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Travel Time to Provider is Associated with Advanced Stage at Diagnosis Among Low Income Head and Neck Squamous Cell Carcinoma Patients in North Carolina

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Abstract

Objective: There is considerable variation in the travel required for a patient with head and neck squamous cell carcinoma (HNSCC) to receive a diagnosis. The impact of this travel on the late diagnosis of cancer remains unexamined, even though presenting stage is the strongest predictor of mortality. Our aim is to determine whether travel time affects HNSCC stage at diagnosis independently of other risk factors, and whether this association is affected by socioeconomic status.

Materials and Methods: Cases were obtained from the CHANCE database, a population-based case-control study in North Carolina (n=808). The mean age was 59.6 and 72% were male. Stage at diagnosis was categorized as early (T1-T2) or advanced (T3-T4) T stage and the presence or absence of nodal metastasis. Multivariate logistic regression models were used to estimate odds ratios for stage-at-diagnosis based on travel time, after adjustment for variables including demographics, income, insurance status, alcohol, and tobacco use.

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Results: The adjusted odds ratio (OR) of advanced T-stage at diagnosis was 1.97 for each hour driven (95% CI 1.36 – 2.87). There was no association with nodal metastases. There was a significant interaction between travel time and income (p = 0.026) with a pattern of higher ORs for increased distance among lower income (<$20,000) patients compared to the ORs for higher income (>$20,000) patients.

Discussion: Travel time was an independent contributor to advanced T stage at diagnosis among low income patients. This suggests travel burden may be a barrier to early diagnosis of HNSCC for impoverished patients.

Keywords

Head and Neck Neoplasms; Neoplasm Staging; Travel; Delayed Diagnosis; Income; Socioeconomic Status

Introduction

Squamous cell carcinoma of the head and neck (HNSCC) is the sixth most common cancer worldwide and the fifth most common cancer in the United States, affecting approximately 40,000 new patients annually.[1–3] It chiefly encompasses cancers of the oral cavity, oropharynx, and larynx. HNSCC also has a high mortality rate, with poorer survival than some other common malignancies such as breast, cervical, and colorectal cancers.[4]

The strongest predictor of mortality in HNSCC is the stage of the tumor at diagnosis.[5] For example, the 3-year survival rate for oral cavity carcinoma ranges from 74% for stage 1 cancer to 35% for stage 4.[6] Furthermore, patients with late-stage tumors typically require aggressive surgery and chemoradiation that can cause speech and swallowing dysfunction and poor quality of life. While more than half of HNSCC is diagnosed at a late stage,[6] early diagnosis may spare substantial morbidity and mortality.

Access-to-care has been associated with late presentation of HNSCC and other cancers.[7] A key determinant of access may be the distance that a patient must travel to obtain a diagnosis.[8–12] This distance may disproportionately affect HNSCC patients, who frequently have a low socioeconomic status and can lack resources for transportation.[13] Nonetheless, travel burden among HNSCC patients has never been examined.

More importantly, prior studies investigating travel for cancer patients have poorly accounted for socioeconomic status, using only regional measures or none at all.[8–12] However, it is possible that disadvantaged patients delay their presentation due to difficulty reaching farther-away providers. Research is needed to determine whether socioeconomic status affects travel burden as it could lead to interventions that aid early diagnosis.

Our objective in this study is to determine whether distance affects stage at diagnosis in a population-based cohort of HNSCC patients in North Carolina. We hypothesized that a longer travel time would be a barrier to diagnosis and associated with a later stage at diagnosis. Furthermore, this relationship would be independent of demographics, socioeconomic status, or residence in an urban or rural location. We finally postulated that distance may disproportionately affect patients with lower socioeconomic status.

Materials and Methods:

Population:

Data for analysis was obtained from a population-based case-control study in North Carolina - the Carolina Head and Neck Cancer Epidemiology Study (CHANCE).[14,15] North Carolina is the 9th most populous state in the United States, and the 28th largest by area. The state's racial composition is 68.5% White, 21.5% Black or African American, and 8.4% Latin or Hispanic American.[16] The median household income is $46,639; it has the 14th highest poverty rate in the US at 17.6%.[17] The population is 66.1% urban, making it the 15th most rural US state.[16]

Cases were identified through rapid case ascertainment with the North Carolina Central Cancer Registry and were eligible if they had been diagnosed with a first primary squamous cell carcinoma of the oral cavity, pharynx, or larynx between January 1, 2002, and February 28, 2006, were ages 20 to 80 years at diagnosis, and resided in a 46-county region in central North Carolina. The Institutional Review Board (IRB) of the University of North Carolina approved this study.

The typical diagnosis and treatment pathway for a North Carolina HNSCC patient is provided for readers unfamiliar with treatment pathways in the US. After a mass is noted by a primary care provider, dentist, or hospital-based provider, the patient is typically referred to an otolaryngologist. The otolaryngologist biopsies the mass to diagnose a cancer. Each pathological cancer diagnosis is reported to the state cancer registry, per state law. Patients are then either treated at local hospitals or referred to larger tertiary care centers depending on the ability of their local specialists and the complexity of the cancer.

Patient Characteristics and Distances:

Demographics, behaviors, income, insurance, and other characteristics and indicators of socioeconomic status were assessed by trained nurse-interviewers using a structured questionnaire during an in-home visit. Cases were interviewed soon after cancer diagnosis (the average time between diagnosis and interview was 5.3 months).

Residential history was obtained from the patient interview and the address at their time of diagnosis was used. Geographic biopsy locations were abstracted from the pathology report containing the initial diagnosis of cancer (n = 51 hospitals). Linear (Euclidean) distances and driving times (network travel times) were calculated in ArcMap 10.5 (ESRI, 2017). The rurality of each address was determined from rural-urban commuting area (RUCA) codes based on census tracts; these were obtained from the United States Department of Agriculture Economic Research Service.[18] For patients with multiple home addresses (n = 127), the address closest to the biopsy location was chosen. There was no material change in the model results using the farther address.

Exclusion Criteria:

Within the CHANCE dataset (N = 1,389), we excluded patients whose medical records were missing the pathology report for the initial biopsy that diagnosed cancer (N = 311), patients without available home addresses (N = 115), and patients who declined to report income, race, tobacco or alcohol use (N = 45, 31, 27 and 2 respectively for each variable; 105 combined). Patients without an available biopsy report were more likely to have a lower T-stage at diagnosis (72% vs. 61%; p = 0.001); there were no differences in income or other measures of socioeconomic status. There were no significant differences in the T-stage for patients who declined to report their addresses, demographics, or behaviors. We further excluded patients with addresses greater than two hours away from the biopsy location (n = 46) due to the possibility that they changed their address between the time of their biopsy and their enrollment in the study. The analysis was subsequently re-run incorporating these fardistance patients with no material change in results.

Outcomes:

Outcomes were early (T1-T2) and late (T3-T4) T stage, and the presence or absence of nodal metastasis, at presentation. Stage at diagnosis was abstracted from medical records specifying the initial treatment plan. All staging used 7th edition AJCC guidelines.

Analysis:

Linear (Euclidean) distances and driving times (network travel times) were calculated in ArcMap 10.5 (ESRI, 2017). Cases were divided into quartiles based on the driving time between the case's home address and the biopsy location. The range for each quartile was 1-12 min, 12-22 min, 22-42 min, and 42 – 119 min. Descriptive statistics were calculated for the 1st and 4th quartiles based on driving time; bivariate testing methods included two-sided t and chi-squared tests. An alpha of 0.05 was used for all testing.

Multivariable logistic regression models were used to determine the odds ratio and 95% confidence interval for advanced T stage or the presence of nodal metastases at presentation (the primary outcomes) in relation to distance quartile (the primary exposure). Age, sex, race, income, insurance status, education, alcohol, and tobacco use were incorporated into the model as covariates; each was used as a categorical variable.

Models were also created with interaction terms to examine for the multiplicative interactions between travel time and age, race, income, education, cancer site, and HPV status The cohort was then stratified by income, with separate models were constructed for low and high-income patients to examine the potential associations between distance and T stage at diagnosis in each group.

Results:

Population Characteristics:

The final study population consisted of 808 HNSCC patients. The mean age of the population was 59.6 (standard deviation (SD) 10.4); and 72% male. The median distances between the patient and their biopsy location were 2.5, 6.5, 14.8, and 34.9 miles, respectively for each quartile based on driving time (table 1). Median driving times were 7.2, 15.8, 31.0, and 61.3 minutes. The population was distributed across the state of North Carolina (figure 1); roughly 60% of the population lived within an urban area.

Distance-Quartile Comparison:

When compared to patients in the first (closest) quartile, patients in the 4th (farthest) quartile were significantly more likely to be male (83% vs. 71%; p = 0.007), white (75% vs. 63%; p = 0.01), and have an annual household income greater than $20,000 (63% vs. 51%; p = 0.030) (table 2). Residence in a more rural area was also associated with increasing driving time (R^2 0.18; p < 0.001). There were no significant differences in age, education, insurance status, tobacco use, alcohol use, or HPV status based on distance quartile.

Unadjusted and Adjusted Models for Stage at Diagnosis

The proportion of patients presenting with an advanced T stage by quartile was 32%, 33%, 40%, and 47%, respectively. In an unadjusted model, each hour of driving time was significantly associated with twice the odds of advanced T-stage at diagnosis (95% CI 1.42 – 2.84). However, there was no significantly increased odds for the presence of nodal metastases (OR 1.10; 95% CI 0.77–1.54).

In a multivariable model incorporating demographics, socioeconomic status, and urban locations, the overall adjusted OR for high T-stage at diagnosis was 1.97 for each hour driven (95% CI 1.36 – 2.87). Patients in the third and fourth (farthest) quartiles were significantly more likely to present with an advanced T stage relative to patients in the first (for the 3rd quartile, adjusted OR 1.63, 95% CI 1.04 – 2.56; for the 4th, adjusted OR 2.08, 95% CI 1.29 – 3.34) (table 3).

The only other associations with T stage at diagnosis were the lack of medical insurance (OR 2.27; 95% CI: 1.63 – 4.64) and an age over 65 (OR 0.41, p = 0.001; 95% CI: 0.24 - 0.71) (table 3). There was no association between distance and nodal disease at presentation (results not shown).

Distance and Income:

To test the hypothesis that distance would affect low and high-income patients differently, a model was constructed to include a travel time X income interaction term (with household income divided into < $20,000 and > $20,000). The interaction term was significant (p = 0.026). When the cohort was stratified by income, there was a pattern of higher ORs for increased distance among lower income (<$20,000) patients compared to the ORs for higher income (>$20,000) patients (figure 2; table 4). For example, the OR for between travel time and T stage among low income patients was OR 3.31 (95% CI 1.53 – 7.61) for 4th quartile relative to first compared to 1.49 (95% CI 0.79 – 2.80) for higher income patients.

Discussion:

In this study, we demonstrated that increased driving time was associated with an advanced T-stage at diagnosis for low-income HNSCC patients. This association was independent of other covariates such as medical insurance, indicators of socioeconomic status, and rural location. These findings suggest that distance may be a barrier to the early diagnosis of HNSCC, especially among disadvantaged patients.

Travel has been shown to be a barrier to the early diagnosis of several other cancers. Holmes et al. (2012) found that distance to a urologist was associated with diagnosis of high-risk prostate cancer.[9] Likewise, Huang et al. (2009) showed that distance to a mammography center was associated with more advanced breast cancer at diagnosis,[10] and similar findings have been reported in melanoma and colorectal cancer.[8,19] HNSCC may be especially susceptible to travel burden as diagnosis typically requires travel to an otolaryngologist. Moreover, HNSCC frequently affects low income patients, due in part to associations with tobacco and tobacco use, who may have additional difficulties in accessing care.[20–24] Nonetheless, this is the first study to find a link between stage-at-diagnosis and travel burden in HNSCC. In one similar study, Tan et al. (2016) has demonstrated that a remote location was associated with a delay between presentation and receipt of treatment among 158 Australian HNSCC patients.[24]

It is notable that there was a significant association between distance and T stage but not between distance and nodal metastases. HNSCC patients frequently present due to symptoms caused by the primary tumor and may be unaware of growing neck metastases. Likewise, prior studies on late presentation of HNSCC patients have only analyzed T stage.[7] Finally, the specific site influences the likelihood of nodal metastases for HNSCC due to variations in lymphatic drainage.[25]

In addition to distance, stage at diagnosis was influenced by age, education, and insurance status. A lack of medical insurance is known to be associated with late-presentation of multiple cancers.[26] Educational attainment has also been previously associated with late presentation of multiple cancers as well.[27,28] Overall, geographic distance may be one of the many barriers that low-income patients face in receiving a prompt diagnosis. Others include health literacy and medical insurance, and even the ability to leave work to seek care.

Advanced age has been associated with late presentation;[29–31] it is notable that it was associated with an earlier presentation in this population. Importantly, race was not significantly associated with advanced stage, and there was no interaction between race and distance. Several prior studies have noted race as a risk factor for advanced HNSCC, [20,32] although these did not account for socioeconomic status, which race may confound.[33,34]

This is the first study in any cancer site to find that distance disproportionately affects low-income patients. Previous studies either did not report socioeconomic status or used area-level variables, such as the median income of a cancer patient’s census tract.[8,10,19] Our population-based study used individual measures obtained by a trained interviewer. The increased precision of these markers likely allowed the detection of an interaction between distance and income.

The differential impact of income implies multiple possible mechanisms for the association between distance and stage at diagnosis. First, low socioeconomic status and limited resources for transportation may present barriers to patients seeking a timely diagnostic biopsy. This may lead to patients waiting until symptoms increase or until they require emergency care due to difficulty with swallowing or airway compromise. Second, patients with limited resources may lack access to screening for head and neck cancer through routine medical or dental visits.

Further research into the mechanism could provide insight for future interventions. These could include improved access to primary career and community efforts for screening among low-income patients without access to primary care. Additionally, care coordinators can be utilized to recommend accessible specialists, ensure follow up, and help with transportation.[35][36] Telemedicine may also have a role in bringing specialists into contact with patients who have transportation limitations.[24][37]

The main limitation of this study is that is represents data from a single state and may be less generalizable than national datasets. However, CHANCE is the largest population-based HNSCC study to date and provides granular social and demographic data that is limited in national cancer registry data. Another limitation is the exclusion of patients due to missing data on biopsy location, home address, demographics, or markers of socioeconomic status. There was no significant difference in the presenting T stage for patients who did not provide information. A lower T stage was seen in patients missing biopsy information, although there were no significant differences in any indicators of socioeconomic status. It is also important to note that there are many other variables intrinsic to the tumor that influence stage at diagnosis for any single patient. These include the site of the tumor (such as glottis vs. subglottis), and the growth rate of the cancer. Many of these variables were not directly measured or adjusted for in this study. However, these intrinsic factors are likely unrelated to income and geographic location, and so meaningful statistical patterns for income and geography can emerge when carefully evaluating data from many patients in a population-based context.

Conclusion:

In this study we identified travel time to diagnosing provider as a significant independent contributor to advanced T stage at diagnosis. We also found a greater impact of increased distance among low income patients with HNSCC. Our findings suggest that distance is a barrier to early diagnosis of HNSCC, especially among disadvantaged patients.

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Highlights:

- We examine whether travel time affects late presentation of cancer
- Travel time among low-income patients was associated with T stage at presentation
- Travel may be a barrier to early diagnosis of HNSCC for disadvantaged patients

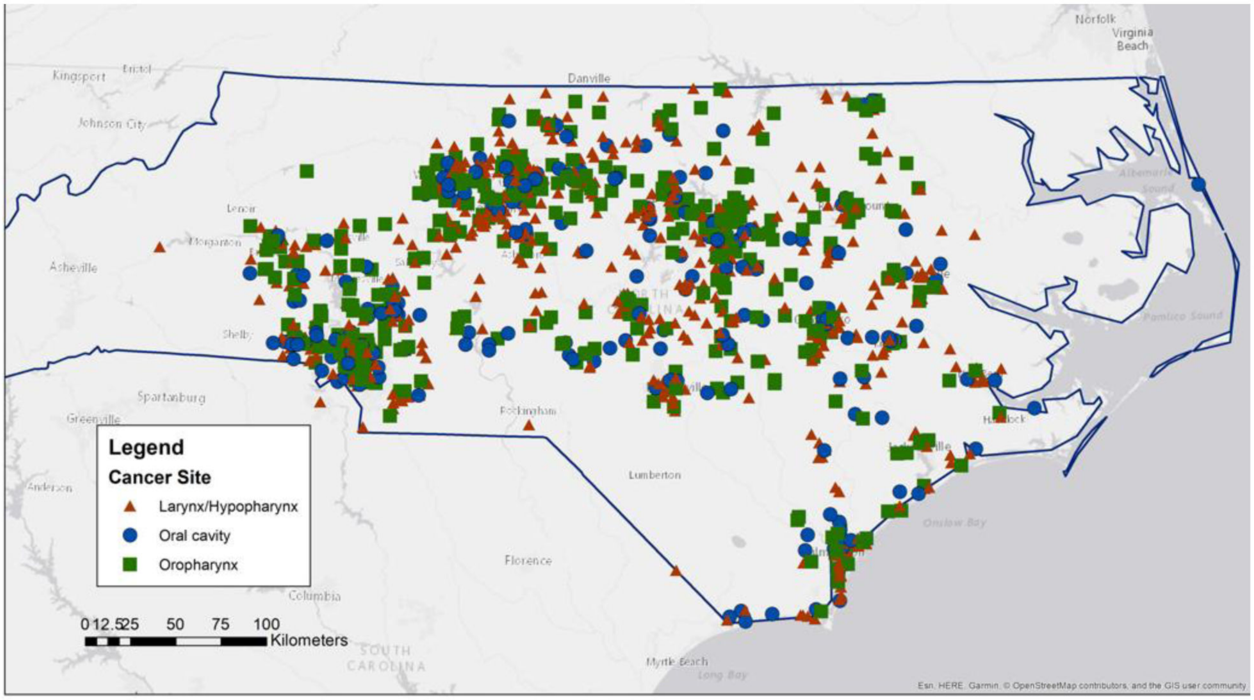

Figure 1:
Geographic mapping of CHANCE patients

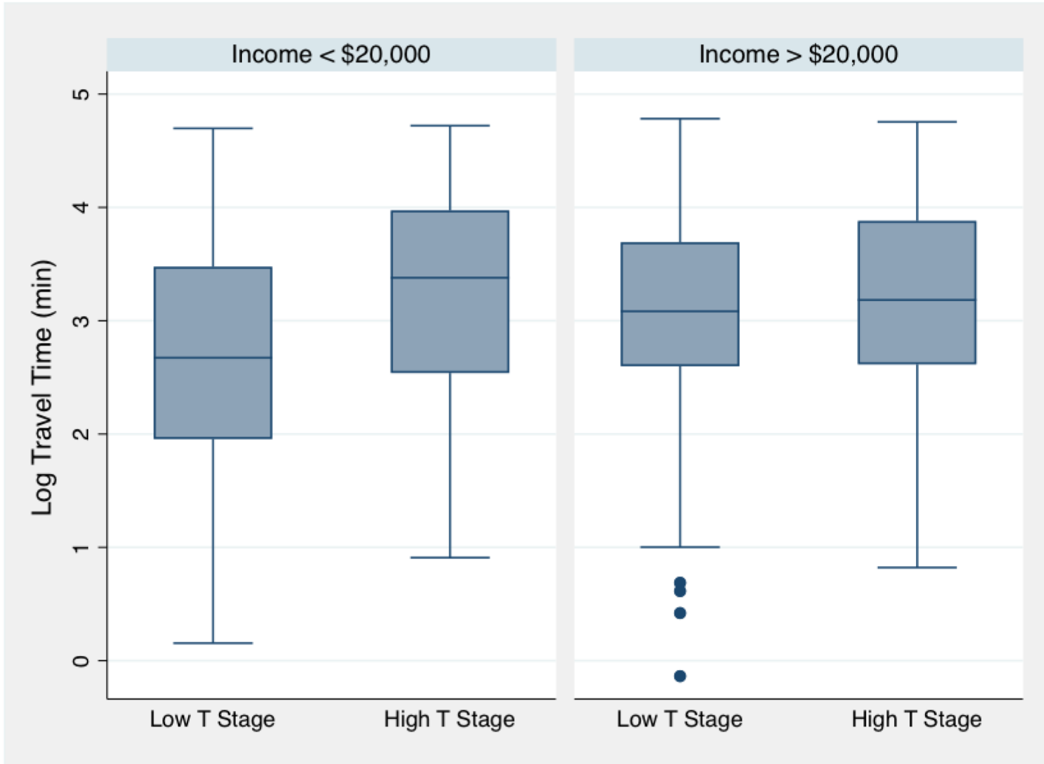

Figure 2:
Log-transformed travel time and T-stage at diagnosis, stratified by income

Table 1:

Travel times, linear distances, and rural-urban index for distance quartiles

	Driving Time (min)		Total Distance (mi)		Rural vs. Urban Address*	
	Median	***IQR***	***Median***	***IQR***	***Mean***	***SD***
1st quartile (n=202)	7.2	3.8	2.5	1.8	1.4	1.0
2nd quartile (n=202)	15.8	4.8	6.5	2.8	1.6	1.3
3rd quartile (n=202)	31.0	9.9	14.8	7.6	2.3	2.0
4th quartile (n=202)	61.3	28.8	34.9	17.4	3.5	2.7
Total (n=808)	22.5	30.6	9.4	16.8	2.2	2.1

* 1 reperesents the most urban location and 10 represents the most rural. RUCA score was associated with travel time; R-squared 0.18, $p < 0.001$

Table 2:

Comparison of 1st and 4th quartiles based on driving time (total n = 808)

	1st quartile (n = 202)		4th quartile (n=202)		P-Value
Total n = 808	**No.**	**%**	**No.**	**%**	
Age Category					
<50 (n=173)	33	16%	43	21%	0.0771 *
50-65 (n=386)	90	45%	97	48%	
65+ (n=249)	79	39%	62	31%	
Sex					
Male (n=630)	144	71%	167	83%	0.007
Female (n=178)	58	29%	35	17%	
Race					
White (n=600)	127	63%	151	75%	0.01
Black (n=208)	75	37%	51	25%	
Education					
Less Than High School (n=272)	78	39%	65	32%	0.255 **
High School Grad (n=234)	58	29%	60	30%	
Greater than High School (n=302)	66	33%	77	38%	
Income					
Income (relative to > 50 K)	36	18%	48	24%	
Income > $50,000 (n=224)	68	34%	80	40%	0.012 ***
Income $20,000 - $50,000 (n=285)	98	49%	74	37%	
Income < $20,000 (n=299)	202	100%	202	100%	
Insuracne Status					
Private (n=301)	54	27%	61	30%	0 44 ****
Medicaid/Medicare (n=271)	95	47%	66	33%	
None (n=114)	29	14%	30	15%	
Other (n=122)	24	12%	45	22%	
Smoking					
< 10 Years (n=154)	28	14%	36	18%	0.282
10+ Years (n=654)	174	86%	166	82%	
Alcohol Use					
< 1 Drink / Week (n=104)	23	11%	22	11%	0.877
> 1 Drink / Week (n=704)	179	89%	180	89%	
Site					
Larynx/Hypopharynx (n=357)	97	48%	82	41%	0.241
Oral NOS (n=133)	33	16%	32	16%	
Oral cavity (n=77)	25	12%	24	12%	
Oropharynx (n=241)	47	23%	64	32%	
P-16 Associated (if tested)					
No (n=157)	42	66%	38	56%	0.282

Total n = 808	1st quartile (n = 202) No.	%	4th quartile (n=202) No.	%	P-Value
Yes (n=107)	22	34%	30	44%	

*P-Value for 65+ vs. < 65

**P-value for high-school education vs. none

***P-value for > $20,000 vs. < $20,000

****P-value for private vs. non-private insuracne

Table 3:

Multivariate logistic regression model for odds of high T-stage at diagnosis (n = 808)

	Odds Ratio	95% CI	P-Value
Driving Time (1st quartile as baseline)			
2nd quartile	1.30	0.82 - 2.04	0.259
3rd quartile	1.63	1.04 - 2.56	**0.035**
4th quartile	2.08	1.29 - 3.34	**0.003**
Age Category (Relative to < 50)			
50-65	0.74	0.50 - 1.10	0.138
65+	0.41	0.24 - 0.71	**0.001**
Female sex (relative to male)	1.02	0.68 - 1.51	0.932
Non-white (vs. white)	1.11	0.76 - 1.63	0.587
Income (relative to > 50 K)			
Income $20,000 - $50,000	1.05	0.68 - 1.61	0.825
Income < $20,000	1.47	0.88 - 2.44	0.141
Education (past high school)	0.70	0.49 - 1.00	0.051
Insurance (relative to private insurance)			
Medicaid/Medicare	1.51	0.90 - 2.53	0.120
None	2.75	1.63 - 4.64	**< 0.001**
Other	1.50	0.88 - 2.55	0.136
Site (Relative to larynx/hypopharynx)			
Oral, NOS	1.06	0.68 - 1.66	0.786
Oral cavity	1.34	0.78 - 2.29	0.293
Oropharynx	0.92	0.63 - 1.34	0.653
Smoking (> 10 pack-years)	1.29	0.84 - 1.97	0.241
Alcohol use (> 1 drink / week)	1.65	0.97 - 2.80	0.064
Residence in Rural Area	1.00	0.93 - 1.09	0.937

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Table 4:

Multivariate logistic regression for odds of high T stage at diagnosis, stratified by Income

	Income < $20,000 (N = 299)			**Income > $20,000 (N = 509)**		
	Odds Ratio	**95% CI**	**P-Value**	**Odds Ratio**	**95% CI**	**P-Value**
Driving Time (1st quartile as baseline)						
2nd quartile	1.12	0.53 - 2.36	0.760	1.14	0.64 - 2.05	0.651
3rd quartile	2.41	1.20 - 4.86	0.014	1.19	0.64 - 2.18	0.583
4th quartile	3.31	1.53 - 7.16	0.002	1.49	0.79 - 2.80	0.220
Age Category (Relative to < 50)						
50-65	0.92	0.45 - 1.87	0.819	0.67	0.41 - 1.08	0.102
65+	0.49	0.21 - 1.15	0.101	0.38	0.18 - 0.80	0.011
Female sex (relative to male)	0.98	0.53 - 1.81	0.954	1.12	0.66 - 1.91	0.675
Non-white (vs. white)	1.05	0.61 - 1.81	0.861	1.14	0.64 - 2.02	0.654
Education past high school	1.00	0.50 - 2.01	0.989	0.64	0.42 - 0.98	0.040
Insurance (relative to private insurance)						
Medicaid/Medicare	1.41	0.49 - 4.04	0.526	1.39	0.68 - 2.85	0.362
None	2.67	0.91 - 7.88	0.075	2.85	1.40 - 5.81	0.004
Other	1.22	0.37 - 4.06	0.746	1.55	0.81 - 3.00	0.189
Site (Relative to larynx/hypopharynx)						
Oral, NOS	1.38	0.66 - 2.86	0.392	0.98	0.55 - 1.74	0.941
Oral cavity	2.37	1.02 - 5.53	0.046	0.94	0.45 - 1.97	0.871
Oropharynx	1.20	0.65 - 2.21	0.568	0.80	0.49 - 1.32	0.380
Smoking > 10 pack-years	0.97	0.47 - 2.01	0.932	1.40	0.81 - 2.42	0.233
Alcohol use > 1 drink / week	2.22	0.89 - 5.51	0.086	1.49	0.76 - 2.92	0.241
Rural Home Address	1.05	0.91 - 1.21	0.521	0.97	0.88 - 1.08	0.625