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## Poor Oral Health Affects Survival in Head and Neck Cancer

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### Abstract

**Introduction**—Poor oral health has emerged as a risk factor for squamous cell carcinoma of the head and neck (HNSCC) but its impact on survival has not been examined. We sought to estimate the impact of oral health indicators on survival in a population-based HNSCC cohort.

**Materials and Methods**—Cases (n=1381) and age-, sex- and race-matched controls (n=1396) were participants in the Carolina Head and Neck Cancer Epidemiologic Study (CHANCE). Vital status was determined via linkage with the National Death Index. Survival was considered at 5 years post-diagnosis or study-enrollment for controls. Oral health was assessed using self-reported indicators including frequency of routine dental exams and tooth brushing. We used Kaplan-Meier analyses and Cox regression to estimate adjusted hazard ratios (HR) and 95% confidence intervals (CI).

**Results**—Routine dental visits during the preceding 10 years were associated with decreased mortality risk (>10 visits: HR=0.6, 95% CI=0.4–0.8) after adjusting for confounders. This effect was most pronounced for oral cavity cancer—(e.g., >10 visits: HR=0.4, 95% CI=0.2–0.9). Dental visits were also positively associated with survival among controls. No other routine health screening (e.g., eye exams) was associated with survival.

**Conclusion**—We found significant associations between markers of oral health and survival among both HNSCC cases and controls. This association was most pronounced for sites closer to the dentition. Oral health may have a direct effect on tumor biology due to the associated immune or inflammatory response. It may also represent a proxy for wellness or unmeasured social determinants of health.

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## Keywords

oral health; head and neck cancer; dental hygiene; oral cancer; cancer survival; case-control studies; oropharyngeal cancer; laryngeal cancer; periodontal disease; squamous cell carcinoma

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## Introduction

Squamous cell carcinoma of the head and neck (HNSCC) contributes substantially to the global burden of cancer.<sup>1-3</sup> It is the sixth most common cancer worldwide,<sup>4</sup> and the fifth most common cancer in the United States, affecting approximately 40,000 new patients each year.<sup>1</sup> It encompasses cancers of the oral cavity, oropharynx, and larynx among others. While the mortality rate for HNSCC has improved recently, it still has poorer survival rates than some other common malignancies such as breast, cervical, and colorectal cancers.<sup>5,6</sup> The traditional risk factors for HNSCC have also been shown to affect survival.<sup>7-11</sup> These include tobacco and alcohol consumption, p16 status, demographics, and socioeconomic status.<sup>2,7-10,12-14</sup>

Poor oral health has recently been recognized as a risk factor for HNSCC.<sup>15-18</sup> Specifically, oral health indicators including good oral hygiene, daily tooth brushing and annual dental visits have been linked to modestly reduced HNSCC risk. Although the mechanisms underlying this postulated association have not been elucidated, oral biofilm-induced conditions, like periodontitis, can confer a substantial systemic and local (i.e., oral cavity) inflammatory burden,<sup>19-22</sup> which can alter both the behavior of tumors and the resulting immunological response. Moreover, good dental health can also be a marker for general wellness and health-promoting behaviors that likely influence cancer risk and survival.<sup>23</sup>

In spite of the accumulating evidence regarding oral health and HNSCC risk, very little information exists on the possible influence of oral health on HNSCC survival. To address this knowledge gap, we carried out this analysis aiming to estimate the impact of oral health indicators on survival in a large population-based HNSCC cohort. We also examined the association by HNSCC site (i.e., oral, laryngeal, pharyngeal) and the relationship of routine dental exams with other behaviors-measures of wellness (e.g., routine physical exams, eye exams, colonoscopies) as predictors of HNSCC survival.

## Methods

### Study population

Data for this analysis was obtained from the Carolina Head and Neck Cancer Epidemiology Study (CHANCE); a population based case-control study in North Carolina.<sup>16,18</sup> Cases were eligible to participate in CHANCE 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. Our inclusion criteria was squamous cell carcinoma of the head and neck; all other diagnoses were excluded (i.e. patients with benign tumors, carcinomas *in situ*, and papillary or adenoid cystic carcinomas). There were 1,381 cases in CHANCE. The control group (n=1,396) was identified through the North Carolina

Department of Motor Vehicle records, and those individuals were frequency-matched with cases on age, race, and sex. The study was approved by the Institutional Review Board at the University of North Carolina at Chapel Hill.

### Exposure Assessment

Oral health was assessed by trained nurse-interviewers using a structured questionnaire during an in-home visit for both cases and controls.<sup>16,18</sup> Cases were interviewed soon after cancer diagnosis (the average time between diagnosis and interview was 5.3 months) and they were specifically asked about their oral health and care before cancer diagnosis. Self-reported oral health variables collected via the interview included: 1) frequency of dental visits in the past 10 years; 2) the number of natural teeth lost, excluding third molars and teeth extracted for orthodontic reasons; 3) frequency of tooth brushing during each participant's adult life; 4) history of tooth mobility or "teeth loose in their socket" because of disease; and 5) gum disease diagnosed by a dentist. The number of dental visits in the past 10 years was chosen as the primary oral health indicator, as it was previously the oral health variable most strongly associated with increased cancer incidence.<sup>16,18</sup> In addition, it was likely the most reliable metric of oral health that could be collected by the trained interviewers.

### Survival Assessment

CHANCE data were linked to the National Death Index (NDI) based on name, social security number, date of birth, sex, race, and state of residence to identify deaths through December 31, 2013. The NDI is a national file of identified death record information, including cause of death compiled from computer files submitted by State Vital Statistics offices. More than 75% of the CHANCE cases were perfect or near-perfect NDI matches on social security number, date of birth, and sex. The remaining near-matches were confirmed by examining the United States Social Security Death Index and obituaries on newspaper websites. We chose 5-year survival as our endpoint for this study, as after 5 years the initial tumor likely plays a diminished role in their overall survival.

### Questionnaire and Clinical Assessment

Demographic, lifestyle, diet, and other data also were collected during the in-home interview. Potential confounders to be adjusted for in statistical models were selected *a priori* based on their potential association with survival and oral health. These included age, race, gender, education, annual income, smoking and alcohol consumption. In order to assess for HPV-associated cancer, p16 immunohistochemistry was retrospectively performed on a subset patients using a previously described protocol.<sup>18</sup> Smoking was dichotomized at 10 pack-years and alcohol use at 1 drink per week.

Clinical information such as tumor site was abstracted from participants' medical records and reviewed independently by a pathologist and a head neck cancer surgeon. Tumors were classified by site according to International Classification of Diseases for Oncology, third edition, topography codes for the oral cavity (C02.0–C02.3, C03.0, C03.1, C03.9, C04.0, C04.1, C04.8, C04.9, C05.0, C06.0–C06.2, C06.8, and C06.9), the larynx (C32.0–C32.3, and C32.8–C32.9), the hypopharynx (C13.0, C13.1, C13.2, C13.8, and C13.9), and the

oropharynx (C01.9, C02.4, C05.1, C05.2, C09.0, C09.1, C09.8, C09.9, C10.0–C10.4, C10.8, and C10.9).

### Statistical Analysis

Descriptive statistics were calculated and bivariate testing methods included *t* and chi-squared tests. Overall survival was calculated as time from diagnosis to either date of death due to any cause or censoring on December 31, 2013, whichever came first. Overall and stratified Kaplan-Meier survival plots were constructed. Hazard ratios (HRs) and 95% confidence intervals (CI) for the independent effects of oral health indicators on overall survival were estimated by Cox proportional hazards regression modeling adjusting for sex, age, race, education, income, insurance status, smoking, and alcohol use. Cases and controls were analyzed in both separate analyses and a pooled analysis. For cases, the Cox proportional hazard models were also adjusted for T, N and M classification. Models were run with and without treatment variables (surgery, chemotherapy, and radiation therapy). The proportional hazards assumption for the oral health indicator variables was tested and satisfied.

We tested for site-specific heterogeneity of survival effect estimates with a global Wald chi-squared test using a conservative criterion of  $p < 0.2$ , and further examined *post hoc* differences between sites using pairwise homogeneity Z-scores and corresponding *p*-values.<sup>24</sup> STATA 13 (StataCorp, College Station, TX) was used for analyses.

### Results

Descriptive information of the CHANCE participants is presented by case/control status and according to receipt of a dental exam during the last 10 years in Table 1. Cases had mean age of 59 years and had mostly high school education or less; affected sites were mostly larynx/hypopharynx ( $n=481$ ), followed by oropharynx ( $n=327$ ) and oral cavity ( $n=164$ ). Almost half (51%) of cases and three-quarters (76%) of controls had a dental exam during the preceding 10 years ( $p < 0.001$ ). Notable differences in dental exam status were found according to most other examined participant characteristics including sociodemographics, behaviors and other oral health indicators; e.g., dental exams were more frequent among whites, more educated and more affluent cases and controls. Lack of dental visits was also associated with other deleterious health behaviors including smoking and alcohol use (among cases), as well as less frequent tooth brushing and increased tooth loss.

During the 5-year follow-up period, there were 578 deaths among cases (survival: 58%; 95% CI=55% – 61%) and 146 deaths among controls (survival: 91%; 95% CI=89% – 0.92%). Routine dental visits during the preceding 10 years were associated with decreased mortality risk among cancer cases (Figure 1). After adjustment for confounders, dental visits were associated with almost 40% decreased survival, although no exposure-response gradient was found. When compared with no visits, 1 to 10 visits were associated with a HR of 0.62 for mortality (95% CI=0.49–0.80) and >10 visits a HR of 0.63 (95% CI=0.46–0.89) (Table 2). Adjustment for tumor stage (T, N M) and other oral health indicators (e.g., frequency of tooth brushing, number of lost teeth, the presence of gum disease) did not result in any material change in the HR estimates. The inverse association between visits and mortality

differed by cancer site (Figure 2). Specifically, the reduced HR was most pronounced for oral cavity cancer (e.g., HR=0.40; 95% CI=0.17–0.93 for 10+ visits), followed by oropharyngeal cancer and then laryngeal/hypopharyngeal cancer (Table 3). The site-heterogeneity was statistically significant ( $X^2$ ,  $p=0.10$  for 1–10 visits;  $p<0.001$  for >10 visits). An exposure-related gradient also appeared for oral cavity cancer and oropharyngeal cancer (Table 3). There were no significant interactions between oral health and alcohol or tobacco use, race, or income. To account for possible confounding by p16 status, the model was run without p16+ cases (new  $n = 988$ ). There were no changes in the magnitude or significance of the hazard ratios for oral health.

We found similar associations between routine dental visits and survival among controls, with 1 to 10 routine and >10 routine dental visits during the last 10 years associated with decreased mortality risk when compared to those with no dental visits (HR=0.57; 95% CI=0.34–0.94 and HR=0.60; 95% CI = 0.34–0.94, respectively) (Table 2, Figure 3). There was no significant interaction between case/control status and frequency of dental visits (ratio of hazard ratios 0.8; 95% CI 0.5–1.2,  $p = 0.3$ ). Daily tooth brushing twice or more was another oral health indicator with similar reduced HRs among both cases (HR=0.80; 95% CI=0.64–1.00) and controls (HR=0.76; 95% CI=0.51–1.15) (Table 4). However, other dental indicators including lost teeth, gum disease, and loose teeth did not show any association with survival.

Because dental visits and tooth brushing can be regarded as measures of overall wellness and health-promoting behaviors, we examined the associations between HNSCC survival and three other types of screening and wellness behaviors: routine physical exams, routine eye exams, and routine colonoscopies in the preceding 10 years. We found no significant associations between any of these screening variables and mortality in cases or controls, with negligible HRs.

## Discussion

In this study among a large cohort of HNSCC patients and population-based controls, we found a significant association with strong HRs between poor oral health indicators and survival, among both cancer cases and controls. This association differed by cancer site and was most pronounced for sites closer to the dentition. Of note, no other type of routine screening such as physical or eye exams affected survival.

Friemel and colleagues produced the only other paper examining the association between oral health and survival and HNSCC.<sup>25</sup> The German case-only study used a composite score for oral health, including information on annual dental visits, daily tooth cleaning and use of dental floss. A low score was associated with a poor prognosis; however, this association was attenuated after controlling for age, sex, tumor stage, tumor site, treatment, education, HPV status, smoking and alcohol consumption (HR=1.30; 95% CI=0.78 – 2.15). In comparison, our study found a stronger association between poor oral health and poor survival with greater precision and a larger sample size (1185 vs. 276 cases), after controlling for a similar set of variables.

There are two possible interpretations of our results: 1) that oral health is a marker of overall wellness, or 2) poor oral health directly affects the cancer progression by affecting the development of the tumor or the associated host immune response. Multiple studies have found good oral health to be a marker for favorable survival. In a study of 21,700 elderly Japanese, tooth brushing and regular dental visits were associated with survival after controlling for age, sex, education level, smoking, drinking, and medical history.<sup>26</sup> Other studies have found an association between tooth loss and overall mortality in Danish,<sup>27</sup> Taiwanese,<sup>28</sup> Scottish,<sup>29</sup> French<sup>30</sup> and Chinese populations.<sup>31</sup> The mechanism is unclear and it has been suggested that markers of oral health such as tooth loss, visits to the dentist, and tooth brushing may serve as a proxy for life and health stressors that can affect mortality.<sup>23</sup> Our study supports oral health as a marker for overall wellness in that the controls, as well as the cases, had associations between oral health and survival.

Although our data suggest that oral health may be a surrogate for overall wellness, the differential impact on survival by head and neck cancer site may suggest an additional biologic mechanism. Oral health had a significantly greater impact on survival for oral and oropharyngeal cancer cases compared to other sites. Several mechanisms have been proposed by which oral health could impact cancer susceptibility and survival; these include alterations to the immunologic response to the tumor and changes in the local environment of the tumor. Periodontitis, resulting from poor oral hygiene and an aberrant inflammatory response,<sup>32</sup> affects local inflammation and immune function,<sup>33–35</sup> and the effect is amenable to periodontal treatment.<sup>19,36–38</sup> Likewise, oral bacterial dysbiosis, particularly involving *Porphyromonas gingivalis* and *F. nucleatum*, have been implicated in the development of oral cancer in human and animal studies.<sup>39–41</sup> Possible mechanisms include the induction of chronic inflammation,<sup>40,42,43</sup> promotion of cellular invasion,<sup>40</sup> and direct production of carcinogens.<sup>40,44,45</sup> These local mechanisms that promote bacterial carcinogenesis could also affect tumor behavior and influence patient survival.

It is noteworthy that patients with poor oral health were less educated, had lower incomes, and had poor health behaviors such as alcohol and tobacco use. It has been well documented that social determinants of health have a strong correlation with prognosis in head and neck cancer.<sup>46–51</sup> Our multivariate models showed that oral health had a significant association with survival independent of education and income. Nonetheless, the overwhelming influence of social determinants of health on oral health is well-established, and a large number of unmeasured or unknown pathways, such as a biological mechanism, could underlie the links between social factors and oral health outcomes, including oral cancer and survival.<sup>52</sup>

The chief strength of this study is the use of a large population-based sample of head and neck cancer patients with a long period of follow up. This is the largest study to examine this association. It is also the first study to examine this association in parallel with matched control patients, and the first study to examine the association of other markers of screening and wellness on survival besides oral health. The main study limitation is in the ascertainment of dental variables. These were collected via interviews conducted by trained nurses instead of examination by trained dental professionals, and they represent surrogates

of oral health instead of clinical endpoints or biomarkers. A further limitation is that this study address overall survival and does not include disease-free survival.

Future studies are needed to determine whether the association between oral health and survival is due to markers of wellness, or if oral health has a direct effect on tumor progression. The best methods would involve direct examination of oral health by dental professionals, identification and quantification of the relevant oral microbiome, and examination of oral and systemic inflammatory markers. A clear delineation of the mechanism behind the effect of oral health on survival would provide an impetus for dental care and oral hygiene recommendations for patients with head and neck cancer.

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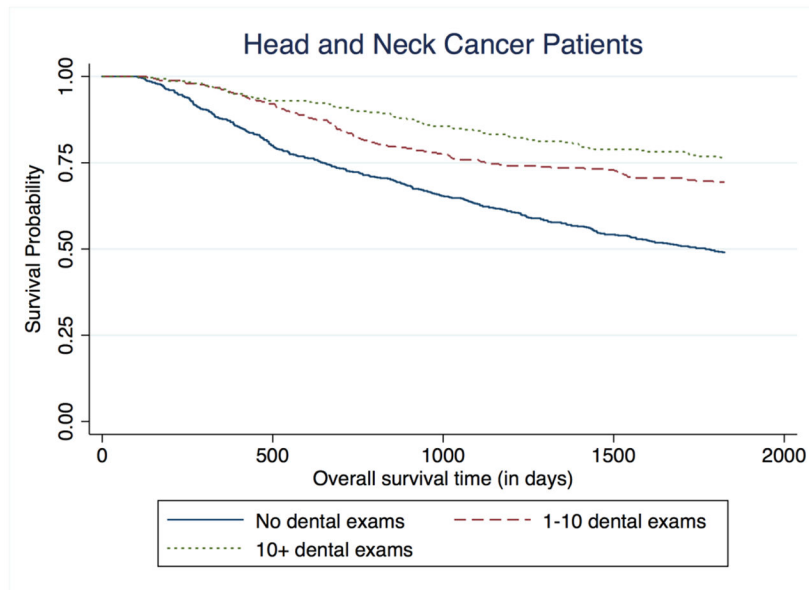
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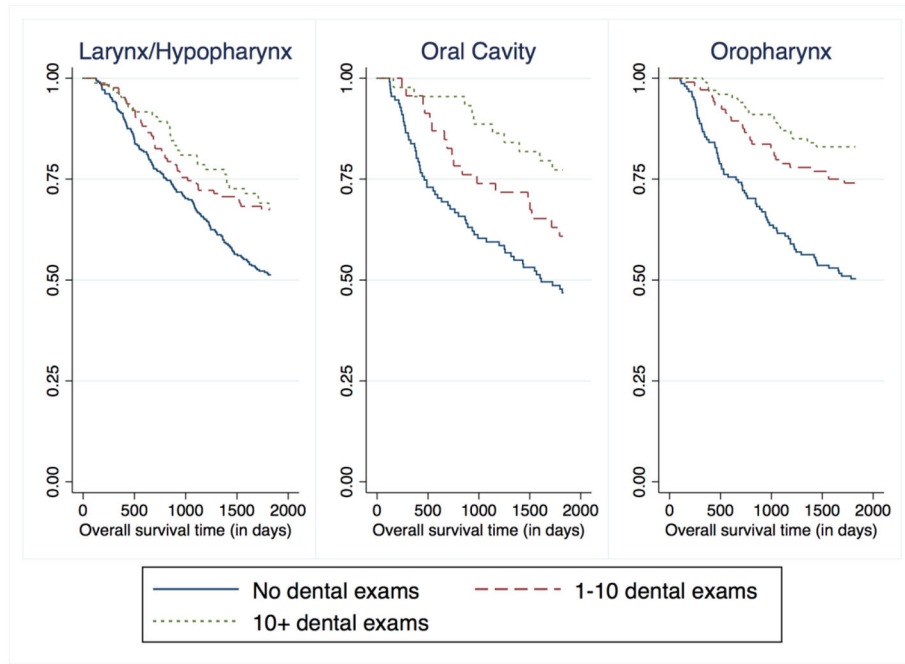
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**Highlights for Poor Oral Health Affects Survival in Head and Neck Cancer**

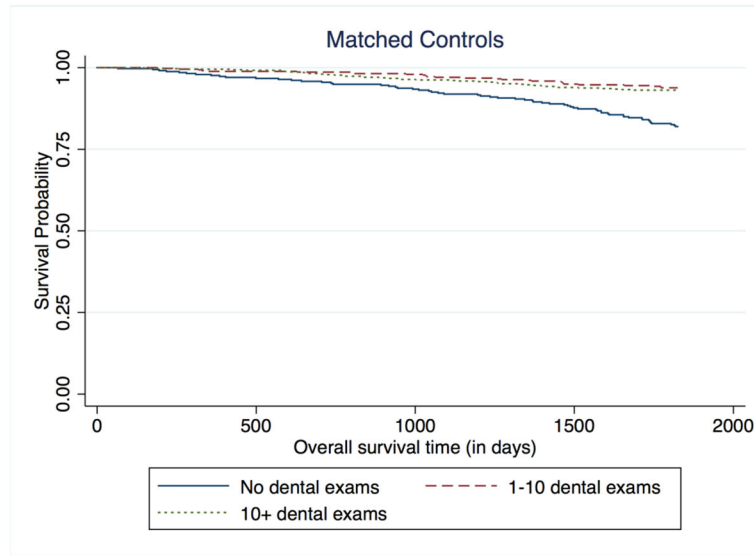
- We found a significant association between markers of oral health and survival
- This association was most pronounced for sites closer to dentition, and present in cases as well as controls
- Oral health may represent a proxy for wellness or unexamined social determinants of health
- It may also have a direct effect on tumor biology or the immune response



**Figure 1.** Kaplan-Meier curve for 5-year overall survival among head and neck cancer patients, stratified by frequency of dental exams (pre-cancer diagnosis) over the past 10 years.



**Figure 2.** Kaplan-Meier curve for 5-year overall survival among larynx/hypopharynx, oral cavity, and oropharynx patients, stratified by frequency of dental exams (pre-cancer diagnosis) over the past 10 years.



**Figure 3.** Kaplan-Meier curve for 5-year overall survival among controls, stratified by frequency of dental exams over the past 10 years.

**Table 1**

**Table 1a. Descriptive statistics for cases and controls by dental visit frequency**

Variable	Cases (1381)			Controls (1396)		
	No Exam	Dental Exam	P-Value	No Exam	Dental Exam	P-Value
<b>Age (SD)</b>	(n = 679)	(n = 702)		(n = 333)	(n = 1063)	
	59.4 (10.0)	58.6 (10.8)	0.125	64.6 (10.0)	60.7 (12.8)	< 0.001
<b>Sex</b>						
<b>Male (%)</b>	528 (77.8)	523 (74.5)	0.156	245 (73.6)	721 (67.8)	0.047
<b>Female (%)</b>	151 (22.2)	179 (25.5)		88 (26.4)	342 (32.1)	
<b>Race (%)</b>						
White	417 (61.4)	589 (83.9)	< 0.001*	229 (68.8)	885 (83.3)	< 0.001
Black	247 (36.4)	100 (14.3)		101 (30.3)	163 (15.3)	
Other	15 (2.2)	13 (1.9)		3 (0.9)	15 (1.4)	
<b>Education (%)</b>						
Less Than High School	347 (72.9)	129 (27.1)	< 0.001	130 (39.0)	89 (8.4)	< 0.001
High School Grad	211 (54.2)	178 (45.8)		109 (32.7)	225 (21.2)	
Greater than High School	121 (23.5)	395 (76.6)		94 (28.2)	749 (70.5)	
<b>Household income (%)</b>						
< 20k	335 (51.9)	154 (22.8)	< 0.001	132 (41.1)	129 (12.6)	< 0.001
20k – 50k	232 (35.9)	233 (34.5)		144 (44.9)	349 (34.1)	
> 50k	79 (12.2)	289 (42.8)		45 (14.0)	545 (53.3)	
<b>Insurance Status (%)</b>						
Private	150 (23.0)	325 (47.9)	< 0.001	70 (21.2)	486 (46.4)	< 0.001
Medicaid/Medicare	286 (43.9)	176 (26.0)		162 (49.1)	275 (26.3)	
None	122 (18.7)	45 (6.6)		42 (12.7)	34 (3.3)	
Other	94 (14.4)	132 (19.5)		56 (17.0)	252 (24.1)	
<b>Smoking (%)</b>						
< 10 PY	74 (11.0)	219 (31.7)	< 0.001	125 (37.7)	650 (61.5)	< 0.001
10+ PY	602 (89.1)	473 (86.4)		207 (62.4)	407 (38.5)	
<b>Alcohol (%)</b>						
< 1 drink/week	76 (11.6)	116 (17.3)	0.003	103 (31.8)	357 (33.9)	0.481

**Table 1a. Descriptive statistics for cases and controls by dental visit frequency**

Variable	Cases (1381)			Controls (1396)		
	No Exam	Dental Exam	P-Value	No Exam	Dental Exam	P-Value
>= 1 drink/week	582 (88.5)	555 (82.7)		221 (68.2)	696 (66.1)	
<b>Lost permanent tooth or have pulled (%)</b>						
0-5	187 (27.8)	412 (59.5)	<0.001	78 (23.5)	757 (71.4)	<0.001
6-15	81 (12.1)	145 (20.9)		46 (13.9)	164 (15.5)	
16-28	404 (60.1)	136 (19.6)		208 (62.7)	139 (13.1)	
<b>Did a dentist say you had gum disease (%)</b>						
No	448 (66.3)	478 (69.0)	0.285	234 (70.9)	788 (74.5)	0.199
Yes	228 (33.7)	215 (31.0)		96 (29.1)	270 (25.5)	
<b>Have loose permanent tooth due to disease (%)</b>						
No	351 (52.0)	492 (70.9)	<0.001	200 (60.2)	871 (82.2)	<0.001
Yes	324 (48.0)	202 (29.1)		132 (39.8)	189 (17.8)	
<b>How often brush teeth (%)</b>						
< Once / Day	98 (16.2)	35 (5.1)	<0.001	51 (16.2)	23 (2.2)	<0.001
Once / Day	336 (55.6)	261 (37.9)		166 (52.7)	379 (35.8)	
>= 2x / Day	170 (28.2)	393 (57.0)		98 (31.1)	657 (62.0)	
<b>Number of dental visits in last 10 years</b>						
0	679 (100)	0		333 (100)		
1-5	0	211 (33.1)		0	226 (21.7)	
6-10	0	129 (20.2)		0	210 (20.1)	
11-20	0	257 (40.3)		0	532 (51.0)	
21-40	0	41 (6.4)		0	76 (7.3)	
<b>Number of Routine Physical Exams (Excluding exams for illness)</b>						
One or Less	338 (49.8)	161 (24.8)	<0.001	48 (17.0)	77 (7.6)	<0.001
2 to 10	152 (22.4)	220 (33.9)		120 (42.4)	406 (40.2)	
10+	189 (27.8)	269 (41.4)		115 (40.6)	527 (52.2)	
<b>Number of Routine Eye Exams</b>						
No eye exams	216 (31.8)	85 (13.1)	<0.001	50 (15.0)	76 (7.3)	<0.001
1 to 5	356 (52.4)	370 (56.9)		195 (58.6)	529 (50.6)	
5+	107 (15.8)	195 (30.0)		88 (26.4)	441 (42.2)	



**Table 1a. Descriptive statistics for cases and controls by dental visit frequency**

Variable	Cases (1381)		Controls (1396)		P-Value
	No Exam	Dental Exam	No Exam	Dental Exam	
<b>Number of Colonoscopies</b>					
No colonoscopy	452 (67.1)	375 (57.9)	167 (50.2)	414 (39.6)	0.001
Colonoscopy	222 (32.9)	273 (42.1)	166 (49.9)	632 (60.4)	

**Table 1b: Descriptive statistics for cases and controls by dental visit frequency**

Tumor Characteristics	No Exam	Dental Exam	P-Value
<b>Hypopharynx</b>	38 (55.9)	30 (44.1)	< 0.001
<b>Larynx</b>	274 (57.2)	205 (42.8)	
<b>NOS</b>	103 (41.4)	146 (58.6)	
<b>Oral cavity</b>	111 (52.6)	100 (47.4)	
<b>Oropharynx</b>	151 (40.7)	220 (59.3)	
<b>T-stage</b>			
T1	161 (37.3)	271 (62.7)	< 0.001 *
T2	230 (50.7)	224 (49.3)	
T3	155 (61.9)	96 (38.3)	
T4	133 (54.5)	111 (45.5)	
<b>N-stage</b>			
N0	379 (51.2)	361 (48.8)	0.102
N1+	300 (46.8)	341 (53.2)	
<b>M-stage</b>			
M0	676 (49.4)	693 (50.6)	0.093
M1	3 (25.0)	9 (75.0)	
<b>Stage</b>			
I	130 (41.8)	181 (58.2)	0.673 *
II	141 (56.9)	107 (43.2)	
III	122 (52.4)	111 (47.6)	
IVA	200 (47.7)	219 (52.3)	
IVB	83 (52.5)	75 (47.5)	
IVC	3 (25.0)	9 (75.0)	

**Table 1b: Descriptive statistics for cases and controls by dental visit frequency**

Tumor Characteristics	No Exam	Dental Exam	P-Value
<b>P16 Overexpression<sup>**</sup></b>			
Negative	160 (58.2)	115 (41.8)	< 0.001
Positive	83 (38.6)	132 (61.4)	
<b>Chemo</b>			
No	378 (50.5)	370 (49.5)	0.772
Yes	234 (49.7)	237 (50.3)	
<b>Radiation</b>			
No	130 (46.6)	149 (53.4)	0.17
Yes	482 (51.3)	458 (48.7)	
<b>Surgery</b>			
No	291 (54.7)	241 (45.3)	0.006
Yes	321 (46.7)	366 (53.3)	

\* P-value for high vs. low stage

\*\* P16 expression was determined by immunohistochemistry on a subset of patients as a marker for HPV-associated disease

**Table 2**

Adjusted hazard ratios from the Cox proportional hazard regression

Variable	Haz. Ratio	[95% Conf. Interval]	P-Value
<b>Cases N = 1185; 468 deaths</b>			
Dental Exams in past 10 years (relative to none)			
1–10 Exams	0.62	0.49 – 0.80	< 0.01
10 + Exams	0.63	0.46 – 0.86	< 0.01
Age	1.01	1.00 – 1.02	0.03
Female Sex (relative to male)	1.03	0.82 – 1.30	0.78
White Race (relative to non-white)	0.79	0.63 – 0.99	0.04
Education > high school (relative to < HS)	0.73	0.58 – 0.92	0.01
Income (relative to < 20 K)			
20k – 50k	1.31	0.98 – 1.74	0.06
> 50k	1.38	1.01 – 1.89	0.04
Private Insurance (relative to Medicare, Medicaid, or other)	0.57	0.44 – 0.73	< 0.01
Smoking > 10 PY (relative to < 10 PY)	1.16	0.88 – 1.53	0.29
Alcohol use > 1 drink / week (relative to < 1 drink / week)	1.25	0.90 – 1.72	0.18
T Stage (relative to T1)			
T2	1.24	0.96 – 1.60	0.10
T3	1.41	1.06 – 1.89	0.02
T4	1.85	1.39 – 2.45	< 0.01
N1 (vs. N0)	1.52	1.25 – 1.84	< 0.01
M1 (vs. M0)	8.23	3.79 – 17.86	< 0.01
<b>Controls N = 1192; 118 deaths</b>			
Dental Exams in past 10 years (Relative to none)			
1–10 Exams	0.57	0.34 – 0.94	0.03
10 + Exams	0.60	0.37 – 0.98	0.04
Age	1.04	1.02 – 1.07	0.00
Female Sex (relative to male)	0.93	0.58 – 1.48	0.75
White Race (relative to non-white)	1.30	0.81 – 2.08	0.28
Education > high school (relative to < HS)	0.87	0.57 – 1.32	0.50
Income (relative to < 20 K)			
20k – 50k	1.48	0.92 – 2.37	0.10
> 50k	1.08	0.58 – 2.00	0.81
Private Insurance (relative to Medicare, Medicaid, or other)	0.59	0.32 – 1.07	0.08
Smoking > 10 PY (relative to < 10 PY)	1.46	0.97 – 2.20	0.07
Alcohol use > 1 drink / week (relative to < 1 drink / week)	1.64	1.02 – 2.64	0.04

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**Table 3**

Hazard ratio by site

Variable*	Hazard Ratio	[95% Conf. Interval]	P-Value	
<b>Oral cavity Cancers (N = 164; 74 deaths)</b>				
1–10 Exams (Relative to none)	0.53	0.28	1.00	0.05
10 + Exams (Relative to none)	0.40	0.17	0.93	0.03
<b>Oropharynx Cancers (N = 327; 111 deaths)</b>				
1–10 Exams (Relative to none)	0.69	0.42	1.13	0.14
10 + Exams (Relative to none)	0.57	0.29	1.11	0.10
<b>Larynx/Hypopharynx Cancers (N = 481; 201 deaths)</b>				
1–10 Exams (Relative to none)	0.64	0.44	0.94	0.02
10 + Exams (Relative to none)	0.82	0.51	1.31	0.41

\* Controlling for age, sex, race, income, education, insurance, tobacco and alcohol use, T-stage, N-stage, and M-stage

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**Table 4**

5-year survival with other dental indicators

Variable*	Haz. Ratio	[95% Conf. Interval]	P-Value
<b>Cases n=1127; 443 deaths</b>			
Dental Exam in last 10 years (vs. none)	0.76	0.61 0.95	0.02
Amount Brush Teeth per day (once/day as comparison group)			
Twice or more	0.80	0.64 1.00	0.05
Less than once	0.99	0.74 1.33	0.95
> 5 Lost Teeth (< 5 as comparison group)	0.94	0.74 1.18	0.57
Gum disease	0.83	0.66 1.04	0.10
Loose teeth	1.13	0.91 1.39	0.27
<b>Controls n=1262; 115 deaths</b>			
Dental Exam in last 10 years (vs. none)	0.64	0.41 1.01	0.05
Amount Brush Teeth per day (once/day as comparison group)			
Twice or more	0.76	0.51 1.15	0.20
Less than once	0.94	0.46 1.90	0.86
> 5 Lost Teeth (< 5 as comparison group)	1.39	0.89 2.16	0.15
Gum disease	0.81	0.52 1.26	0.35
Loose teeth	1.15	0.73 1.81	0.56

\* Controlling for age, sex, race, income, education, insurance, tobacco and alcohol use, and T, N, and M-stage for cases

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