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Population analysis of socioeconomic status and otolaryngologist distribution on head and neck cancer outcomes

Nitin A Pagedar, MD, MPH¹, Andrew B Davis, MD¹, Steven M Sperry, MD¹, Mary E Charlton, PhD², and Charles F Lynch, MD, PhD²

¹Department of Otolaryngology – Head and Neck Surgery, University of Iowa, Iowa City, IA

²Department of Epidemiology, University of Iowa, Iowa City, IA

Abstract

Background: The relationship between clinical outcomes and geographic determinants is not well known for head and neck cancer. Socioeconomic status (SES) factors and the distribution of healthcare resources might impact outcomes.

Methods: Head and neck cancer cases in the Surveillance, Epidemiology, and End Results (SEER) database were studied. Patient-level prognostic factors were identified from SEER, and county-level factors from the Area Health Resource File. Stage at presentation and observed survival were the outcomes of interest, with predictive factors identified by multivariate logistic and Cox proportional hazards regression.

Results: On multivariate analysis, tumor site, sex, race, marital status, rural residence, and county poverty level predicted stage at presentation. Sex, race, marital status, and county-level poverty and number of otolaryngologists predicted observed survival.

Conclusions: Adverse county-level SES predicted advanced cancer stage at presentation and diminished observed survival. SES was a stronger predictor of patient outcomes than rurality or number of otolaryngologists.

Keywords

health services; socioeconomic status; epidemiology; early detection of cancer; survival outcomes

Introduction

Head and neck cancer is a source of significant morbidity and mortality throughout the United States. Many different factors influence a patient's odds of survival, including stage at presentation, race/ethnicity, smoking and alcohol intake and HPV status.^{1,2} One modifiable factor that may improve health is proximity to healthcare services.³ It has been suggested that patients residing in rural areas are more likely to have late stage at presentation and diminished overall life expectancy because of their distance to tertiary care

Corresponding author: Nitin A Pagedar, MD, MPH, Department of Otolaryngology – Head and Neck Surgery, University of Iowa, 200 Hawkins Drive, 21200 PFP, Iowa City, IA 52242, Phone: 319-384-6980, Fax: 319-356-4547, nitin-pagedar@uiowa.edu.

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centers.⁴ Early cancer detection and treatment are goals of any healthcare system, and the distance to an academic medical center has been shown to increase the time to diagnosis and treatment.⁵ It has been shown that the presence of 1 dermatologist in a given county was associated with 35% lower melanoma mortality, and the presence of up to 2 dermatologists reduced it by 53%.⁶ Also, having a higher number of gastroenterologists and primary care physicians in non-metropolitan areas was found to decrease late stage colorectal cancer diagnoses by 14-17%.⁷ Given that primary care physicians and dentists are often unfamiliar with the physical findings associated with head and neck cancer, distribution of otolaryngologists or other subspecialists who diagnose or manage such cancers may have a similar effect on early diagnosis and effective treatment.

Socioeconomic status (SES) is another factor that has been shown to affect delivery of healthcare services and patient outcomes. Much of the research done on SES and head and neck cancer has looked at how race affects treatment patterns and outcomes. Although research has shown that non-white groups tend to present at a more advanced stage and have worse overall survival,⁸⁻¹⁰ other SES variables are important to the overall treatment of a patient. Men who have less than a high school education have higher rates of head and neck cancer.¹¹ Molina et al. evaluated over 20,000 head and neck cancer patients in Florida and found that patients with low socioeconomic background had poorer survival when confounding variables (e.g., smoking history) were controlled.

In this report, we first investigate the association between otolaryngologist distribution and SES variables on stage at presentation. Second, we investigate the effect of otolaryngologist distribution and SES variables on observed survival after diagnosis of head and neck cancer. Understanding how otolaryngologist density and socioeconomic status impact head and neck cancer may guide development and implementation of health care policies in the United States.

Methods

This study did not meet the regulatory definition of human subjects research and consequently did not require review by the institutional review board. The SEER database provides comprehensive data about incident cancers in patients living in 18 geographic areas that comprise 28% of the US population. All head and neck cancer cases from the years 2008-2012 were identified in the Surveillance, Epidemiology, and End Results (SEER) database.¹² These included patients with primary sites of the oral cavity (excluding lips and major salivary glands), oropharynx, nasopharynx, hypopharynx, and larynx. AJCC 6th Edition stages were recorded from SEER. Analysis was limited to patients with known stage and microscopically confirmed invasive carcinoma (ICD-O-3 histology codes 8010-8084, ICD-O-3 behavior code 3).

Data on the geographic distribution of health care resources were obtained from the Area Health Resource File 2015-16 (AHRF).¹³ We included the number of non-federal otolaryngologists, primary care physicians, radiation oncologists and dentists in each county, along with the county population, the number of acute-care hospital beds, and the number of hospitals with 300 or more beds. The following county-level measures of socioeconomic

status for 2010 were obtained from AHRF: proportion of the population living in households below federal poverty level, proportion nonwhite population, proportion of uninsured, and proportion of adults over age 25 with less than high-school education. We also recorded each county's 2013 Rural-Urban Continuum Code (RUCC) as reported by the U.S. Department of Agriculture.¹⁴

We analyzed stage at presentation as a binary variable, with Stages I-II referred to as "early" and Stages III-IV as "advanced." We explored otolaryngologist number as a continuous variable as well as binary, dichotomized by presence of 2 or fewer otolaryngologists (representing the 75th percentile). Numbers of general practice physicians, dentists, and radiation oncologists were entered into models as continuous variables after exploration of that data as binary variables dichotomized by their median values. Socioeconomic status variables were included in models as continuous variables. Rural-urban continuum codes were analyzed as a binary variable, with codes 1-4 and 6 (counties in metropolitan areas or those adjacent to a metropolitan area with population 2,500 or more) compared with codes 5 and 7-9 (nonmetropolitan counties not adjacent to metropolitan area with population less than 20,000). The latter grouping defined rural residence.

We conducted univariate logistic regression analyses to identify associations between independent variables and stage at presentation. Multivariate analysis was then performed with a stepwise model selection procedure to identify the most parsimonious predictive model. We included an interaction term between poverty and rurality. We tested models that included provider-level data both as binary (defined by county medians) and continuous; there was no difference in the variables selected into the final model; we report results with continuous variables for ease of interpretation.

The same independent variables were used in univariate Cox proportional hazards regression analysis of observed survival, with multivariate analysis conducted through stepwise model selection to calculate adjusted hazard ratios for death associated with the optimal sequence of covariates. For all analyses, $p=0.05$ was considered statistically significant.

Results

Characteristics of the 609 counties comprised by the 17 included SEER registries are shown in Table 1. Alaska counties were excluded because county-level data were not made available in SEER due to low case counts. There were large between-county differences in most physician and hospital variables with strongly non-normal distributions. Table 1 also shows distributions of the four socioeconomic variables included in the analysis. Table 2 shows pairwise Spearman correlation coefficients for the county-level variables. Of note, all pairwise correlation coefficients were statistically significantly different from null.

Table 3 describes the characteristics of the cohort. There were 44,962 upper aerodigestive tract cancer cases in the SEER database diagnosed between 2008 and 2012 for which staging information was available. Oropharynx was the most common site with 16,813 cases, 37% of the total. In terms of stage at presentation, 28,360 (63%) cases were diagnosed at advanced stage, with proportions varying by site (42.9% for laryngeal cancers to 85.7%

oropharyngeal cancers). Patients diagnosed at advanced stage were younger, more likely male, black, and unmarried, and less likely to reside in a rural county. Their counties of residence had greater non-white, uninsured, and impoverished proportions. In absolute numbers, there were progressively more cases from 2008 to 2012. Univariate regression did not show a significant association between number of radiation oncologists, dentists, or primary care physicians and stage at presentation, with odds ratios 1.00 for each.

Results of univariate logistic regression analysis to determine the effect of county-level physician, hospital, and SES variables and patient-level factors on stage at presentation are shown in Table 3. Most covariates were statistically significant as predictors of advanced stage at presentation, but odds ratios were small. Rural patients were less likely to be diagnosed at advanced stage, as were patients residing in counties with 2 or fewer otolaryngologists. Table 4 shows results of multivariate logistic regression with stepwise model selection. Cancer site, older age, male sex, black race, unmarried status, and higher county poverty rate predicted advanced stage at presentation, while diagnosis in 2008 and rural residence were associated with lower likelihood of advanced stage at presentation. Number of otolaryngologists and other county-level socioeconomic and healthcare resource variables were not selected into the final model, nor was an interaction term between rurality and poverty.

Survival data were available for 44,950 patients, of whom 16,925 died during the follow up period. Results of univariate Cox proportional hazard regression on observed survival are shown in Table 5. As expected, older age and advanced stage were associated with worse survival. Female sex, black race, and unmarried status were also associated with worse survival. The county-level numbers of radiation oncologists, primary care physicians, and dentists did not show associated with survival (hazard ratio = 1.00 for each). The results of multivariate Cox proportional hazard regression are shown in Table 6. The final model included age and stage at diagnosis, male sex, cancer site, year of diagnosis, race, and marital status. In addition, higher poverty rate, lower number of hospital beds, and 2 or fewer otolaryngologists were associated with worse survival. An interaction term between year of diagnosis and tumor site was not selected into the final model, nor was rurality or a variable encoding interaction between rurality and poverty.

Discussion

The results reported demonstrate an association between depressed socioeconomic condition and stage at presentation and survival after diagnosis of head and neck cancers. Residence in urban counties was associated with diagnosis at advanced stage, while residence in a county with two or fewer otolaryngologists was associated with poorer survival after cancer diagnosis, but not with diagnosis at advanced stage. These findings are relevant to healthcare policy makers, patients, and providers.

It is established that SES can affect outcomes negatively across many different cancer types.¹⁵ The effect of race on outcomes has been studied in patients with head and neck cancer,⁸ but the effect of other socioeconomic indicators has been studied to a lesser extent. Our univariate analysis showed that low income, low educational attainment, minority status, and

lack of health insurance were each associated with advanced stage at presentation. As might be expected, the socioeconomic indicators correlated strongly with each other. The fact that only poverty was maintained in the final regression model means that poverty was the most predictive, given all other covariates in the model, and that the other factors did not add more predictive value to a model already containing poverty.

The interaction between rurality and socioeconomic status is also of interest. Urban and rural poverty are distinct phenomena. We included an interaction term between poverty and rurality in the regression models for both stage and survival, neither of which entered into the final model, indicating that the predicted effect of poverty was not different between residents of rural and urban counties. The lower odds of diagnosis at early stage in urban counties may indicate greater barriers to care in those populations than in rural areas.

An important finding was that living in a county with more than two otolaryngologists was not clearly associated with improved outcomes. The multivariate hazard ratio was statistically significant, but showed an effect size that was modest in magnitude. Several publications have shown correlations between important health outcomes and proximity to relevant specialist physicians, including cancers of the bladder and prostate with urologists, cutaneous melanoma and dermatologists, and neonatal mortality and neonatal intensive care units.^{16–18} Those studies did not account for differences in socioeconomic factors between communities – differences that likely correlate with where physicians work.

These results support and expand upon previous research that has been conducted on SES and relevant head and neck cancer outcomes. Chu et al.¹ identified an association between neighborhood-level socioeconomic indicators and head and neck cancer mortality among Asians and Pacific Islanders living in California. Johnson et al.¹¹ extended the analysis to conclude that head and neck cancer incidence rates were also higher in men with socioeconomic disadvantage. The use of the SEER database allowed our study to have not only a large sample size but also a population basis, so that patients were selected based on their place of residence rather than their attendance at any particular hospital or facility, leading to a more generalizable analysis including patients treated at small hospitals. Molina et al.⁸ demonstrated similar findings using a data set from Florida; our analysis also included the effect of rurality and a wider set of socioeconomic indicators.

There might be other system factors that may be relevant in predicting outcomes but could not be studied using the resources available for this study: for example, proximity of subspecialty physicians and the teaching status of the hospitals where treatment was performed. We selected outcomes that might be sensitive to the availability of health care resources and could be studied using the data available. For head and neck cancer, there are no well-defined metrics of care quality that could serve as universal and useful process measures, so we limited analysis to stage and survival.

Our analysis entailed defining county rurality based on inclusion within a metropolitan area, proximity to such an area, and population. There is no natural cut-point to define rurality. We chose a binary definition because the small numbers of cases arising in residents of the most rural counties would not permit useful analysis of a classification with three or more

categories. We included counties with RUCC 6 among the urban counties because we assumed their proximity to a metropolitan area might make medical practice and care closer to that found in metropolitan counties.

The analysis of our data requires the assumption that county-level socioeconomic indicators are descriptive of patient-level experiences. We made that assumption in the absence of any large-scale data source combining patient-level socioeconomic and health outcome information. Clearly, there is within-county socioeconomic heterogeneity across the United States. Therefore, the conclusions of our analysis are best made on a population basis rather than a patient-level basis. We also assumed that socioeconomic characteristics of the 609 counties did not change during the years in which cancers were diagnosed, treated, and followed. Selection of socioeconomic and physician distribution data from the year at the midpoint of a 5-year time interval should serve to minimize the systematic error introduced by that assumption.

Conclusions

In a population-based analysis, county socioeconomic factors were predictive of stage at presentation and survival outcomes for head and neck cancers. County poverty rate appeared to have a stronger impact than rurality or the presence of otolaryngologists. These results are important in considering population interventions to improve head and neck cancer outcomes.

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Table 1:Characteristics of the 609 counties in SEER registry areas^{*}

Characteristic	Minimum	Median	Interquartile range	Maximum	Mean
Population	695	25,011	13,333 – 82,916	9,818,605	140,982.7
# Otolaryngologists	0	0	0 – 2	318	4.6
# Primary care physicians	0	11	4 – 44	6,544	96.2
# Radiation oncologists	0	0	0 – 1	143	2.0
# Dentists	0	7	3 – 31	6,969	87.4
# Hospital beds	0	57	24 – 228	25,763	389.3
# Hospitals with 300+ beds	0	0	0	27	0.4
% Uninsured, <65 years old	4.9	19.4	15.1 – 22.3	36.3	18.7
% persons in poverty	3.2	17.5	12.8 – 22.7	40.3	18.2
% Non-white race	1.1	15.3	5.3 – 34.3	84.8	21.5
% under 25 with < high school	0.7	18.1	11.8 – 25.2	43.2	19.0

^{*} Characteristics are 2010 data derived from AHRF 2015-16 database; there are 401 urban counties (RUCC 1-4,6) and 208 rural counties (RUCC 5,7-9); Alaskan counties are excluded since SEER incidence data are provided only at a state level due to small numbers of cases.

Table 2:

Spearman correlations for 609 counties by county-level variables

	# Oto	# Rad onc	# Dentist	Hosp beds	Population	% Non white	% Poverty	% Uninsured	% HS Educ
# PCP	0.81	0.74	0.94	0.84	0.94	0.33	−0.25	−0.18	−0.30
# Oto		0.79	0.80	0.77	0.79	0.32	−0.20	−0.16	−0.27
# Rad onc			0.73	0.70	0.72	0.29	−0.22	−0.18	−0.30
# Dentists				0.79	0.93	0.23	−0.35	−0.30	−0.40
# Hosp beds					0.78	0.33	−0.13*	−0.15*	−0.22
Population						0.35	−0.25	−0.17	−0.27
% Non white							0.35	0.45	0.25
% Poverty								0.69	0.80
% Uninsured									0.67

Abbreviations: PCP=primary care physician; Oto=otolaryngologists; Rad Onc=radiation oncologists; Hosp=hospital

All pairwise correlations were statistically significant with $p < 0.0001$ except those marked with asterisks, which were statistically significant between $p = 0.001$ and $p = 0.0001$.

Table 3:

Univariate comparison of head and neck cancer cases diagnosed at Stages III & IV vs Stages I & II (n=44,962)

Characteristic	Stages I & II (n=16,602)	Stages III & IV (n=28,360)	Odds ratio (95% CI)	p-value
Mean age (s.d.)	65.1 (12.6)	61.4 (11.7)	0.98 (0.97-0.98)	<0.0001
Female sex (%)	4,865 (29.3)	6,151 (21.7)	0.67 (0.64 – 0.70)	<0.0001
Race (%)				<0.0001
White	14,024 (37.8)	23,038 (62.2)	Reference	
Black	1,410 (28.6)	3,523 (71.4)	1.52 (1.43-1.62)	
Other	1,168 (39.4)	1,799 (60.6)	0.94 (0.87–1.01)	
Marital status (%)				<0.0001
Married	9,301 (39.4)	14,89 (60.6)	Reference	
Unmarried	6,236 (33.1)	12,622 (66.9)	1.32 (1.27–1.37)	
Unknown	1,065 (42.4)	1,449 (57.6)	0.87 (0.82–0.96)	
Site (%)				<0.0001
Oral cavity	6,206 (54.6)	5,151 (45.4)	Reference	
Oropharynx	2,399 (14.3)	14,414 (85.7)	7.24 (6.84–7.66)	
Nasopharynx	605 (29.8)	1,427 (70.2)	2.84 (2.57–3.15)	
Hypopharynx	387 (15.5)	2,109 (84.5)	6.57 (5.86–7.36)	
Larynx	7,005 (57.1)	5,259 (42.9)	0.91 (0.86–0.95)	
Rural residence (%)	1,227 (7.4)	1,782 (6.3)	0.84 (0.78–0.91)	<0.0001
2 Otolaryngologists (%)	3,767 (22.7)	5,995 (21.1)	0.91 (0.87–0.95)	<0.0001
Year of diagnosis (%)				<0.0001
2008	3,259 (38.7)	5,170 (61.3)	0.88 (0.83–0.93)	
2009	3,248 (37.1)	5,505 (62.9)	0.94 (0.88–0.99)	
2010	3,387 (37.5)	5,649 (62.5)	0.92 (0.87–0.98)	
2011	3,318 (36.0)	5,909 (64.0)	0.99 (0.93–1.05)	
2012	3,390 (35.6)	6,127 (64.4)	Reference	
County attribute means (s.d)				
% Less than HS Ed	16.1 (6.5)	16.1 (6.4)	1.001 (0.998–1.004)	0.51
% Non-white race	32.4 (16.9)	33.4 (16.7)	1.004 (1.003–1.005)	<0.0001
% Uninsured	17.8 (4.9)	18.0 (4.9)	1.008 (1.004–1.012)	<0.0001
% Persons in poverty	15.3 (5.4)	15.5 (5.4)	1.007 (1.010–1.013)	0.0003
# Hospital beds (000s)	3,886.9 (6680.8)	3,970.9 (6670.4)	1.002 (0.999–1.005)	0.19

Table 4:

Multivariate logistic regression of Stages III & IV vs Stages I & II at presentation: results of stepwise model selection (n=44,962)

Characteristic	Odds ratio (95% CI)	p-value
Site		<0.0001
Oral	Reference	
Oropharynx	6.73 (6.35–7.14)	
Nasopharynx	2.47 (2.21–2.74)	
Hypopharynx	6.18 (5.50–6.94)	
Larynx	0.84 (0.80–0.89)	
Male sex	1.27 (1.21–1.33)	<0.0001
Diagnosis year		0.0031
2008	0.89 (0.83–0.95)	
2009	0.93 (0.87–1.00)	
2010	0.93 (0.87–1.00)	
2011	0.98 (0.91–1.05)	
2012	Reference	
Race		<0.0001
White	Reference	
Black	1.48 (1.38–1.59)	
Other	1.04 (0.96–1.14)	
Marital status		<0.0001
Married	Reference	
Unmarried	1.45 (1.39–1.52)	
Unknown	0.92 (0.84–1.01)	
Rural residence	0.91 (0.84–0.99)	0.043
Age at diagnosis	0.985 (0.983–0.986)	<0.0001
County % poverty	1.008 (1.004–1.012)	0.0001

Regression c-score = 0.758.

Table 5:

Results of univariate Cox proportional hazards regression on observed survival (n=44,950)

Characteristic	Hazard ratio (95% CI)	p-value
Stage at presentation		<0.0001
I	Reference	
II	1.76 (1.66 – 1.86)	
III	2.00 (1.89 – 2.12)	
IV	2.72 (2.60 – 2.84)	
Age at diagnosis (y)	1.03 (1.029 – 1.031)	<0.0001
Male sex	0.93 (0.90 – 0.96)	<0.0001
Race (%)		<0.0001
White	Reference	
Black	1.58 (1.51 – 1.65)	
Other	0.93 (0.87 – 0.99)	
Marital status (%)		<0.0001
Married	Reference	
Unmarried	1.71 (1.66 – 1.76)	
Unknown	1.17 (1.09 – 1.26)	
Site (%)		<0.0001
Oral cavity	Reference	
Oropharynx	0.76 (0.73 – 0.79)	
Nasopharynx	0.85 (0.79 – 0.92)	
Hypopharynx	1.92 (1.81 – 2.04)	
Larynx	0.86 (0.82 – 0.89)	
Rural (% RUCC 5,7-9)	1.07 (1.01 – 1.14)	0.017
2 Otolaryngologists (%)	1.09 (1.05 – 1.13)	<0.0001
Year of diagnosis (%)		0.0085
2008	1.10 (1.05 – 1.16)	
2009	1.05 (1.00 – 1.11)	
2010	1.05 (1.00 – 1.11)	
2011	1.06 (1.01 – 1.12)	
2012	Reference	
County attribute means		
% Less than HS Ed	1.01 (1.010 – 1.014)	<0.0001
% Non-white race	1.003 (1.002 – 1.004)	<0.0001
% Uninsured	1.013 (1.010 – 1.016)	<0.0001
% Persons in poverty	1.023 (1.020 – 1.026)	<0.0001

Characteristic	Hazard ratio (95% CI)	p-value
# Hospital beds (000s)	1.000 (0.998 – 1.003)	0.71

Table 6:

Results of multivariable Cox proportional hazards regression on observed survival using stepwise model selection (n=44,950)

	Hazard ratio (95% CI)	p-value
Stage		<0.0001
I	Reference	
II	1.82 (1.72 – 1.94)	
III	2.49 (2.35 – 2.63)	
IV	3.80 (3.61 – 3.99)	
Site		<0.0001
Oral	Reference	
Oropharynx	0.58 (0.55 – 0.60)	
Nasopharynx	0.91 (0.84 – 0.99)	
Hypopharynx	1.22 (1.15 – 1.30)	
Larynx	0.84 (0.81 – 0.88)	
Age at diagnosis	1.037 (1.035 – 1.038)	<0.0001
Male sex	1.07 (1.03 – 1.11)	0.0005
Year of diagnosis		<0.0001
2008	1.15 (1.09 – 1.22)	
2009	1.09 (1.03 – 1.15)	
2010	1.08 (1.03 – 1.14)	
2011	1.07 (1.01 – 1.13)	
2012	Reference	
Race		<0.0001
White	Reference	
Black	1.38 (1.32 – 1.44)	
Other	0.98 (0.91 – 1.05)	
Marital status		<0.0001
Married	Reference	
Unmarried	1.55 (1.50 – 1.60)	
Unknown	1.19 (1.10 – 1.28)	
2 Otolaryngologists	1.09 (1.05 – 1.13)	<0.0001
% Poverty	1.015 (1.012 – 1.018)	<0.0001
Hospital beds (000s)	0.997 (0.995 – 1.000)	0.023