The Role of Health Literacy on Hospital Utilization for Head and Neck Cancer Patients

by

Kailen Jane Heath

Bachelor of Science in Nursing, University of Pittsburgh, 2021
Bachelor of Philosophy, University of Pittsburgh, 2021

Submitted to the Graduate Faculty of the

School of Nursing in partial fulfillment

of the requirements for the degree of

Bachelor of Science in Nursing

University of Pittsburgh

2021

UNIVERSITY OF PITTSBURGH

UNIVERSITY HONORS COLLEGE

This thesis was presented

by

Kailen Jane Heath

It was defended on

March 31, 2021

and approved by

David Anthony Clump II, MD, PHD, Department of Radiation Oncology, School of Medicine

Sarah Gallups, PHD, MPH, RN, University of Alabama at Birmingham, School of Nursing

Susan Sereika, PHD, Department of Health and Community Systems, School of Nursing

Thesis Advisor: Marci Lee Nilsen PHD, RN, Department of Acute and Tertiary Care, School of Nursing

The Role of Health Literacy on Hospital Utilization for Head and Neck Cancer Patients

Kailen Jane Heath, BSN BPhil

University of Pittsburgh, 2021

Abstract

Background: Research to date has focused heavily on clinical factors associated with increased hospital utilization for head and neck cancer (HNC) patients. Studies in other chronic conditions have found associations between health literacy and hospital utilization, but there is little research about the association in the HNC population.

Purpose: This study aims to determine the rate of hospital utilization during radiation treatment and the 90 day follow-up period and assess whether health literacy plays a role in hospital utilization for HNC survivors.

Methods: This is a retrospective analysis of 95 survivors seen at the UPMC Head and Neck Cancer Survivorship Clinic. During the pre-radiation evaluation, health literacy was assessed using question 1 of the Brief Health Literacy Screen (BHLS) to evaluate confidence in filling out medical forms by oneself. Hospital utilization during radiation treatment and the 90 day follow-up period were the outcome variables of interest. Single-predictor regression models were run to assess which predictors met the criteria for inclusion in multivariable regression analysis. Multivariable analysis was performed using negative binomial regression or poisson regression to determine which predictors were associated with hospital utilization.

Results: Of the 95 survivors, 17 survivors (17.9%) had inadequate health literacy, which was more prevalent in those who did not undergo surgery, were current cigarette smokers and had laryngopharynx cancer. The rate of total hospital utilization during the entire study period is

46.3%, with 30.5% during treatment and 31.6% in the follow-up period. Health literacy was associated with total hospital utilization and ER visits alone during treatment. Additional factors related to the outcomes included concurrent chemoradiation, advanced cancer stage, neighborhood deprivation, feeding tube placement, race, and age in various multivariable models.

Conclusion: There was an association between health literacy and hospital utilization that requires additional research utilizing a prospective approach to further explore this phenomenon. Such research should use variables assessing broader domains of health literacy, social determinants of health, and patient outcomes.

Table of Contents

List of Tables

List of Figures

Preface

Throughout my time at the University of Pittsburgh, I have deeply appreciated the mentorship from the faculty members at the School of Nursing. As a freshman, Dr. Kathryn Puskar fostered my interest in head and neck cancer patients, introduced me to my future thesis advisor, Dr. Marci Nilsen, and encouraged me to pursue a Bachelor of Philosophy degree. I am extremely grateful for the expertise, support, and dedication of Dr. Nilsen and Karley Atchison, Senior Research Coordinator, while overseeing the development, analysis, and refinement of this project. I am grateful to contribute to the body of research coming from the UPMC Head and Neck Cancer Survivorship Clinic. I would also like to thank the University Honors College for acceptance into the Brackenridge Fellowship where I was given the unique opportunity to collect data in an interdisciplinary community, along with other undergraduates completing their own independent projects. This opportunity was especially relevant while researching health literacy as it further emphasized the importance of simplifying medical jargon to speak with a general audience. The statistical analysis was made possible by Dr. Susan Sereika. I would like to thank my committee members, Dr. Sarah Gallups and Dr. David Anthony Clump II, for their feedback and guidance. Finally, thank you again to the University Honors College for this experience that has significantly enriched my education and will be instrumental in my future endeavors. Last but not least, thank you to my parents, siblings, and friends who constantly remind me how I am loved and supported in everything I do.

1.0 Introduction

Nearly half of the head and neck cancer (HNC) population presents with spread from the primary tumor to the adjacent lymph nodes; thus the standard of care utilizes multimodal treatment methods to increase survival rates but also preserve function (Argiris et al., 2008; Koyfman et al., 2019; Surveillance, Epidemiology, and End Results Program [SEER], 2020b). While advancements in treatments, such as intensity-modulated radiation therapy, have shown to improve locoregional control, they result in increased acute toxicities and complex, yet poorly understood long-term and late effects (Cohen et al., 2016; Forastiere et al., 2003; Gooi et al., 2017; Nekhlyudov et al., 2017; Trotti et al., 2007). Acute toxicities that result from damage to the delicate mucosa and surrounding structures of the head and neck include mucositis, dehydration, nausea, vomiting, oral pain, dysphagia, odynophagia, deterioration in oral and dental health, painful swelling and ulcers in the oral cavity, tissue scarring, and thickened secretions (Fulcher et al., 2017; Ling et al., 2015; Trotti et al., 2003; Trotti et al., 2007).

With such side effects, survivors may utilize hospital resources to seek supportive care through the emergency department (ED) or inpatient units. A study of 109 survivors found that 35% were hospitalized up to eight weeks after receiving chemotherapy alone or in combination with radiation (Hazelden, 2017). Eskander et al. (2018) found that out of 3,898 HNC survivors, over half of those who received concurrent chemoradiation, as their primary treatment (55%) or secondary to surgery (53%), had at least one unplanned hospital admission or ED visit within 90 days of their last treatment. Similarly, Moore et al. (2019) investigated chemoradiation therapy alone or secondary to surgery and concluded 36% of survivors had at least one encounter during treatment and up to one month after. While the previously mentioned studies used chemotherapy

as a point of reference, Ling et al. (2015) found 34.7 % of survivors receiving definitive or adjuvant intensity-modulated radiation therapy with or without chemotherapy were hospitalized for treatment-related toxicities during or within 8 weeks of treatment. Variables associated with an increased rate of ED visit or hospitalization were residence in a rural region, cancer subsite (larynx/hypopharynx vs. oral cavity/oropharynx), higher comorbidity burden, prior pulmonary disease, diabetes, increasing prescribed radiation dose, and higher cancer stages (Eskander et al., 2018; Ling et al., 2015).

These studies focus mainly on the clinical factors that contribute to hospitalization, which may be overlooking how social determinants of health, specifically health literacy (HL), are associated with hospital utilization. Literacy does not translate to HL because the medical field has its own terminology the general public is unfamiliar with. HL expands upon the ability to read and write, including the ability to obtain, communicate, process, and understand basic health information to make appropriate decisions (Center for Disease Control and Prevention, 2021). A summary of national data collected on health literacy noted that one-third (i.e., 36%) of U.S. adults have below basic HL or basic HL defined as their ability to understand written text, documents, and numbers for computations to make informed decisions and navigate the healthcare system. Below basic HL was determined to be well below the ability necessary to adequately utilize health information (Cutilli & Bennett, 2009). In the general populations, inadequate HL is linked to poor adherence to treatment plans, elevated health care costs, a predictor of all-cause mortality, increased ED visits, and increased hospitalization (Baker et al., 2004; Berkman et al., 2011; Cartwright et al., 2017; Cox et al., 2017; Halverson et al., 2015; Haun et al., 2015; Miller et al., 2016). Within the cancer population specifically, those with inadequate health literacy and colorectal cancer were less likely to receive chemotherapy in later cancer stages, which is usually

recommended (Busch et al., 2015). A systematic review of adult cancer patients' self-management behaviors found that inadequate health literacy is associated with less uptake of cancer screening, less uptake of prescribed chemotherapy, greater likelihood of postoperative complications, higher information needs, and less information seeking behaviors (Papadakos et al., 2018). Halverson et al. (2015) found a decreased overall quality of life in various cancer patients when investigating outcomes of inadequate health literacy.

Little research exists regarding the effects of HL on outcomes in HNC survivors. Koay et al. (2013) found 11.9% of HNC and lung cancer survivors had limited health literacy. Likewise, Nilsen et al. (2018) demonstrated that 13.8% of HNC patients at a single-site survivorship clinic had self-reported scores indicating inadequate HL. To address this gap in knowledge, the project aims to determine the rate of hospital utilization during and 90 days after treatment for HNC survivors undergoing radiation therapy and assess whether HL is associated with hospital utilization for HNC survivors.

2.0 Methods

2.1 Design

A retrospective analysis of HNC survivors was performed to determine hospital utilization rate, including emergency department visits and inpatient admissions, during and 90 days after radiation therapy. In addition, the role of health literacy in hospital utilization was assessed. The study was approved by the University of Pittsburgh Institutional Review Board (PRO13030372).

2.2 Setting and Sample

Adult survivors (>18 years) seen in the UPMC Head and Neck Cancer Survivorship Clinic between August 2017 and September 2020 for pre-radiation evaluation were assessed for inclusion. To be included in the study, the survivor must have a diagnosis of squamous cell carcinoma, the most common histologic type of HNC, in the oral cavity, oropharynx, hypopharynx, or larynx and treated with radiation therapy with or without other systemic therapies. Those with second primaries, distant metastasis, or recurrence were excluded. For a detailed breakdown of excluded patients, refer to the Consolidated Standards of Reporting Trials diagram (Figure 1).

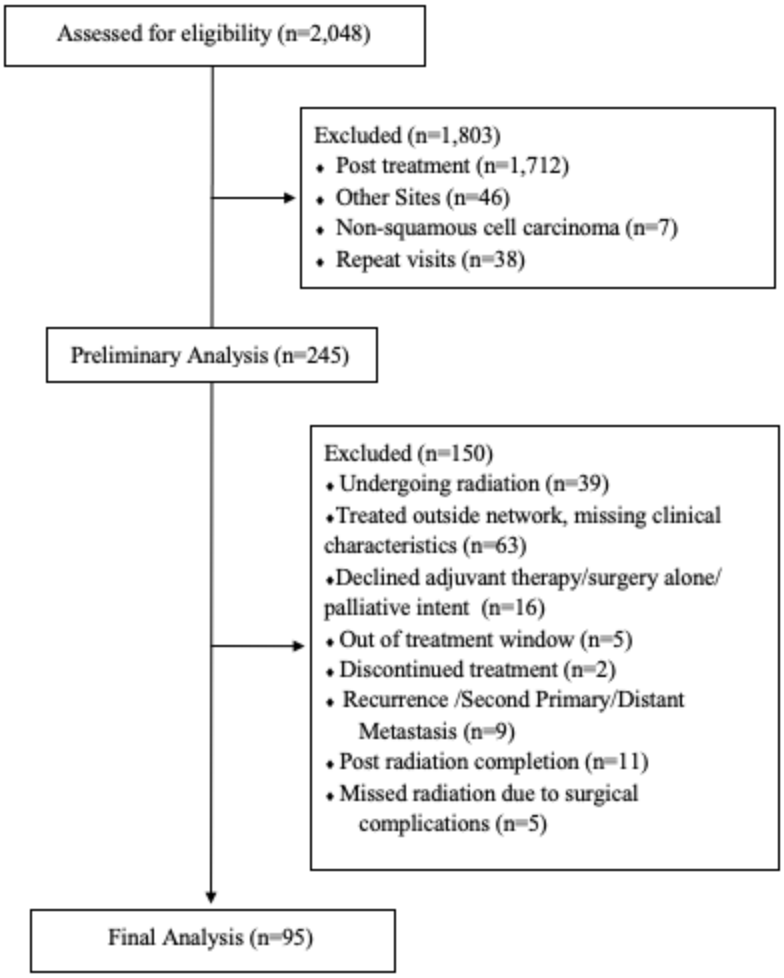

Figure 1. Consolidated Standards of Reporting Trials diagram.

2.3 Demographic, Clinical, and Cancer Characteristics

Demographic and clinical characteristics were extracted from the electronic medical record and included sex (i.e., male and female), race (i.e., white and other), and marital status (i.e., married vs. not married). Age (in years) was calculated as the survivor's age at the start of radiation therapy. For alcohol use [i.e., current user (yes/no)], we defined current use as anyone reporting yes, occasionally, socially, or drinks per week at the pre-radiation evaluation. Smoking status [i.e.,

current smoker (yes/no)] defined current smokers as those who actively smoked at the day of diagnosis or pre-radiation evaluation. Due to the retrospective design of this study, socioeconomic data such as income and education were unavailable in patient charts. Therefore, the 2015 Area Deprivation Index (ADI) through the Neighborhood Atlas was utilized to describe neighborhoods by the socioeconomic disadvantage of the HNC survivors in the study. The ADI mapping function utilizes a patient's full address to rank their neighborhood by how disadvantaged the residents are (i.e., 10 being the most disadvantaged and 1 being the least disadvantaged) according to income, education, employment, and housing quality found in census block data at the state level (University of Wisconsin School of Medicine and Public Health, 2015). Patients were further categorized into low- (i.e., 1-3), medium- (i.e., 4-6) and high-deprivation (i.e., 7-10) groups accordingly.

Cancer characteristics extracted included prescribed dose [in Gray (Gy)] of radiation (i.e., 50-59, 60-69, >70), treatment modalities [i.e., surgery (yes/no), chemotherapy (yes/no), and immunotherapy (yes/no)] and cancer site (i.e., oral cavity, oropharynx, and laryngopharynx). For those with oropharynx cancer, Human Papilloma Virus (HPV) status (i.e., positive or negative) was recorded. Functional status prior to treatment was measured on the Eastern Cooperative Oncology Group scale (i.e., 0 being fully active to 5 being dead) (Oken et al., 1982). Staging of the cancer was assessed using primary tumor stage (i.e., T stage), denoting size and extent of the primary tumor (i.e., 1 and 2 vs. 3 and 4) and regional lymph node stage (i.e., N stage), denoting the spread to adjacent lymph nodes (0 and 1 vs. 2 and 3). For T and N staging, the higher numbers represent more advanced cancer. Feeding tube placement (i.e., no feeding tube, prophylactic tube, or reactive tube) was categorized in relation to the start of radiation, meaning prophylactic tubes were placed before radiation and reactive tubes were placed during or after radiation.

2.4 Health Literacy

Health literacy scores were obtained during the survivorship clinic visit using the Brief Health Literacy Screen (BHLS) as part of usual care (Chew et al., 2004; Chew et al., 2008). The BHLS uses three questions, each measured on a 5-point Likert Scale: (1) "How confident are you filling out medical forms by yourself?" (extremely, quite a bit, somewhat, a little bit, or not at all); (2) "How often do you have someone help you read hospital materials?" (always, often, sometimes, occasionally, or never); and (3) "How often do you have problems learning about your medical condition because of difficulty understanding written information?" (always, often, sometimes, occasionally, or never). The total health literacy score is the sum of all responses ranging between 3 to 15 with a score of less than or equal to 9, indicating inadequate health literacy. (Chew et al., 2004; Chew et al., 2008). Question 1 is no less effective at determining inadequate health literacy than the combination of questions (Wallace et al., 2006; Chew et al., 2008). Therefore, we utilized the suggested cut point of "somewhat" confident filling out medical forms and grouped those survivors with "a little bit" and "not at all" to inadequate health literacy.

2.5 Hospital Utilization

Survivors were evaluated for hospital utilization during two time periods: during radiation treatment and for 90 days after radiation completion. The study attempted to account for unplanned hospital utilization; therefore, if a feeding tube or port placement was planned in the outpatient setting, the encounter for the procedure was not counted. The two possible unplanned hospital encounters are treat-and-release ED visits and hospitalization, including direct admission from an

outpatient clinic and ED visits that resulted in hospital admission. We summated all emergency room visits and hospital admissions for the two time periods for total hospital utilization. The same process was followed to evaluate hospitalizations and ED visits individually. Therefore, if a patient visited the emergency department and was admitted to the hospital, their count for hospital utilization encounters is 2, their count for hospitalizations is 1, and their count for emergency department visits is 1. Furthermore, the average length of hospital stay was determined for hospitalizations.

2.6 Statistical Analysis

Prior to analysis, all data were screened for anomalies such as outliers, missing data, and violations of statistical assumptions. Descriptive statistics were computed with frequency counts and percentages for categorical variables and means and standard deviations for continuous variables. To assess for associations between categorical predictor variables and health literacy (adequate, inadequate), contingency table analyses with Chi-square tests of independence were utilized; Fisher's Exact Test was used when the expected cell counts were spare (i.e., less than 5). The independent two-sample t-test (or the Mann-Whitney U-test, if non-normality was observed) was used to assess differences in central tendency between adequate and inadequate health literacy categories continuous-type predictor variables (e.g., age).

To examine the associations between the primary predictor variable of health literacy and the frequencies of hospital utilization, hospitalizations and ER visits during and after treatment for HNC controlling for possible covariates or confounders, either Poisson regression or negative binomial regression was employed. If overdispersion in the dependent variable was identified,

negative binomial regression was employed. The regression model used is noted in the column labels in Tables 2 through 7. An offset was included in all models to account for variability in the duration of treatment and for the exponentiation of a regression coefficient to yield the incidence rate ratio (IRR) with a 95% confidence interval (CI). Regression models were first estimated considering predictor variables one at a time to yield crude/unadjusted IRRs for health literacy and to identify predictor variables with potential associations with hospital utilization outcome variables. In addition to health literacy, those predictor variables with a p-value < 0.25 based on likelihood ratio chi-square tests from the single predictor models were included as candidate predictor variables in the multivariable regression models. As age is a continuous variable measured in years, the appropriate scaling of age was determined using a Box-Tidwell approach to assess for in the single predictor models. If non-linearity was indicated, both linear and quadratic terms for age were included in the models. Additionally, a parsimonious model was developed using a backward elimination approach using a 0.05 p-value to retain, where health literacy could be dropped from the model if $p \geq 0.05$. The values of the likelihood-ratio chi-square tests, the degrees of freedom, their corresponding p-values, and the IRRs with confidence intervals were reported as for all single predictor and multivariable models including the screened candidate predictor variables and those models limited to the set of predictor variables where $p<.05$.

3.0 Results

3.1 Survivor Characteristics

Of the 245 survivors assessed for eligibility, 95 met inclusion criteria (see Figure 1 above). The majority of the survivors were male (n=82, 86.3%), white (n=81, 85.3%), and married (n=65, 68.4%) with an average age of 59.9 years (range 31 to 91 years; SD=9.33). At the time of diagnosis, most were not current smokers (n=75, 75.8%) but were current alcohol drinkers (n=57, 60.0%). Nearly half of the survivors (n= 42, 44.2%) lived in high-deprivation neighborhoods.

Primary tumor sites occurred most frequently in the oropharynx (n = 54, 56.8) and almost all oropharynx cancers were HPV positive (n=52, 96.3%). More than half of the survivors had a T stage of 1 or 2 (n=50, 52.6%) and an N stage of 0 or 1 (n=50, 52.6%). The most common prescribed radiation dose was 60-69 Gy (n=43, 45.3%), and most survivors received concurrent chemotherapy (n=61, 64.2%). Feeding tubes were not placed in more than half of the survivors (n=54, 56.8%), but when needed, they were mostly placed reactively (n=23, 24.2%). The ECOG scale assessing functional status was heavily skewed to 0 (n=70, 73.7%), meaning patients were fully active and able to carry on life without restriction at the time of diagnosis.

3.2 Health Literacy

Of the 95 survivors, 17.9% (n=17) of survivors were classified as having inadequate health literacy based on their defined confidence filling out medical forms as “not at all,” “a little bit,” or

"somewhat". Survivors with inadequate health literacy were more likely to have cancer of the laryngopharynx (p=0.015), currently smoke cigarettes (p=0.001), and not undergo surgery (p=0.021).

Table 1. Survivor Characteristics

	Total (N=95) Mean±SD or n (%)	Adequate Health Literacy (n=78) Mean±SD or n (%)	Inadequate Health Literacy (n=17) Mean±SD or n (%)	Test Statistic (df) P-value
Patient and Clinical Characteristics				
Sex				0.116†
Male	82 (86.3)	65 (83.3)	17 (100.0)	
Female	13(86.3)	13 (16.7)	0 (0.0)	
Race				0.269†
White	81 (85.3)	68 (87.2)	13 (76.5)	
Other	14 (14.7)	10 (12.8)	4 (23.5)	
Marital status				0.883 (1) 0.347
Married	65 (68.4)	55 (70.5)	10 (58.8)	
Not married	30 (31.6)	23 (29.5)	7 (41.2)	
Age (years)	59.71±9.296	59.47±9.578	60.76±8.051	-0.461 (93) 0.646
Current alcohol use				0.967 (1) 0.325
Yes	57 (60.0)	45 (57.7)	12 (70.6)	
No	38 (40.0)	33 (42.3)	5 (29.4)	
Current smoking status				**0.001†**
No	72 (75.8)	13 (16.7)	10 (58.8)	
Yes	23 (24.2)	65 (83.3)	7 (41.2)	
Neighborhood Deprivation				0.170†
Low deprivation	28 (29.5)	24 (30.8)	4 (23.5)	
Middle deprivation	25 (26.3)	23 (29.5)	2 (11.8)	
High deprivation	42 (44.2)	31 (39.7)	11 (64.7)	
Cancer Characteristics				
Site				**0.015†**
Oral cavity	18 (18.9)	16 (20.5)	2 (11.8)	
Oropharynx	54 (56.8)	48 (61.5)	6 (35.3)	
Laryngopharynx	23 (24.2)	14 (17.9)	9 (52.9)	

Table 1. Survivor Characteristics (continued)

T stage				2.496 (1) 0.114
1 & 2	50 (52.6)	44 (56.4)	6 (35.3)	
3 & 4	45 (47.4)	34 (43.6)	11 (64.7)	
N stage				2.496 (1) 0.114
0 & 1	50 (52.6)	44 (56.4)	6 (35.3)	
2 & 3	45 (47.4)	34 (43.6)	11 (64.7)	
Treatment Modality				
Surgery				5.360 (1) **0.021**
Yes	52 (54.7)	47 (60.3)	5 (29.4)	
No	43 (45.3)	31 (39.7)	12 (70.6)	
Chemotherapy				1.354 (1) 0.245
Yes	61 (64.2)	48 (61.5)	13 (76.5)	
No	34 (35.8)	30 (38.5)	4 (23.5)	
Immunotherapy				0.067 (1) 0.796
Yes	31 (32.6)	25 (32.1)	6 (35.3)	
No	64 (67.4)	53 (67.9)	11 (64.7)	
Prescribed Radiation Dose				0.130†
50-59	23 (24.2)	22 (28.2)	1 (5.9)	
60-69	43 (45.3)	34 (43.6)	9 (52.9)	
>70	29 (30.5)	22 (28.2)	7 (41.2)	
Feeding tube placement				0.200†
No feeding tube	54 (56.8)	47 (60.3)	7 (41.2)	
Prophylactic	18 (18.9)	15 (19.2)	3 (17.6)	
Reactive	23 (24.2)	16 (20.5)	7 (41.2)	

†For the Fisher's Exact test, only the p-value is reported.
‡For age, the value and p-value from an independent two-sample t-test is reported.

3.3 Healthcare Utilization

During the entire study period, 44 survivors (46.3%) had 128 total encounters as either ED visits or hospitalizations. The range was 1 to 14 encounters, with 13 survivors (13.7%) having 1

encounter, 13 survivors (13.7%) having 2 encounters, 7 survivors (7.4%) having 3 encounters, and 11 survivors (11.6%) having 4 or more encounters (mean 1.3474; SD=2.21584). During the radiation treatment period, 29 survivors (30.5%) had 63 encounters including 9 survivors (9.5%) with 1 encounter, 11 survivors (11.6%) with 2 encounters, and 9 survivors having 3 or more encounters (9.5%) (mean 0.6632; SD=1.16336). In the 90 day follow-up period, 30 survivors (31.6%) had 65 encounters, including 12 survivors (12.6%) with 1 encounter, 13 survivors (13.7%) with 2 encounters, and 5 survivors (5.3%) having 3 or more encounters and a maximum of 10 encounters (mean 0.6842; SD= 1.43855).

For hospitalizations alone, including those admitted through the ED and those admitted directly from outpatient visits, 34 survivors (35.7%) had 57 hospitalizations ranging from 1 to 5 hospitalizations during the entire study period. Twenty-one survivors (22.1%) had 1 hospitalization,7 survivors (7.4%) had 2 hospitalizations, 6 survivors (6.3%) had 3 or more hospitalizations (mean 0.6000; SD= 1.02521). The average length of stay was 5.15 days (range 1.0-17.0; SD=4.40469). During radiation therapy, 25 survivors (26.3%) had 32 hospitalization. Eighteen survivors (18.9%) had 1 hospitalization and 7 survivors (7.4%) had 2 hospitalizations (mean= 0.3368; SD= 0.61212). In the 90 day follow up period, 19 patients (20.0%) had 25 hospitalization including 14 patients (14.7%) with 1 hospitalization, 4 patients (4.2%) with 2 hospitalizations, and 1 patient (1.1%) with 3 hospitalizations (mean 0.2632; SD = 0.58729).

For ED visits alone, including treat and release visits and visits resulting in hospitalization, 40 survivors (42.1%) had 71 ED visits ranging from 1 to 9 visits during the entire study period. The number of encounters ranged from 1 to 9 visits with 24 survivors (25.3%) having 1 visit and 16 survivors (20.0%) having 2 or more visits (mean 0.7474; SD=1.27970). During radiation, 23 survivors (24.3%) had 30 ED visits including 16 survivors (16.8%) with 1 visit and 7 survivors

(7.4%) with 2 visits (mean 0.3158; SD=0.60605). In the 90 day follow-up period, 27 survivors (28.4%) had 41 visits ranging from 1 to 7 visits. Twenty survivors (21.1%) had 1 visit and 7 survivors (7.4%) with 2 or more visits (mean 0.4316; SD=0.95263).

3.4 Single Predictor Regression Models for Hospital Utilization

For total hospital utilization during radiation therapy, the following variables met criteria to be included as candidate predictors in the multivariate model: Health literacy (p=0.124), neighborhood deprivation (p=0.120), race (p=0.157), cancer site (p=0.222), surgery (p=0.100), chemotherapy treatment (p=0.008), prescribed radiation dose (p=0.249), timing of feeding tube placement (p=0.053), and age (i.e. age linear, p=0.841, age quadratic, p=0,105). As previously described in the statistical analysis section, both age linear and age quadratic must be included if either one is significant. See table 2 for more detail. In the 90 day follow up period, the following variables met criteria to be included as predictors: Health literacy (p=0.738), neighborhood deprivation (p=0.002), current smoking status (p=0.084), T Stage (p= 0.002), surgery (p=0.147), chemotherapy treatment (p=0.001), immunotherapy treatment (p=0.022), prescribed radiation dose (p= 0.009), and timing of feeding tube placement (p= <0.001). See table 3 for more detail.

Table 2. Predictors of Total Hospital Utilization During Radiation

	Univariate		Multivariate (Negative Binomial)			
	LRX^2(DF) IRR CI (lower, upper)	P-value	(HLQ1+ Candidate Predictors, p<.25)	P-value	Multivariate Parsimonious	P-value
HLQ1 (ref, adequate)	2.363 (1) 0.473 (.162, 1.219)	0.124*	3.854 (1), 0.341 (0.104, 0.998)	<0.05†		
Neighborhood Deprivation (ref, Low deprivation)	4.246 (2)	0.120*	2.133 (2)	0.344		
NA Middle Deprivation	2.447 (0.971, 6.548)		1.773 (0.558, 5.934)			
NA High Deprivation	2.223 (0.945, 5.603)		2.158 (0.772, 6.475)			
Sex (ref, male)	0.576 (1) 1.397 (0.584, 3.320)	0.448				
Marital status (ref, married)	0.107 (1), 1.122 (0.564, 2.266)	0.744				
Race (ref, white)	2.00 (1), 1.799 (0.796, 4.097)	0.157*	0.846 (1) 1.687 (0.554, 5.298)	0.358	3.909 (1) 2.435 (1.008, 6.154)	0.048†
Current alcohol use (ref, no)	0.306 (1), 0.833 (0.436, 1.594)	0.580				
Current smoking status (ref, no)	0.064 (1), 0.908 (0.424, 1.908)	0.801				
Site (ref, oral cavity)	3.013(2),	0.222*	1.108 (2)	0.575		
Oropharynx	1.567 (0.610, 4.402)		1.624 (0.340, 8.526)			
Larynx	2.405 (0.868, 7.215)		2.242 (0.470, 11.577)			
T stage recode (ref, 1 &2)	0.131 (1), 1.125 (0.594, 2.141)	0.717				
N stage recode (ref, 0 & 1)	0.112 (1), 0.897 (0.472, 1.701)	0.738				

Table 2. Predictors of Total Hospital Utilization During Radiation (continued)

Surgery (ref, no)	2.706 (1), 0.580 (0.299, 1.109)	0.100*	0.052 (1), 1.148 (0.346, 3.862)	0.820		
Chemotherapy (ref, no)	7.145 (1), 2.982 (1.323, 7.436)	0.008*	3.697(1), 2.958 (0.980, 9.726)	0.055	9.053 (1) 3.604 (1.533, 9.517)	0.003†
Immunotherapy (ref, no)	0.106 (1), 1.119 (0.566, 2.197)	0.744				
RT Dose (ref, 50-59 Gy)	2.781 (2),	0.249*	0.858 (2),	0.651		
60-69 Gy	1.391 (0.554, 3.751)		1.381 (0.380, 5.191)			
>70 Gy	2.108 (0.835, 5.746)		0.748 (0.142, 3.899)			
Time of FT Placement (ref, no feeding tube)	5.865 (2)	0.053*	2.305 (2)	0.316		
Prophylactic	1.345 (0.539, 3.285)		1.154 (0.293, 4.510)			
Reactive	2.443 (1.181, 5.157)		2.281 (0.737, 7.451)			
Age (centered around mean 59.705263)	2.634 (2)	0.268				
Age (linear)	0.040 (1) 0.996 (0.953, 1.039)	0.841	0.031(1) 0.996 (0.947, 1.045)	0.861		
Age (quadratic)	2.621(1) 0.998 (0.994, 1.000)	0.105*	1.514 (1) 0.998 (0.993, 1.001)	0.219		

Total Hospital Utilization includes both inpatient hospitalizations and Emergency Department visits.
LRX^2 = Likelihood ratio chi-square; DF = degrees of freedom; IRR = incidence rate ratio; CI = confidence interval; ref = reference group; HLQ1 = Health Literacy Question 1; FT = feeding tube; RT=radiation therapy; NA=Neighborhood Atlas Score; * indicates $p < 0.25$; † indicates $p < 0.05$

Table 3. Predictors of Total Hospital Utilization Follow-Up Period

	Univariate		Multivariate (Negative Binomial)			
	LRX^2(DF) IRR CI (lower, upper)	P-value	HLQ1+ Candidate Predictors, p<.25)	P-value	Multivariate Parsimonious	P-value
HLQ1 (ref, adequate)	0.112 (1) 1.147 (0.506, 2.553)	0.738	0.085 (1) 0.856 (0.295, 2.435)	0.771		
Neighborhood Deprivation (ref, Low deprivation)	12.094 (2)	0.002*	7.933 (2)	0.019 †	6.597 (2)	0.037†
NA Middle Deprivation	5.413 (2.031, 16.403)		4.445 (1.333, 16.678)		3.543 (1.202, 11.537)	
NA High Deprivation	3.333 (1.293, 9.804)		4.2442 (1.436, 14.390)		3.272 (1.216, 9.978)	
Sex (ref, male)	0.315 (1), 1.285 (0.528, 3.082)	0.575				
Marital status (ref, married)	0.009 (1), 0.967 (0.493, 1.915)	0.923				
Race (ref, white)	0.139 (1), 1.179 (0.489, 2.784)	0.709				
Current alcohol use (ref, no)	0 (1) 1.000 (.526, 1.912)	1.000				
Current smoking status (ref, no)	2.977 (1), 1.832 (0.921, 3.668)	0.084*	0.068 (1) 1.128 (0.452, 2.800)	0.795		
Site (ref, oral cavity)	0.879 (2),	0.645				
Oropharynx	0.917 (0.394, 2.180)					
Larynx	1.304 (0.509, 3.404)					
T stage recode (ref, 1 &2)	10.056 (1), 2.901 (1.494, 5.805)	0.002*	2.233(1) 2.082 (0.797, 5.621)	0.135	4.034 (1) 2.200 (1.019, 4.819)	0.045†
N stage recode (ref, 0 & 1)	0.002 (1), 1.013 (0.538, 1.907)	0.968				
Surgery (ref, no)	2.104 (1), 0.626 (0.329, 1.178)	0.147*	4.402 (1) 3.689 (1.086, 14.667)	0.036†		

Table 3. Predictors of Total Hospital Utilization Follow-Up Period (continued)

Chemotherapy (ref, no)	11.801 (1), 3.971 (1.768, 9.878)	0.001*	2.378 (1), 2.687 (0.769, 10.464)	0.123		
Immunotherapy (ref, no)	5.278 (1), 2.129 (1.117, 4.099)	0.022*	0.635(1), 1.551 (0.527, 4.674)	0.426		
RT Dose (ref, 50-59 Gy)	9.384 (2),	0.009*	0.097 (2)	0.952		
60-69 Gy	1.471 (0.580, 3.990)		1.135 (0.210, 6.120)			
>70 Gy	3.470 (1.394, 9.354)		1.329 (0.203, 8.802)			
Time of FT Placement (ref, no feeding tube)	17.918(2)	<0.001*	5.808 (2)	0.055	6.606 (2)	0.037†
Prophylactic	2.294 (0.930, 5.665)		1.041 (0.341, 3.107)		1.519 (0.559, 4.100)	
Reactive	4.834 (2.301, 10.525)		3.408 (1.182, 10.346)		3.088 (1.294, 7.539)	
Age (centered around mean 59.705263)	0.196 (2)	0.907				
Age (linear)	0.184 (1) 1.008 (0.973, 1.044)	0.668				
Age (quadratic)	0.042 (1) 1.000 (0.998, 1.002)	0.838				

Total Hospital Utilization includes both inpatient hospitalizations and Emergency Department visits.
LRX^2 = Likelihood ratio chi-square; DF = degrees of freedom; IRR = incidence rate ratio; CI = confidence interval; ref = reference group; HLQ1 = Health Literacy Question 1; FT = feeding tube ; RT=radiation therapy; NA=Neighborhood Atlas Score; * indicates $p < 0.25$; † indicates $p < 0.05$

For hospitalizations alone during radiation therapy, the following variables met the criteria to be included as candidate predictors: Health literacy (p=0.320), neighborhood deprivation (p= 0.102), race (p=0.129), surgery (p=0.038), chemotherapy treatment (p=0.005), prescribed radiation dose (p=0.126), and timing of feeding tube placement (p=0.008). See table 4 for more details. In the 90 day follow-up period, the following variables met criteria to be included as a

predictor of hospitalizations: Health literacy (p=0.810), neighborhood deprivation (p= 0.037), surgery (p= 0.189), T stage (p=0.026), chemotherapy treatment (p= <0.001), immunotherapy treatment (p=0.078), prescribed radiation dose (p=0.035), and timing of feeding tube placement (p=0.002). See table 5 for more detail.

Table 4. Predictors of Hospitalizations During Treatment

	Univariate		Multivariate (Poisson)			
	LRX^2(DF) IRR CI (lower, upper)	P-value	(HLQ1+Including Candidate Predictors, p<.25)	P-value	Multivariate Parsimonious	P-value
HLQ1 (ref, adequate)	0.987 (1) 0.607 (0.180, 1.547)	0.320	2.689 (1), 0.437 (0.126, 1.159)	0.101		
Neighborhood Deprivation (ref, Low deprivation)	4.571 (2)	0.102*	1.647 (2)	0.439		
NA Middle Deprivation	2.860 (0.978, 10.320)		2.043 (0.637, 7.903)			
NA High Deprivation	2.671 (0.989, 9.282)		1.960 (0.656, 7.240)			
Sex (ref, male)	0.485 (1) 1.386 (0.516, 3.149)	0.486				
Marital status (ref, married)	0.018 (1), 1.053 (0.512, 2.324)	0.893				
Race (ref, white)	2.299 (1), 1.928 (0.811, 4.113)	0.129*	1.248 (1) 1.761 (0.636, 4.454)	0.264		
Current alcohol use (ref, no)	0.713 (1), 0.740 (0.369, 1.500)	0.398				
Current smoking status (ref, no)	0.801 (1), 0.677 (0.252, 1.539)	0.371				
Site (ref, oral cavity)	2.678 (2),	0.262				
Oropharynx	2.024 (0.685, 8.638)					
Larynx	2.669 (0.833, 11.800)					
T stage recode (ref, 1 &2)	0.126 (1), 1.134 (0.565, 2.298)	0.723				
N stage recode (ref, 0 & 1)	0.000 (1), 1.001 (0.497, 2.017)	0.997				

Table 4. Predictors of Hospitalizations During Treatment (continued)

Surgery (ref, no)	4.315 (1), 0.466 (0.211, 0.959)	0.038*	0.091 (1), 0.840 (0.274, 2.696)	0.763		
Chemotherapy (ref, no)	7.982 (1), 4.138 (1.471, 17.276)	0.005*	3.768(1), 3.708 (0.988, 18.500)	0.052	7.982 (1) 4.138 (1.471, 17.276)	0.005†
Immunotherapy (ref, no)	0.380 (1), 1.255 (0.596, 2.533)	0.538				
RT Dose (ref, 50-59 Gy)	4.136 (2),	0.126*	0.486 (2),	0.784		
60-69 Gy	1.185 (0.405, 4.276)		0.697 (0.193, 2.903)			
>70 Gy	2.309 (0.854, 8.022)		0.589 (0.155, 2.900)			
Time of FT Placement (ref, no feeding tube)	9.577 (2)	0.008*	3.488 (2)	0.175		
Prophylactic	1.345 (0.456, 4.116)		1.045 (0.299, 3.302)			
Reactive	3.302 (1.537, 7.482)		2.232 (0.88, 5.918)			
Age (centered around mean 59.705263)	1.387 (2)	0.500				
Age (linear)	0.193 (1) 1.010 (0.965, 1.061)	0.661				
Age (quadratic)	1.259(1) 0.998 (0.994, 1.001)	0.262				

LRX2 = Likelihood ratio chi-square; DF = degrees of freedom; IRR = incidence rate ratio; CI = confidence interval; ref = reference group; HLQ1 = Health Literacy Question 1; FT = feeding tube ; RT=radiation therapy; NA=Neighborhood Atlas Score; * indicates $p < 0.25$; † indicates $p < 0.05$

Table 5. Predictors of Hospitalization Follow-Up Period

	Univariate		Multivariate (Negative Binomial)			
	LRX^2(DF) IRR CI (lower, upper)	P-value	HLQ1+ Candidate Predictors, p<.25)	P-value	Multivariate Parsimonious	P-value
HLQ1 (ref, adequate)	0.058 (1) 1.147 (0.344, 3.315)	0.810	0.067 (1) 0.834 (0.213, 3.016)	0.796		
Neighborhood Deprivation (ref, Low deprivation)	6.598 (2)	0.037*	4.525 (2)	0.104		
NA Middle Deprivation	6.160 (1.472, 42.348)		5.366 (1.005, 43.913)			
NA High Deprivation	4.00 (0.992, 26.974)		4.716 (0.986, 35.881)			
Sex (ref, male)	0.085 (1), 1.201 (0.314, 3.809)	0.770				
Marital status (ref, married)	0.002 (1), 0.981 (0.390, 2.633)	0.968				
Race (ref, white)	0.126 (1), 0.789 (0.171, 2.688)	0.723				
Current alcohol use (ref, no)	0.134(1) 1.185 (0.483, 3.057)	0.714				
Current smoking status (ref, no)	0.606 (1), 1.473 (0.541, 3.787)	0.436				
Site (ref, oral cavity)	0.400 (2),	0.819				
Oropharynx	0.778 (0.0.267, 2.465)					
Larynx	0.652 (0.164, 2.500)					
T stage recode (ref, 1 &2)	4.973 (1), 2.857 (1.132, 7.933)	0.026*	0.176(1) 1.343 (0.336, 5.499)	0.675		

Table 5 Predictors of Hospitalization Follow-Up Period (continued)

N stage recode (ref, 0 & 1)	0.591 (1), 1.414 (0.584, 3.494)	0.442				
Surgery (ref, no)	1.727 (1), 0.551 (0.219, 1.338)	0.189*	1.337(1) 3.181 (0.471, 33.438)	0.675		
Chemotherapy (ref, no)	12.558 (1), 13.377 (2.640, 244.218)	<0.001*	4.130 (1), 9.534 (1.074, 236.548)	0.042†	12.558 (1) 13.337 (2.640, 244.218)	<0.001†
Immunotherapy (ref, no)	3.108 (1), 2.237 (0.913, 5.539)	0.078*	1.401(1), 2.402 (0.568, 11.501)	0.237		
RT Dose (ref, 50-59 Gy)	6.697(2),	0.035*	0.110 (2)	0.947		
60-69 Gy	2.407 (0.561, 16.660)		1.489 (0.121, 21.566)			
>70 Gy	5.552 (1.367, 37.667)		1.460 (0.112, 26.802)			
Time of FT Placement (ref, no feeding tube)	12.499 (2)	0.002*	2.921 (2)	0.232		
Prophylactic	3.600 (0.975, 13.898)		1.533 (0.307, 7.844)			
Reactive	6.574 (2.236, 22.342)		3.402 (0.834, 15.966)			
Age (centered around mean 59.705263)	0.257 (2)	0.880				
Age (linear)	0.006 (1) 0.998 (0.951, 1.044)	0.937				
Age (quadratic)	0.224 (1) 1.001 (0.998, 1.003)	0.636				

LRX2 = Likelihood ratio chi-square; DF = degrees of freedom; IRR = incidence rate ratio; CI = confidence interval; ref = reference group; HLQ1 = Health Literacy Question 1; FT = feeding tube ; RT=radiation therapy; NA=Neighborhood Atlas Score; * indicates $p < 0.25$; † indicates $p < 0.05$

For ED visits alone during radiation the following variables met criteria to be included as candidate predictors: health literacy (p=0.044), race (p=0.247), chemotherapy (p=0.074), and age (i.e. age linear, p= 0.387 and age quadratic, p=0.065). See table 6 for more detail. In the 90 day follow-up period, the following variables met criteria to be included as a predictor: Health literacy (p=0.775), neighborhood deprivation (p= 0.037), current smoking status (p=0.069), T stage (p=0.006), chemotherapy treatment (p=0.029), immunotherapy treatment (p=0.059), prescribed radiation dose (p=0.055), and timing of feeding tube placement (p=0.004). See table 7 for more detail.

Table 6. Predictor of Emergency Department Visits During Radiation

	Univariate		Multivariate (Poisson)			
	LRX^2(DF) IRR CI (lower, upper)	P-value	(HLQ1+Including Candidate Predictors, p<.25)	P-value	Multivariate Parsimonious	P-value
HLQ1 (ref, adequate)	4.060 .293 (.047, .972)	0.044*	.067 (1), 1.153 (0.428, 4.008)	0.795	5.886 (1) 0.235 (0.038, 0.787)	0.015†
Neighborhood Deprivation (ref, Low deprivation)	2.710 (2)	.258				
NA Middle Deprivation	2.288 (0.832, 7.261)					
NA High Deprivation	1.886 (0.731, 5.797)					
Sex (ref, male)	0.600 (1) 1.442 (0.536, 3.29)	0.443				
Marital status (ref, married)	0.160 (1), 1.170 (0.556, 2.678)	.689				
Race (ref, white)	1.341 (1), 1.687 (0.671, 3.717)	0.247*	1.079 (1) 1.623 (0.626, 3.701)	0.299		
Current alcohol use (ref, no)	0.076 (1), 0.904 (0.446, 1.886)	0.783				
Current smoking status (ref, no)	0.208 (1), 1.201 (0.524, 2.525)	0.648				
Site (ref, oral cavity)	2.684(2),	0.261				
Oropharynx	1.265 (0.459, 4.437)					
Larynx	2.184 (0.761, 7.812)					
T stage recode (ref, 1 &2)	0.033 (1), 1.067 (0.525, 2.180)	0.856				

Table 6. Predictor of Emergency Department Visits During Radiation (continued)

N stage recode (ref, 0 & 1)	0.286 (1), 0.825 (0.400, 1.672)	0.593				
Surgery (ref, no)	0.689 (1), 0.741 (0.355, 1.502)	0.406				
Chemotherapy (ref, no)	3.184 (1), 2.226 (0.930, 6.580)	0.074*	3.581(1), 2.367 (0.972, 7.074)	0.058	4.206 (1) 2.505 (1.038, 7.443)	0.040†
Immunotherapy (ref, no)	0.000 (1), 0.996 (0.449, 2.064)	0.992				
RT Dose (ref, 50-59 Gy)	1.084 (2)	0.582				
60-69 Gy	1.508 (0.541, 5.321)					
>70 Gy	1.765 (0.625, 6.268)					
Time of FT Placement (ref, no feeding tube)	2.099 (2)	0.350				
Prophylactic	1.350 (0.474, 3.416)					
Reactive	1.793 (0.806, 3.952)					
Age (centered around mean 59.705263)	3.809 (2)	0.149*				
Age (linear)	0.748(1) 0.977 (0.921, 1.030)	.387	0.565(1) 0.980 (0.972, 7.074)	0.452	0.0642 (1) 0.978 (0.923, 1.032)	0.423
Age (quadratic)	3.411 (1) 0.996 (0.990, 1.000)	0.065*	2.921(1) 0.996 (0.990, 1.000)	0.087	5.017 (1) 0.995 (0.989, 1.000)	0.025†

LRX2 = Likelihood ratio chi-square; DF = degrees of freedom; IRR = incidence rate ratio; CI = confidence interval; ref = reference group; HLQ1 = Health Literacy Question 1; FT = feeding tube ; RT=radiation therapy; NA=Neighborhood Atlas Score* indicates $p < 0.25$; † indicates $p < 0.05$

Table 7. Predictor of Emergency Department Visits Follow-Up Period

	Univariate		Multivariate (Negative Binomial)			
	LRX^2(DF) IRR CI (lower, upper)	P-value	HLQ1+ Candidate Predictors, p<.25)	P-value	Multivariate Parsimonious	P-value
HLQ1 (ref, adequate)	0.082 (1) 1.147 (0.431, 2.859)	0.775	0.446 (1) 0.676 (0.204, 2.104)	0.504		
Neighborhood Deprivation (ref, Low deprivation)	8.194 (2)	0.017*	3.816 (2)	0.148	7.707 (2)	0.021†
NA Middle Deprivation	5.040 (1.625, 19.267)		3.443 (0.902, 15.507)		4.998 (1.570, 19.494)	
NA High Deprivation	3.000 (.994, 11.219)		2.896 (0.875, 11.754)		2.981 (0.965, 11.336)	
Sex (ref, male)	0.316 (1), 1.338 (0.467, 3.575)	0.574				
Marital status (ref, married)	0.011 (1), 0.959 (0.439, 2.155)	0.917				
Race (ref, white)	0.554 (1), 1.446 (0.533, 3.720)	0.457				
Current alcohol use (ref, no)	0.073 (1) 0.902 (.427, 1.925)	0.787				
Current smoking status (ref, no)	3.307 (1), 2.087 (0.944, 4.596)	0.069*	0.390 (1) 1.369 (0.506, 3.670)	0.532		
Site (ref, oral cavity)	2.395 (2),	0.302				
Oropharynx	1.056 (0.378, 3.259)					
Larynx	1.957 (0.652, 6.420)					

Table 7. Predictor of Emergency Department Visits Follow-Up Period (continued)

T stage recode (ref, 1 &2)	7.408 (1), 2.929 (1.343, 6.758)	0.006*	3.037(1) 2.608 (0.889, 8.181)	0.081	6.921 2.910 (1.306, 6.852)	0.009†
N stage recode (ref, 0 & 1)	0.269 (1), 0.821 (0.386, 1.724)	0.604				
Surgery (ref, no)	1.069 (1), 0.677 (0.319, 1.418)	0.301				
Chemotherapy (ref, no)	4.756 (1), 2.628 (1.098, 7.040)	0.029*	0.332 (1), 1.489 (0.387, 6.119)	0.564		
Immunotherapy (ref, no)	3.557 (1), 2.065 (0.972, 4.416)	0.059*	0.004 (1), 1.041 (0.312, 3.474)	0.947		
RT Dose (ref, 50-59 Gy)	5.791 (2),	0.055*	0.471 (2)	0.790		
60-69 Gy	1.159 (0.400, 3.666)		0.747 (0.128, 4.219)			
>70 Gy	2.776 (1.004, 8.590)		0.563 (0.094, 3.106)			
Time of FT Placement (ref, no feeding tube)	10.937(2)	0.004*	2.866 (2)	0.239		
Prophylactic	1.750 (0.576, 5.067)		0.989 (0.266, 3.489)			
Reactive	4.834 (1.765, 9.971)		2.500 (.790, 8.264)			
Age (centered around mean 59.705263)	0.544 (2)	0.762				
Age (linear)	0.469 (1) 1.015 (0.973, 1.060)	0.493				
Age (quadratic)	0.057 (1) 1.000 (0.997, 1.002)	0.811				

LRX2 = Likelihood ratio chi-square; DF = degrees of freedom; IRR = incidence rate ratio; CI = confidence interval; ref = reference group; HLQ1 = Health Literacy Question 1; FT = feeding tube ; RT=radiation therapy; NA=Neighborhood Atlas Score; * indicates $p < 0.25$; † indicates $p < 0.05$

3.5 Multivariable Regression Models for Hospital Utilization

The multivariable regression model shown in the fourth and fifth columns of tables 2 through 7, included all predictors that met the criteria to be included along with health literacy. For total hospital utilization during radiation (see table 2 above), health literacy ($p < 0.05$; IRR=0.341) was significant. In the follow up period for total hospital utilization (see table 3 above), neighborhood deprivation [p=0.019; i.e. middle deprivation (IRR=1.333) and high deprivation (IRR= 1.436)] and surgery (p=0.036; IRR=3.689) were significant. For hospitalizations alone, only chemotherapy treatment (p=0.042; IRR=9.534) was significant during the follow-up period (see table 5 above). There were no significant findings for hospitalizations during radiation or emergency department visits during radiation or in the follow-up period.

The parsimonious model shown in the sixth and seventh columns in tables 2 through 7, utilized a backward elimination approach until all variables remaining in the model were significant. For total hospital utilization during radiation (see table 2 above), race (p=0.048; IRR=2.435) and chemotherapy treatment (p=0.003; IRR=3.604) were included in the final parsimonious model. During the follow up period for total hospital utilization (see table 3 above), neighborhood deprivation [i.e. p=0.037; medium deprivation (IRR=3.543) and high deprivation (IRR=3.272)], T stage (p=0.045; 2.200) and timing of feeding tube placement [i.e. p=0.037; prophylactic (IRR=1.519) and reactive (IRR=3.088)] were included in the model. For hospitalizations, only chemotherapy remained significant during radiaiton in table 4 (p=0.005; IRR=4.138) and in the follow-up period in table 5 (p=<0.001; IRR=13.337). For ED visits during radiation (see table 6 above), health literacy (p=0.015; IRR=0.235), chemotherapy treatment (p=0.040; IRR=2.505), and age [i.e. age linear (p=0.423; IRR=0.978) and age quadratic (p=0.025; IRR=0.995)] were included in the model. In the follow up period for ED visits (see table 7 above),

neighborhood atlas [i.e. p=0.021; medium deprivation (IRR=4.998) and high deprivation (IRR=2.981)] and T stage (p=0.009; IRR=2.910) remained significant. All incidence rate ratios signified a risk factor, with an IRR > 1, for hospital encounters except health literacy question 1 and age in the model for ED visits during treatment. Therefore, having inadequate health literacy resulted in a decreased incidence of 0.235 times compared to those with adequate literacy.

4.0 Discussion

For many survivors, treatment for HNC contributes to a high symptom burden, which may result in emergency room visits and inpatient hospital stays. Our documented hospital utilization rates are 46.3% for the entire period, with 30.5% during treatment and 31.6% in the follow-up period. Previous studies investigating hospital utilization, including ER visits and hospitalizations among HNC patients, reported rates between 33-55% depending on treatment modality and follow-up period length (Eskander et al., 2018; Moore et al., 2019). However, previous studies did not evaluate these two time periods separately. Our study found 35.7% of survivors had an inpatient admission during the entire treatment period. This is similar to current research reporting 34.7% and 35% (Hazelden et al., 2017; Ling et al., 2015). Specifically, we noted a 26.3% admission rate during the study period, which is similar to the previous studies (25.2% and 26%) (Ling et al., 2015; Moore et al., 2019). Compared to Ling et al. (2015), our study revealed a higher rate during the follow-up period for hospitalizations (11.6% vs. 20% respectively). However, our follow-up period (90 days) was longer than previous work (8 weeks) (Ling et al., 2015). Rates for ED visits are incomparable to existing research because we included ED visits that resulted in hospitalizations as an ED encounter while other studies did not making our reported rates for the entire study period higher than previous work by Moore et al. (i.e., 42.1% vs. 17.5%).

Our findings align with existing knowledge that concurrent chemotherapy increases acute toxicities that are associated with increased total hospital utilization and hospitalizations alone (Cooper et al., 2004; Forastiere et al., 2003; Ling et al., 2015; Moore et al., 2019). Concurrent chemotherapy accounted for increased hospital utilization for total hospital utilization during radiation, increased hospitalizations during radiation and follow-up, and ED visits during radiation

in multivariable regression. We differentiated between during treatment while controlling for variations in treatment length and the 90 day follow-up period because it may suggest different factors put patients at risk of increased utilization at different points in their treatment.

Our findings add to the research in clinical and cancer characteristic predictors, specifically feeding tube placement and advanced cancer staging. The study found an association between the timing of feeding tube placement and increased hospital utilization in multivariable regression, which was found in existing studies in univariate analysis (Ling et al., 2015; Moore et al., 2019). Depending on institutional protocols and clinical characteristics, feeding tubes may be placed prophylactically or reactively to decrease rates of adverse effects of treatment, but research has not definitely determined a clear risk versus benefit (Koyfman & Adelstein, 2012). Our results suggest that feeding tubes should be used with caution in HNC patients especially reactive feeding tubes. Finally, our study agrees that more advanced cancers have increase hospital utilization (Eskander et al., 2018). Because our recruitment period overlapped with a change in HNC staging from the American Joint Committee on Cancer 7th edition to the 8th edition on January 1st, 2018, and there is no translation between the two editions, we chose to assess stage by T and N stage. While reviewing other published literature, there were no studies to our knowledge that had an overlapping recruitment period with the change in editions. Other suggested predictors for hospital utilization that our study did not agree with previous multivariable analysis include being married, laryngeal primary site, female gender, and N2 stage (Moore et al., 2019; Ling et al., 2015; Eskander 2018). This inconsistency is most likely due to the limitations of the study discussed later.

The study found other social determinants of health, specifically low socioeconomic status indirectly assessed by neighborhood deprivation, lead to increased encounters. With low deprivation as the reference, medium deprivation neighborhoods had a 3.543 times higher

incidence for total hospital utilization and 4.998 higher incidence in ED visits, similar to high deprivation neighborhoods with 3.272 and 2.981 incidence rates, respectively. The study did not utilize post-hoc analysis to determine if this difference is statistically significance. Current research utilizing the ADI from the Neighborhood Atlas shows living in the top 5% most disadvantaged neighborhoods has been shown to increase 30-day readmission rates 70% compared to less disadvantaged neighborhoods after controlling for discharge diagnosis, comorbidities, and other patient characteristics at a large urban teaching hospital (Hu, Kind, & Nerenz, 2018). As previously mentioned, the neighborhood deprivation score accounts for income, education, employment, and housing quality. These factors fit into the subcategories of social determinants of health laid out in the Health People 2020 initiative by the Office of Disease Prevention and Health Promotion (n.d.). Our findings suggest that suboptimal social determinants of health (i.e., living in middle or high deprivation neighborhoods compared to low deprivation) may contribute to increased hospital utilization. More research utilizing specific predictor variables for employment, education level, income, or insurance status broadly assessing multiple domains of social determinants of health are needed.

While there is little research investigating health literacy and HNC patients our study demonstrated 17.9 % (n=17) of survivors had inadequate health literacy, which is higher than previous HNC studies reporting 11.9% and 13.8% (Koay et al, 2013; Nilsen et al., 2018). This could be as a result of liberalizing our standards by utilizing only question 1 of the BHLS; however, the approach we used has been validated (Chew et al., 2008; Wallace et al., 2006). However, compared to the general population with below basic health literacy (14%) and basic health literacy (22%), our findings align (Cutilli & Bennett, 2009). The BHLS is designed to be a fast approximation of a self-reported measure of health literacy in the clinical setting. By definition,

there are other components of health literacy like finding health information, the communication of health information by providers and the healthcare system and utilizing this information to make informed decisions that are not accounted for when assessing one's confidence filling out medical records. In a systematic review, multi-level interventions targeting the multiple areas of health literacy (i.e., numeracy, listening, speaking, reading) showed improvements in prevention, screening, diagnosis, and treatment (Housten et al., 2021). Assessing more domains of health literacy could identify areas where interventions can have the most impact.

It was hypothesized based on previously established research in other chronic conditions that health literacy is associated with hospital utilization (Baker et al., 2004; Cox et al., 2017; Fabbri et al. 2018; Koay et al., 2012; McNaughton et al., 2015; Omachi et al., 2012; Wu et al., 2013). Specifically, our findings showed inadequate health literacy is associated with decreased ED visits during radiation treatment as indicated by an IRR <1 in our parsimonious model and decreased total hospital utilization during radiation health literacy with an IRR <1 in the multivariable regression analysis. In colorectal cancer, those with inadequate health literacy and advanced stage cancer were less likely to receive chemotherapy (Busch et al., 2015). Other studies have looked at the impact of inadequate health literacy in HNC survivors and found poorer self-management behaviors, poorer functional health-related quality of life, lower scores for social-emotional quality of life, and increased fear of recurrence compared to those with adequate health literacy (Clarke et al., 2021; Nilsen et al., 2019). Future studies should investigate treatment outcomes, like hospital utilization, patient-reported outcomes, and survival.

The findings of this study are limited in their generalizability to the entire head and neck population because of a small, homogenous sample size at a single institution. Also, the retrospective chart review limited the ability to assess key social factors like income, insurance

status, education, and comorbidity measurements. Prospective data collection should include variables that account for the multiple factors contributing to and encompass health literacy (e.g., numeracy). Finally, there is a possibility for missing data due to access to in-network encounters only, and the retrospective nature limits the ability to inquire about out-of-network hospital utilization.

5.0 Conclusion

Our study demonstrated an association between health literacy and hospital utilization that is inconsistent with findings in other chronic conditions. Our results showed that concurrent chemotherapy, neighborhood deprivation, feeding tube placement, advanced cancer stage, race and age to be strong predictors of hospital utilization. This study emphasizes the need to consider individual risk factors for hospital utilization beyond clinical characteristics, including social determinants of health, specifically the multiple domains of health literacy. Further prospective research should broaden their measurements of social determinants of health, including factors such as income, employment status, education, and insurance status. Additionally, studies should measure treatment outcomes along with outcomes specific to survivors.

Bibliography

Argiris, A., Karamouzis, M. V., Raben, D., & Ferris, R. L. (2008). Head and neck cancer. *Lancet, 371*(9625), 1695-1709. https://doi.org/10.1016/S0140-6736(08)60728-X

Baker, D. W., Parker, R. M., Williams, M. V., Pitkin, K., Parikh, N. S., Coates, W., & Imara, M. (1996). The health care experience of patients with low literacy. *Archives of Family Medicine, 5*, 329-334.

Baker, D. W., Gazmararian, J. A., Williams, M. V., Scott, T., Parker, R. M., Green, D., Ren, J., Peel, J. (2004). Health literacy and use of outpatient physician services by medicare managed care enrollees. *Journal of General Internal Medicine*, *19*(3), 215–220. http://doi.org/10.1111/j.1525-1497.2004.21130.x

Busch, E. L., Martin, C., DeWalt, D. A., & Sandler, R. S. (2015). Functional health literacy, chemotherapy decisions, and outcomes among a colorectal cancer cohort. *Cancer Control, 22*(1), 95-101.

Berkman, N. D., Sheridan, S. L., Donahue, K. E., Halpern, D. J., & Crotty, K. (2011). Low health literacy and health outcomes: An updated systematic review. *Annals of Internal Medicine*, *155*(2), 97-107. http://doi.org/10.7326/0003-4819-155-2-201107190-00005

Cartwright, L. A., Dumenci, L., Cassel, B., Thomson, M. D., Matsuyama, R. K. (2017). Health literacy is an independent predictor of cancer patient's hospitalizations. *Health Literacy Research and Practice, 1*(4), e153-e162. https://doi.org/10.3928/24748307-20170808-01

Center for Disease Control and Prevention. (2018, May 28). *Head and Neck Cancers.* Retrieved from https://www.cdc.gov/cancer/headneck/index.htm

Center for Disease Control and Prevention. (2021, January 28). *What is Health Literacy?* Retrieved from https://www.cdc.gov/healthliteracy/learn/index.html

Chew, L. D., Bradley, K. A. & Boyko, E. J. (2004). Brief questions to identify patients with inadequate health literacy. *Family Medicine, 36*(8), 588-594.

Chew, L. D., Briffin, J. M., Partin, M. R., Noorbaloochi, S., Grill, J. P., Snyder, A., Bradley, K. A., Nugent, S. M., Baines, A. D., & Vanryn M. (2008). Balidation of screening questions for limited health literacy in a large VA outpatient population. *Journal of General Internal Medicine, 25*(5), 561-566. https://doi.org/10.1007/s11606-008-0520-5

Clarke, N., Dunne, S., Coffey, L., Sharp, L., Desmond, D., O'Conner, J., O'Sullivan E., Timon, C., Cullen, C., & Gallagher, P. (2021). Health literacy impacts self-management, quality of life and fear of recurrence in head and neck cancer survivors. *Journal of Cancer Survivorhsip,* https://doi.org/10.1007/s11764-020-00978-5

Cooper, J. S., Pajak,T. F., Forastiere, A. A., Jacobs, J., Campbell, B. H., Saxman, S. B., Kish, J. A., Kim, H. E., Cmelak, A. J., Rotman, M., Ensley, J. F., Chao, D., Schultz, C.J., Lee, N., Fu, K. F. (2004). Postoperative concurrent radiotherapy and chemotherapy for high risk squamous-cell carcinoma of the head and neck. *New England Journal of Medicine, 350*, 1937-1944. https://doi.org/10.1056/NEJMoa032646

Cox, S. R., Lieble, M. G., McComb, M. N., Chau, J. Q., Wilson, A. A., Achi, M., Garey, K. W., & Wallace, D. (2017). Association between health literacy and 30-day healthcare use after hospital discharge in heart failure population. *Research in Social and Administrative Pharmacy, 13*(4), 754-758. https://doi.org/10.1016/j.sapharm.2016.09.003

Cohen, E. E., LaMonte, S. J., Erb, N. L., Beckman, K. L., Sadeghi, N., Hutchenson, K. A., Stubblefield, M. D., Abbot, D. M., Fisher, P. S., Stein K. D., Lyman, G. H., & Pratt-Chapman, M. L. (2016). American cancer society head and neck cancer survivorship care guideline. *CA: A Cancer Journal for Clinicians*, *66*(3). https://doi.org/10.3322/caac.21343

Cutilli, C. C., & Bennett, I. M. (2009). Understanding the health literacy of America: Results of the national assessment of adult literacy. *Orthopedic Nursing*, *28*(1), 27–34. https://doi.org/10.1097/01.NOR.0000345852.22122.d6

Eskander, A., Krzyzanowska, M.K., Fischer, H. D., Liu, N., Austin, P. C., Irish, J.C., Enepekides, D. J., Lee, J., Gutierrez, E., Raphael, M., & Singh, S. (2018). Emergency department visits and unplanned hospitalizations in the treatment period for head and neck cancer patients treated with curative intent: A population-based analysis. *Oral Oncology, 83*, 107-114. https://doi.org/10.1016/j.oraloncology.2018.06.011

Fabbri, M., Youst, K., Finney Rutten, L. J., Manemann, S. M., Boyd, D. M., Jensen, D., Weston, S. A., Jiang, R., & Roger, V. L. (2018). Health literacy and outcomes in patients with heart failure: A prospective community study. *Mayo Clinic Proceedings*, *93*(1), 9-15. https://doi.org/10.1016/j.mayocp.2017.09.018

Forastiere, A. , Goepfert, H., Maor, M., Pajak, T. F., Weber, R., Morrison, W., Glisson B., Trotti, A., Ridge, J. A., Chao, D., Peters, G., Lee, D. J, Leaf, A., Ensley, J., & Cooper, J. (2003). Concurrent chemotherapy and radiotherapy for organ preservation in advanced laryngeal cancer. *New England Journal of Medicine, 349,* 2091-2098. https://doi.org/10.1056NEJMoa031317

Fulcher, C. D., Haigentz, M. Jr., Ow, T. J., & Education Committee of the American Head and Neck Society (ANHS). (2017). AHNS series: Do you know your guidelines? Principles of treatment for locally advanced or unresectable head and neck squamous cell carcinoma. *Head & Neck, 40*(4), 676-686. http://doi.org/10.1002/hed.25025

Gooi, Z., Fakhry, C., Goldenberg D., Richmon, J., Kiess, A. P., & Education Committee of the American Head and Neck Society [AHNS]. (2016). AHNS series: Do you know your guidelines? Principles of radiation therapy for head and neck cancer: A review of the National Comprehensive Cancer Network guidelines. *Head & Neck, 38*(7), 987-992. https://doi.org/10.1002/hed.24448

Halverson, J. L., Martinez-Donate, A. P., Palta, M., Leal, T., Lubner, S., Walsh, M. C., Strickland, S. J., Smith, P.D., & Trentham-Dietz, A. (2015). Health literacy and health-related quality of life among a population-based sample of cancer patients. *Journal of Health Communication, 20*(11), 1320-1329. http://doi.org/10.1080/10810730.2015.1018638.

Haun, J. N., Patel, N. R., French D. D., Campbell R. R., Bradham D. D., & Lapcevic, W. A. (2015). Association between health literacy and medical care costs in an integrated healthcare system: A regional population-based study. *BMC Health Services Research, 15*, 249. http://doi.org/10.1186/s12913-015-0887-z

Hazelden L. A., Newman, M. J., Shuey, S., Waldfogel, J. M., & Brown V. T. (2019). Evaluation of the head and neck cancer patient population and the incidence of hospitalization at an academic medical center. *Journal of Oncology Pharmacy Practice, 25*(2), 333-338. https://doi.org/10.1177/1078155217735688

Housten, A.J., Gunn, C. M., Paasche-Orlow, M. K., Basen-Engquist, K.M. (2021). Health literacy interventions in cancer: A systematic review. *Journal of Cancer Education, 36*, 240-252, https://doi.org/10.1007/s13187-020-01915-x

Hu, J., Kind, A. J. H., & Nerenz, D. (2018). Area deprivation index predicts readmission risk at an urban teaching hospital. *American Journal of Medical Quality, 33*(5), 493-501. https://doi.org/10.1177/1062860617753063

Koay, K., Schofield, P., & Jefford, M. (2012). Importance of health literacy in oncology. *Asia-Pacific Journal of Clinical Oncology, 8*, 14-23. https://doi.org/10.1111/j.1743-7563.2012.01522.x

Koay, K., Schofield, P, Gough, K., Buchbinder, R., Rischin, D., Ball, D., Corry, J., Osborne, R. H., & Jefford, M. (2013). Suboptimal health literacy in patients with lung cancer or head and neck cancer. *Supportive Care in Cancer, 21*(8), 2237-2245. https://doi.org/10.1007/s00520-013-1780-0.

Koyfman, S. A. & Adelstein, K. J. (2012) Enteral feeding tubes in patients undergoing definitive chemoradiation therapy for head-and-neck cancer: A critical review. *International Journal of Radiation Oncology, Biology, and Physics, 84*(3), 581-589. https://doi.org/10.1016/j.ijrobp.2012.03.053.

Koyfman S. A., Ismaila, N., Crook, D., D'Cruz, A., Rodriguez, C. P., Sher, D. J., Silbermins, D., Sturgis, E. M., Tsue, T. T., Weiss, J., Yom, S. S., & Holsinger, F. C. (2019). Management of the neck in squamous cell carcinoma of the oral cavity and oropharynx: ASCO clinical practice guidelines. *Journal of Clinical Oncology, 37*(20), 1753-1774. https://doi.org/10.1200/JCO.18.01921

Levy, H., & Janke, A. (2017). Health literacy and access to care. *Journal of Health Communication, 21*, 43-50. https://doi.org/10.1080/10810730.2015.1131776

Ling, D. C., Kabolizadeh, P., Heron, D. E., Ohr, J. P., Wang, H., Johnson, J., & Kubiced, G. J. (2015). Incidence of hospitalization in patients with head and neck cancer treated with intensity-modulated radiation therapy. *Head & Neck, 37*(12), 1750-1755. http://doi.org/10.1002/hed.23821

Lydiatt, W. M., Patel S. G., O-Sullivan, B., Brandwein, M. S., Rige, J. A., Migliacci, J. C., Loomis A. M., & Shah, J. P. (2017). Head and neck cancers-Major changes in the American Joint Committee on Cancer eighth edition cancer staging manual. *CA: A Cancer Journal for Clinicians, 67*(2), 122-137. https://doi.org/10.3322/caac.2138

McNaughton, C. D., Cawthon, C., Sripalami, S., Liu, D., Storrow, A. B., & Roumie, C. L. (2015) Health literacy and mortality: A cohort study of patients hospitalized for acute heart failure. *Journal of the American Heart Association, 4*(5), https://doi.org/10.1161/JAHA.115.001799

Miller, T. A. (2016). Health literacy and adherence to medical treatment in chronic and acute illness: A meta-analysis. *Patient education and counseling, 99*(7), 1079-1086. http://doi.org/10.1016/j.pec.2016.01.020

Moore, Z. R., Pham, N., Shah, J. L., Nedzi, L., Sumer, B. D., Day, A . T., Shan, S. A., & Sher, D. J. (2019). Risk of unplanned hospital encounters in patients treated with radiotherapy for head and neck squamous cell carcinoma. *Journal of Pain and Symptom Management, 57*(4), 738-745.e3. https://doi.org/10.1016/j.jpainsymman.2018.12.337

National Cancer Institute, (2021, January 29) *Laryngeal cancer treatment (Adult)- Health professional version.* Retrieved from https://www.cancer.gov/types/head-and-neck/hp/adult/laryngeal-treatment-pdq

Nekhlydov, L., Lacchetti, C., Davis, N. B., Garvey, T. Q., Goldstein, D. P., Nunnink, J. C., Ninfead, J. I. R., Salner, A. L., Salz, T., & Siu, L. L. (2017). Head and neck cancer survivorship care guideline: American society of clinical oncology clinical practice guideline endorsement of the American cancer society guideline. *Journal of Clinical Oncology, 35*(14), 1606-1621. http://doi.org/10.1200/JCO.2016.71.8478

Nilsen, M. L., Moskovitz, J., Lyu, L., Harrison, C., Randazza, E., Peddade, S. D., & Johnson, J. T. (2019). Health literacy: Impact on quality of life in head and neck cancer survivors. *Laryngoscope, 130*(10), 2354-2359. https://doi.org/10.1002/lary.28360.

Oken, M. M., Creech, R. H., Tourney, D C., Horton, J., Davis T.E., McFadden, E. T., & Carbone, P. P. (1982). Toxicity and response criteria of the Eastern Cooperative Oncology Group. *American Journal of Clinical Oncology, 5*, 649-655.

Omachi, T. A., Sarkar, U., Yelin, E. H., Blanc, P. D., & Katz, P. P. (2012). Lower health literacy is associated with poorer health status and outcomes in chronic obstructive pulmonary disease. *Journal of General Internal Medicine, 28*(1), 74-81, https://doi.org/10.1007/s11606-012-2177-3

Office of Disease Prevention and Health Promotion. (n.d.) *Social Determinants of Health.* Retrievedfrom https://www.healthypeople.gov/2020/topics-objectives/topic/social-determinants-of-health

Paasche-Orlow, M. K., Parker, R. M., Gazmararian, J. A., Nielsen-Bohlman, L. T., Rudd, R. R. (2005). The prevalence of limited health literacy. *Journal of General Internal Medicine, 20*(2), 175-184. https://doi.org/10.1111/j.1525-1497.2005.40245.x

Papadakos, J. K., Hasan, S. M., Barnsley, J., Berta, W., Fazelzad R., Papadakos, C. J., Guiliani, M. E., & Howell, D. (2018). Health literacy and cancer self-management behaviors: A scooping review. *Cancer, 124*(21), 4202-4210. https://doi-org.pitt.idm.oclc.org/10.1002/cncr.31733

Surveillance, Epidemiology, and End Results Program [SEER] (2020b, June). *Cancer stat facts: Oral cavity and pharynx cancer*. Retrieved from https://seer.cancer.gov/statfacts/html/oralcav.html

Trotti, A, Bellum, L. A., Epstein, J. B., Frame, D., Fuchs, H. J., Gwede, C. K., Komaroff, E., Nalsnyk, L., & Zilberberg, M. D. (2003). Mucositis incidence, severity and associated outcomes in patients with head and neck cancer receiving radiotherapy with or without chemotherapy: A systematic review. *Radiation & Oncology, 66*(3), 253-262. https://doi.org/10.1016/s0167-8140(02)0040-8

Trotti, A., Paja, T. F., Gwede, C. K., Paulus, R., Cooper, J., Forastiere, A., Ridge, J. A., Watkins-Bruner, D., Garden A. S., Ang, K. K., & Curran W. (2007). TAME: Development of a new method for summarizing adverse events of cancer treatment by the radiation therapy oncology group. *Lancet Oncology, 8*(7). 613-624. https://doi.org/10.1016/S1470-2045(07)70144-4

University of Wisconsin School of Medicine and Public Health. 2015 Area Deprivation Index v2.0. Downloaded from https://www.neighborhoodatlas.medicine.wisc.edu/ June 1, 2020.

Wallace, L. S., Rogers, E. S., Roskos, S. E., Holiday, D. B., & Weiss, B. D. (2006). Brief report: Screening items to identify patients with limited health literacy skills. *Journal of General Internal Medicine, 21*(8), 874-877. https://doi.org/10.1111/j.1525-1497.2006.00532.x

Wu, J. R., Holmes, G. M., DeWalt, D. A., Macabasco-O'Connell, A., Bibbins-Domingo, K., Ruo, B., Baker, D. W., Schilliner, D., Weinberger, M., Broucksou, K. A., Erman, B., Jones, C. D., Cene, C. W., Pignone, M. (2013). Low literacy is associated with increased risk of hospitalization and death among individuals with heart failure. *Journal of General Internal Medicine, 28*(9), 1174-1180. https://doi.org/10.1007/s11606-013-2394-4