disparities seem multifactorial, inferred biases need to be the subject of future study in order to close the disparity gap in treatment received and improve survival.

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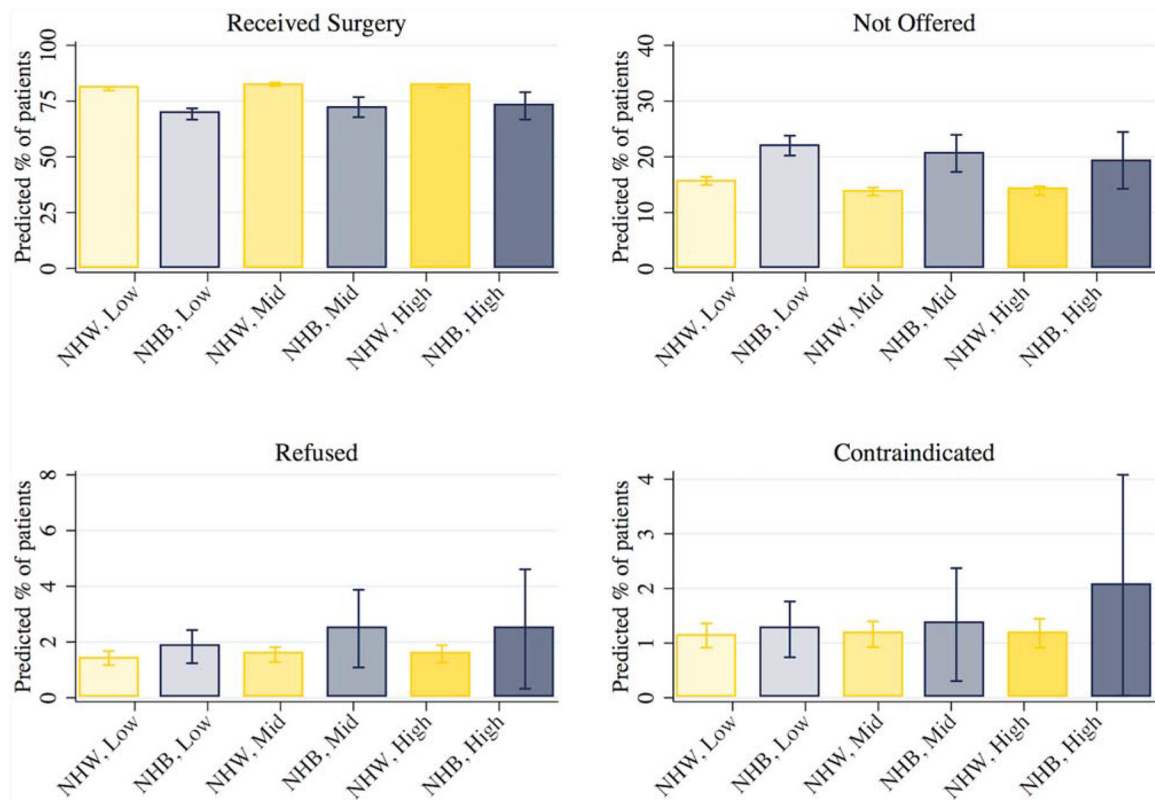
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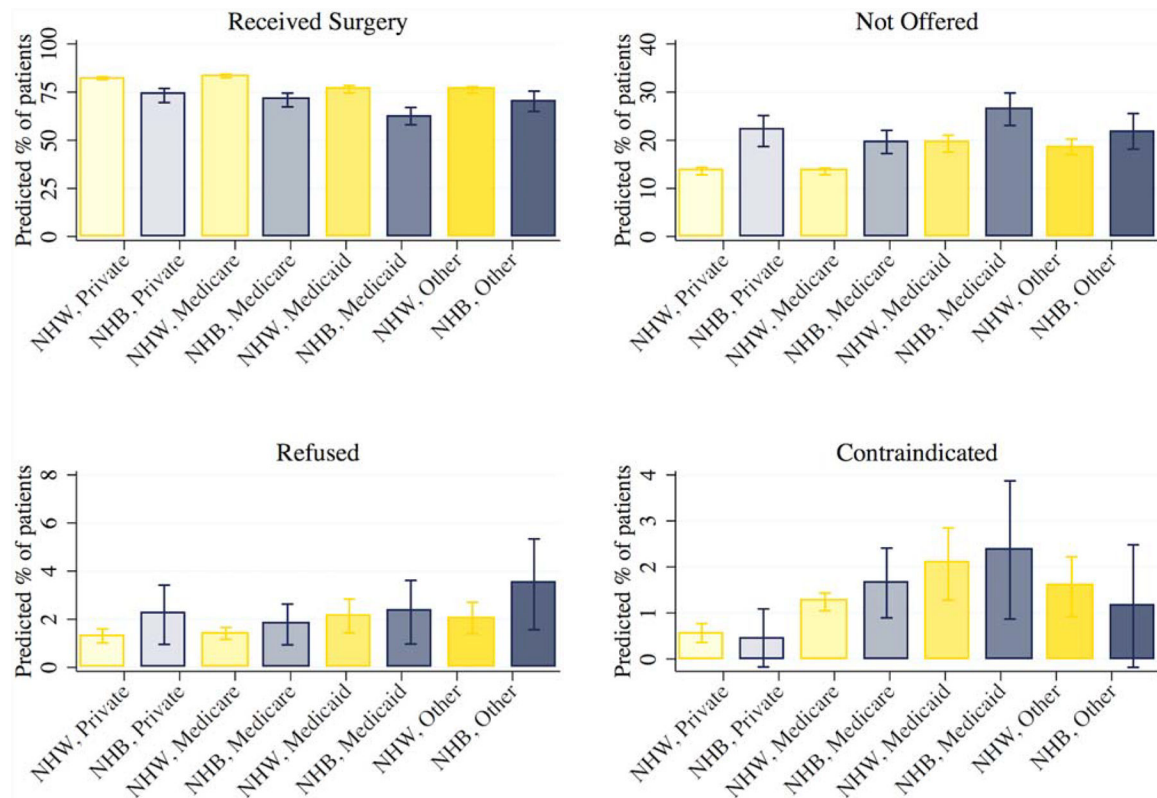
**FIGURE 1.**

Kaplan-Meier curves for overall survival; A, by primary treatment (surgery, chemoradiotherapy [C/RT]) and by race; B, by a composite of primary treatment and race. The  $P$  values from corresponding log-rank tests. NHB, non-Hispanic black; NHW, non-Hispanic white [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]



**FIGURE 2.**

Composite race/socioeconomic status and estimated absolute percentage of patients: A, receiving surgery; B, not offered surgery; C, refusing recommended surgery; and D, having a contraindication to surgery. Estimates are shown from separate Poisson regression models. Error bars correspond to 95% confidence interval. NHB, non-Hispanic black; NHW, non-Hispanic white [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

**FIGURE 3.**

Composite race/insurance status and estimated absolute percentage of patients: A, receiving surgery; B, not offered surgery; C, refusing recommended surgery; and D, having a contraindication to surgery. Estimates are shown from separate Poisson regression models. Error bars correspond to 95% confidence interval. NHB, non-Hispanic black; NHW, non-Hispanic white [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]



Demographic, clinical, and facility characteristics for patients with oral cavity squamous cell carcinoma (2004–2013) by patient race (n = 25 357)

**TABLE 1**

Characteristic, %	Patient race		P value
	Non-Hispanic white (n = 23 384)	Non-Hispanic black (n = 1973)	
Primary treatment			< .001
Definitive CRT	17.7	35.8	
Surgery	82.3	64.2	
Age, mean, years	62.5	59.3	< .001
Sex			< .001
Male	59.4	63.8	
Female	40.6	36.2	
SES <sup>a</sup>			< .001
Low	33.2	71.2	
Middle	34.4	19.2	
High	32.5	9.6	
Insurance status			< .001
Private	41.8	26.3	
Medicare	42.1	34.6	
Medicaid	7.8	23.0	
Other government	1.4	1.9	
Uninsured	5.1	10.8	
Unknown	1.8	3.4	
Clinical variables			
T classification			< .001
T1–T2	67.4	40.6	
T3–T4	32.6	59.4	
N classification			< .001
N0	31.5	12.6	
N1	22.8	15.2	
N2	13.6	13.9	
N3	32.1	58.2	

Characteristic, %	Patient race		P value
	Non-Hispanic white (n = 23 384)	Non-Hispanic black (n = 1973)	
TNM classification			
I	31.5	12.6	< .001
II	22.8	15.2	
III	13.6	13.9	
IV	32.1	58.2	
Primary site			< .001
Oral tongue	50.5	37.5	
Alveolar ridge	12.2	10.4	
Floor of mouth	21.5	35.4	
Hard palate	3.0	4.8	
Buccal mucosa	5.8	5.5	
Retromolar trigone	6.4	5.9	
Other	0.6	0.4	.005
Charlson Comorbidity Index			
0	77.5	76.6	
1	17.5	16.7	
2	5.0	6.7	< .001
Facility type			
Community	6.3	6.2	
Comprehensive community	31.3	21.7	
Academic/research	52.1	62.7	
Other	10.2	9.3	

Abbreviations: CRT, chemoradiotherapy; SES, socioeconomic status.

<sup>a</sup>SES is a composite variable dependent on average income and education for each patient.

**TABLE 2**

Multivariable Poisson regression model predicting receipt of primary surgery<sup>a</sup>

Characteristic	aRR for surgery	(95% CI)	Absolute difference, % receiving surgery	(95% CI)
Race/ethnicity				
Non-Hispanic white	Ref		Ref	
Non-Hispanic black	0.87	(0.84–0.89)	–10.9	(–13.1 to –8.7)
Age, per year	1.00	(0.99–1.00)	–0.4	(–0.4 to –0.3)
Sex				
Male	Ref		Ref	
Female	1.03	(1.02–1.04)	2.1	(1.2–3.0)
SES				
Low	Ref		Ref	
Middle	1.03	(1.01–1.04)	2.1	(0.9–3.2)
High	1.02	(1.01–1.03)	1.4	(0.3–2.5)
Insurance				
Private	Ref		Ref	
Medicare	1.01	(1.00–1.03)	1.0	(–0.2 to 2.3)
Other government	0.92	(0.87–0.98)	–6.4	(–10.7 to –2.1)
Medicaid	0.92	(0.90–0.94)	–6.5	(–8.4 to –4.6)
Uninsured	0.93	(0.90–0.95)	–5.9	(–8.1 to –3.8)
Unknown	0.95	(0.91–1.00)	–3.7	(–7.4 to –0.1)
Charlson Comorbidity Index				
0	Ref		Ref	
1	1.08	(1.06–1.09)	6.3	(5.2–7.4)
2	1.06	(1.03–1.08)	4.6	(2.5–6.7)
T clinical classification				
T1–T2	Ref		Ref	
T3–T4	0.84	(0.83–0.85)	–13.6	(–14.8 to –12.3)
N clinical classification				
N0	Ref		Ref	
N1	0.86	(0.84–0.88)	–12.0	(–13.6 to –10.5)

Characteristic	aRR for surgery	(95% CI)	Absolute difference, % receiving surgery	(95% CI)
N2	0.78	(0.76–0.80)	–19.0	(–20.6 to –17.5)
N3	0.39	(0.33–0.48)	–52.2	(–58.7 to –45.8)
Primary site				
Oral tongue	Ref		Ref	
Alveolar ridge	1.11	(1.09–1.12)	8.5	(7.1–9.9)
Floor of mouth	1.03	(1.02–1.05)	2.6	(1.4–3.8)
Hard palate	0.83	(0.79–0.88)	–13.4	(–16.8 to –10.0)
Buccal mucosa	0.98	(0.95–1.00)	–1.8	(–3.9 to 0.3)
Retromolar trigone	0.87	(0.84–0.90)	–10.8	(–13.2 to –8.4)
Other	0.96	(0.88–1.05)	–3.2	(–10.2 to 3.8)
Facility type				
Community	Ref		Ref	
Comprehensive community	1.17	(1.13–1.21)	10.6	(8.2–13.0)
Academic/research	1.40	(1.35–1.45)	25.0	(22.6–27.3)
Other	1.25	(1.20–1.30)	15.9	(13.2–18.5)
Year of diagnosis, per annum	1.02	(1.02–1.02)	1.7	(1.6–1.9)

Abbreviations: aRR, adjusted relative risk; CI, confidence interval; Ref, reference; SES, socioeconomic status.

<sup>a</sup>Results presented as aRR of receiving surgery and estimates of absolute difference in likelihood of receiving surgery (predicted marginal differences) (n 5 25 357).

TABLE 3

Multivariable Poisson regression models for reasons for not receiving surgery<sup>a</sup>

Reason for no surgery	aRR <sup>a</sup>	(95% CI)	Absolute difference <sup>a</sup>	(95% CI)
Not offered				
Non-Hispanic white	Ref		Ref	
Non-Hispanic black	1.42	(1.31–1.54)	6.12	(4.54–7.71)
Offered/not performed				
Non-Hispanic white	Ref		Ref	
Non-Hispanic black	1.38	(1.02–1.87)	0.58	(–0.03 to 1.18)
Contraindicated				
Non-Hispanic white	Ref		Ref	
Non-Hispanic black	1.17	(0.80–1.70)	0.19	(–0.31 to 0.69)

Abbreviations: aRR, adjusted relative risk; CI, confidence interval; Ref, reference; SES, socioeconomic status.

<sup>a</sup>Models adjusted for year of diagnosis, age, sex, insurance, facility type, tumor stage, and primary site. Results presented as aRR and absolute difference (from predicted marginal differences; n = 25 357).