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Predictors of Unplanned Hospitalizations in Patients With Nonmetastatic Lung Cancer During Chemotherapy

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Abstract

Purpose—Determine predictors of unplanned hospitalizations in patients with lung cancer intended to receive chemotherapy in the outpatient setting, and examine the potential financial burden of these events.

Design—Retrospective, longitudinal cohort study.

Setting—The National Cancer Institute’s Surveillance, Epidemiology and End Results (SEER)-Medicare linked database.

Population—Of 104,388 incident cases of lung cancer diagnosed in 2005-2009, 2,457 cases with lung cancer who received outpatient chemotherapy were identified. Cases were aged 66 years or older at diagnosis, had uninterrupted Medicare Part A and B coverage with no HMO enrollment, and received intravenous chemotherapy at least one time.

Main Research Variables—Patient age, sex, race, marital status, degree of residential urbanization, median income, educational level, stage, receipt of radiation therapy and comorbidities.

Findings—Younger age, non-white race, lower education, higher income, receipt of radiation therapy and lack of pre-existing comorbidity were significant predictors of the likelihood of an initial unplanned hospitalization for lung cancer. Non-white race, receipt of radiation therapy, and comorbidity were factors associated with an increased number of hospitalizations. Among 2,257 hospitalizations, total Medicare charges equaled \$74,187,751, with a median Medicare charge per hospitalization of \$31,036.

Conclusions—Unplanned hospitalization are frequent, disruptive and costly. This work defines areas for further exploration to identify patients at high risk for unexpected complications.

Implications for Nursing—This work represents a foundation for development of risk models to enable nursing evaluation of patient risk for chemotherapy treatment interruption and unplanned hospitalization.

Keywords

SEER-Medicare; lung neoplasms; comorbidity; hospitalization; chemotherapy

Unplanned hospitalizations in patients receiving chemotherapy for non-metastatic cancer disrupt potentially curative treatment regimens, significantly affect quality of life and are costly to the patient and healthcare system. Efforts to identify patients at risk of requiring unexpected care are needed to prevent negative outcomes and improve care quality and value. Lung cancer is the second most commonly diagnosed cancer in Americans, with an average age of 70 at presentation, and the leading cause of cancer deaths (American Cancer Society, 2015). Treatment typically includes combinations of surgical resection, chemotherapy, radiation therapy, targeted agents and biotherapy, dependent on histology, stage and molecular characteristics. Extensive study has focused on identification of factors associated with increased risk of readmission post-surgery in this population (Hu, McMurphy, Isbell, Stukenborg, & Kozower, 2014; McDevitt et al., 2013; Puri et al., 2015; Stitzenberg, Chang, Smith, & Nielsen, 2015), but less is known about predictors of hospitalizations occurring during chemotherapy.

Purpose/Objectives

This study examined a cohort of patients in the National Cancer Institute (NCI) Surveillance, Epidemiology and End Results (SEER)-Medicare database with non-metastatic lung cancer who received outpatient chemotherapy. It was part of a larger project where both colorectal and lung cancer data were simultaneously obtained from the NCI SEER-Medicare linked database and then analyzed in parallel using the same methods to determine predictors of the initial as well as repeated unplanned hospitalizations. These tumor types were selected based upon two main criteria; first, standard treatment for these solid tumors typically involves an initial surgical resection followed by a period of ambulatory chemotherapy administration with no planned inpatient component, and second, a review of the literature indicated the most frequent rates of hospital admission in these groups (Gonzalez et al., 2005; Grant, Ferrell, Rivera, & Lee, 1995; Hassett et al., 2011; Weaver et al., 2006). An exploratory aim examined the potential financial burden of these events. The colorectal data analysis is published elsewhere (Fessele, Hayat, Mayer, & Atkins, 2016).

Chemotherapy for patients with solid tumors such as lung cancer is intended to be administered and managed on an outpatient basis, but due to crises related to disease progression, intractable symptoms or toxicity associated with anti-cancer treatment, some patients will require hospital admission. The demographic, clinical and setting of care factors associated with an initial hospitalization, or the characteristics of those patients repeatedly admitted to manage severe symptoms during cancer treatment are not well understood, especially among older adults who are poorly represented among clinical trial data (Zulman et al., 2011). This study uses a large, nationally representative, population-

based database to overcome this limitation in a population of older adults (Warren, Klabunde, Schrag, Bach, & Riley, 2002).

The problem of readmission, where a patient returns to the hospital after an initial “index” stay, is a well-defined phenomenon (Jencks, Williams, & Coleman, 2009). An initial unplanned hospitalization, defined in this study as an event where a patient is intended to receive all treatment in the ambulatory setting, but experiences a crisis that requires inpatient care, is distinct from readmission, which is conditional upon a prior related or unrelated hospitalization (Fessele & Atkins, 2012; Jencks et al., 2009; Mulder, Tzeng, & Vecchioni, 2012).

Patients with lung cancer frequently visit the emergency department (ED) and hospital for unplanned care (Mayer, Travers, Wyss, Leak, & Waller, 2011). For those receiving chemotherapy, the majority of literature has reported on patients with metastatic (Stage IV) disease, where surgical resection of the presenting tumor is not possible, and admissions are frequently related to symptoms of disease burden or progression (Elkin, O’Neill, Atoria, O’Reilly, & Bach, 2015; Hurria et al., 2011; Zauderer, Sima, Korc-Grodzicki, Kris, & Krug, 2013). We were unable to locate data addressing unplanned hospitalizations specific to the non-metastatic lung cancer population receiving chemotherapy, which is concerning as the treatment intent in this population may be cure or long-term remission.

Methods

Data Source

The SEER–Medicare database links CMS claims data with information from the National Cancer Institute’s SEER program to produce research-grade administrative and clinical data that represents a longitudinal view across settings of care at the individual patient level (Warren, Klabunde, Schrag, Bach, & Riley, 2002). The SEER program, implemented in 1973, collects data on newly diagnosed cancer cases across 17 registries within the United States, representing about 28% of all cases nationally (NCI, 2012). For each primary malignancy, SEER data records cancer stage, histology, initial radiation or surgical interventions (due to the wide variation and complexity of chemotherapy options, the record will indicate whether a patient received chemotherapy as part of the initial treatment, but not the regimen received), patient demographics and survival.

Approximately 93% of those over age 65 in the United States are covered by Medicare (U.S. Department of Health and Human Services, 2014), which is comprised of different benefits, also referred to as “parts.” Hospitalization, hospice, skilled nursing facility and home health costs are covered under Part A benefits. Part B, an optional benefit elected by about 96% of covered beneficiaries, provides coverage for outpatient and services. Optional Parts C and D offer CMS-managed Health Maintenance Organization (HMO) plans, and benefits for prescription medications, respectively (CMS, 2012).

The SEER–Medicare database includes a number of file types joined together by a unique patient identifier. Information from the SEER registry informs the Patient Entitlement and Diagnosis Summary File (PEDSF). Medicare Part A claims data generates the Medicare

Provider Analysis and Review (MEDPAR) File. The National Carrier History (NCH) and Outpatient (OUTPT) files list claims for physician, advanced practice nurse, and physician assistant and other provider visits and treatments administered in the ambulatory setting. OUTPT data are specific to hospital-based outpatient facilities.

The study was reviewed by the Rutgers University Institutional Review Board prior to study start. The project was found to be non-human subject research, and authorized to proceed.

Study Population

Eligible patients in the SEER-Medicare database had stages I-III non-small cell lung cancer diagnosed in the years 2005 through 2007, with claims data followed longitudinally through 2009, were at least 66 years old at time of cancer diagnosis, and had continuous Medicare Parts A and B coverage as the primary payer without an HMO component for at least 12 months prior to a subsequent initial cancer diagnosis to permit identification of comorbidities. The cohort was then limited to include those cases where there was at least one billed claim for a chemotherapy drug prior to the initial and subsequent unplanned hospitalizations (see Figure 1). As a population-based study, no sampling was conducted.

Main Research Variables

Factors including patient age, sex, race, marital status, degree of residential urbanization, median income, educational level, stage, receipt of radiation therapy and comorbidities were studied and considered as potential predictors. Demographics and cancer diagnostic information was obtained from the PEDSF file. Patients who received chemotherapy were identified by searching the multiyear ambulatory claims files (NCH and OUTPT) for observations with a Healthcare Common Procedure Coding System (HCPCS) value containing a J9 code, designating chemotherapy agents (Lamont et al., 2005). Cancer-related hospitalizations were identified by searching the multiyear hospital claims file (MEDPAR) for the tumor type of interest in either the first or second position of 10 possible ICD-9-CM diagnostic codes assigned to the admission (Mayer et al., 2011). When a patient identification number was located in both the “received chemotherapy” and “had a cancer-related hospitalization” files, that case was assigned to the “Hospitalized” group (See Figure 1). Where a case was found in the “received chemotherapy” file only, that patient was assigned to the “No Hospitalization” group ($n = 978$).

The “All Cancer-Related Hospitalizations” file was then restricted to include only admissions associated with dates within the hospitalization observation period (First Chemotherapy Administration plus 1 day through Last Chemotherapy Administration plus 30 days) for the eligible patient cases (See Figure 2). The remaining observations formed the final Hospitalization group for analysis (See Figure 3). Both Hospitalized and Non-Hospitalized cases underwent weighted pre-existing comorbidity analysis, utilizing the NCI Combined Index (Klabunde et al., 2007).

To obtain a general estimation of potential financial burden associated with these unplanned hospitalizations, the MEDPAR file was examined to calculate the total charges submitted by the hospital for each admission in US dollars through use of the Medicare total charge variable TOTCHRG. The variable REIMBAMT captured the amount the hospital was paid

for each of the MEDPAR file unplanned hospitalizations. No additional adjustments or calculations, such as cost-to-charge ratios were conducted as part of this study.

Statistical Analysis

Patient cases were included from the 16 NCI-SEER registries that contributed complete data at the time. Consistent with previous reports (Du, Osborne, & Goodwin, 2002; Nurgalieva, Liu, & Du, 2009) that illustrated the importance of including geography at the SEER registry level as a variable, the 16 registries were grouped into four SEER regions (see Table 1) to facilitate analysis. The NCI Combined Index (Klabunde, Legler, Warren, Baldwin, & Schrag, 2007) was used to produce a weighted comorbidity score for each case. This method evolved from the inpatient-developed Charlson Comorbidity Index (Charlson, Pompei, Ales, & MacKenzie, 1987) to enable use with hospital and outpatient administrative data. Claims data are examined to detect the whether any of 14 noncancer conditions are present, and then apply a coefficient estimate for 2-year noncancer mortality to obtain a weighted score (Klabunde, Potosky, Legler, & Warren, 2000).

In order to properly account for geographical differences, and the resulting within-region correlations that may occur, advanced statistical modeling techniques were used. Generalized estimating equations (GEE), a statistical modeling technique that builds on generalized linear modeling to correctly adjust standard error estimates and account for within region correlated data (Liang & Zeger, 1986).

To examine the demographic and clinical factors predictive of *initial* unplanned hospitalizations within the defined study period, a binary “hospitalized/not hospitalized” outcome was used with a binomial distribution and logit link to predict the probability of the event as a function of linear predictors, in a similar manner to logistic regression. However, the variance of the binary response was adjusted for the likelihood that cases from the same region are more similar. Results are interpreted in terms of odds ratios, giving the likelihood of hospitalization versus not for each independent variable.

Exploration of factors that *predict the number* of unplanned hospitalizations considers count data. The dependent variable was defined as the number of hospitalizations in the defined study period, conditional on at least one recorded hospitalization. A GEE model with a Poisson distribution and log link was used to predict the number of hospitalizations occurring among those patients with one or more admissions. Results are interpreted through use of incidence rates (Rothman, 2002).

Data step programming in SAS, version 9.3, was used to perform data management, integration, and manipulation. Statistical modeling was completed with the PROC GENMOD procedure. After assessing the characteristics and frequency distributions of the independent variables, bivariate models were fit to assess the association between each independent variable with the dependent variable. A nominal level of significance of .05 was used initially, followed by model-building steps retaining independent variables with statistical results at the $\alpha = 0.15$ level. Advanced statistical modeling was then performed. After considering independent variables that were known to be associated with hospitalization, and including in each model by default regardless of statistical significance,

statistical results (p-values) and the QIC (quasi-likelihood under the independence model criterion) goodness of fit statistic were used throughout to determine the best final models (Pan, 2001).

Results

The cohort included 2,457 patients, 54.3% male, and 9.4% of a self-reported non-white race, with a mean age of 76.8 years. The Hospitalized group comprised 60.2% of the cohort ($n = 1,479$), and experienced a mean of 1.5 hospitalizations per patient (SD 0.9, range 1-9). There were 2,257 unplanned hospitalizations, with a median length of stay of 4 days (range 1-432 days). The total charges billed for the 2,257 unplanned hospitalizations identified in this study equaled \$74,187,751. The median Medicare charge and payment per hospitalization were \$31,036 and \$8,633, respectively.

The characteristics of the Hospitalized and Non-Hospitalized patients were similar with the exception of comorbidity score (see Table 1). The Hospitalized group had a significantly higher proportion of patients with no pre-existing comorbidity than the Non-Hospitalized group in our cohort ($X^2 = 300.31$, 3, $p < .0001$).

Initial unplanned hospitalization

For each year of increasing age, the likelihood of hospitalization decreased by 5.4% [OR=0.9524, 95% CI: (0.9386, 0.9665), $p < .0001$]. Comorbidity was significant in the multivariate model, whereas after controlling for other factors, compared with a weighted NCI Combined Index score of 0, indicating no comorbidities, patients with one or more comorbidities had a decreased likelihood of hospitalization. Compared with patients with no comorbidities, those with a score of 1 had a decreased likelihood of 82.2% [OR=0.1781, 95% CI: (0.1497, 0.2120), $p < .0001$]; in those with a score of 2, the likelihood of hospitalization decreased by 76.4% [OR=0.2360, 95% CI: (0.1595, 0.3492), $p < .0001$], and for those patients with a score of 3 or higher, the likelihood of hospitalization decreased by 54.7% [OR=0.4532, 95% CI: (0.3150, 0.6519), $p < .0001$].

Non-white patients experienced an increased likelihood of hospitalization of 58.7% as compared to whites [OR=1.5877, 95% CI: (1.1372, 2.2165), $p = 0.0066$]. After controlling for other factors, for each 10% increment decrease in census tract level rate of high school completion, the likelihood of hospitalization increased by 9.78% [OR=1.0978, 95% CI: (1.0261, 1.1746), $p = 0.0068$]. For each \$10,000 increment increase in census tract level median income, the likelihood of hospitalization increased by 8.25% [OR=1.0825, 95% CI: (1.0126, 1.1573), $p = 0.02$]. The influence of degree of urbanization as a predictive factor is complex; as compared to patients living in an area designated as completely rural (defined by Census 2000 data as an urban population less than 20,000), those in areas with an urban population of between 20,000 and 1 million (Metro/Urban) have a decreased likelihood of hospitalization of 40.9% [OR=0.5905, 95% CI: (0.4266, 0.8174), $p = 0.0015$], but living in counties metro areas of 1 million or more (Big Metro) did not significantly impact likelihood of the event [OR=0.7744, 95% CI: (0.5132, 1.1687), $p = 0.2234$].

Number of unplanned hospitalizations

Controlling for clustered SEER registry, education and median income (See Table 3), cases designated in the SEER record with a non-white race had 1.0763 times the number of unplanned hospitalizations as compared to whites [Estimate=1.0763, 95% CI: (1.0027, 1.1553), $p=0.0420$]. After controlling for other factors, patients who received radiation therapy had 1.0398 times the number of repeated hospitalizations compared to those who did not undergo that treatment [Estimate=1.0398, 95% CI: (1.0070, 1.0736), $p=0.0170$], and those with a comorbidity score of 1 had 1.1511 times the number of repeated hospitalizations as compared to those with a score of 0 [Estimate=1.1511, 95% CI: (1.0686, 1.24), $p=0.0002$]. As compared to those patients living in a completely rural area, those in a Metro/Urban area had 0.9024 times the number of hospitalizations [Estimate=0.9024, 95% CI: (0.8327, 0.9779), $p=0.0122$].

Discussion

This study illustrates that unplanned hospitalizations are frequently and repeatedly experienced by patients with non-metastatic lung cancer in the SEER-Medicare database, and result in significant Medicare charges. We found that younger age, non-white race, a lower high school graduation rate, but higher median income in the census tract of residence, living outside of an urban area, receipt of radiation therapy and lower comorbidity scores were significant predictors of the likelihood of initial unplanned hospitalizations. Non-white race, receipt of radiation therapy, living outside of an urban area and comorbidity were factors associated with the number of hospitalizations experienced.

Numerous sources discuss the impact of comorbid conditions on the patient's ability to tolerate anticancer treatments and on the natural history of the cancer process itself (Geraci, Escalante, Freeman, & Goodwin, 2005; Gross, McAvay, Guo, & Tinetti, 2007; Hernandez et al., 2009; Janssen-Heijnen et al., 2005; Lemmens et al., 2005). In this lung cancer cohort, a mixed set of observations was noted. After controlling for other factors in the model, as compared to patients with a weighted score of 0 (indicating no comorbid conditions), the odds ratio for likelihood of initial hospitalization for scores of 1, 2 or 3 or more was 0.178, 0.236, and 0.453 respectively, which is not the trend we would have expected. It is important to note that among the ultimately eligible cases, there were significant differences in the comorbidity scoring categories between the Hospitalized and Non-Hospitalized groups, where the latter appeared to present at the time of cancer diagnosis with more pre-existing illnesses, and this may contribute to these unexpected results.

In both the lung and previously published colorectal cohorts, age was a statistically significant predictor related to the incidence of initial unplanned hospitalization, but not in regards to the number of hospitalizations experienced. Each year of additional age was associated with a 4.7% decrease in the likelihood of initial unplanned hospitalization. Though this may appear a counterintuitive result, a bias towards offering less aggressive anticancer treatments to patients based upon their chronologic age is evident in the literature (Hurria et al., 2008; Sargent et al., 2001; Sundararajan et al., 2002) and could contribute towards the appearance of fewer severe toxicities leading to hospitalization. Though the specific drugs administered could be precisely identified through billing data, the exact dose

could not, as the unit of measurement is at the billed vial size, rather than indicative of true milligram per meter squared dosing.

Taken together, these unexpected trends where younger chronologic age and lower weighted comorbidity scores were associated with increased likelihood of unplanned hospitalization support the need for further study investigating whether more aggressive therapy is offered preferentially to this group, and the related outcomes, including ability to tolerate full courses of therapy at intended doses. Hurria et al. (2016) recently validated a scoring algorithm to predict the likelihood of chemotherapy-related toxicity in older adults. Among other components including age, hemoglobin level, cancer type and multiple functional assessment questions, the planned number of chemotherapy drugs and intended dose were significant factors in the model. Future work to compare chemotherapy doses planned versus actually delivered, explored in the context of the patient's "physiologic age," including factors such as organ function and physical performance status is needed.

Though less than 10% of the lung and colorectal cohorts were non-white, race was a significant predictor of unplanned hospitalizations in both studies, though other SEER-Medicare analyses have shown mixed results (Du et al., 2002; Nurgalieva et al., 2009). Other socioeconomic variables including education, income and degree of urbanization were also statistically significant factors across the lung cohort, and further investigation to understand their impact is needed.

Limitations

There are notable limitations associated with the use of administrative and claims data, including the unavoidable time lapse between data collection, curation and linkage by SEER and Medicare administrators and later analysis and publication by investigators. We believe that study design utilizing demographic and clinical variables such as those in this work remain relevant despite data aging.

An additional limitation of the analysis related to unavailability of complete disease staging data. Though stage IV/metastatic disease was excluded from this study, escalating stage of disease has been implicated in increasing the risk of unplanned hospitalization in this population in other studies (Hassett, O'Malley, Pakes, Newhouse, & Earle, 2006; Hassett et al., 2011; Nurgalieva et al., 2009). Stage was unable to be retained in this analysis as in approximately 30% of the cases examined, SEER staging value at diagnosis was entered by the local registry as "Unknown" (not "missing"). The proportion of cases where the diagnostic stage was coded as "Unknown" was significantly higher in the Non-Hospitalized groups ($X^2 = 25.82, 1, p < .0001$). Most cancer registries reside within a hospital setting where direct access to documents verifying the staging work up are available, providing a possible explanation for the higher rate of SEER diagnostic classification among those patients in the Hospitalized group.

This study was not designed to examine the relationship of time on or how specific regimens or intervals of chemotherapy treatment influenced unplanned hospitalizations, and we hope to undertake this more complex, but more informative type of analysis in future work. In addition, more advanced exploration of financial factors, such as cost-to-charge ratios, and

direct vs. indirect costs should be included in next steps to more fully describe the impact of these potentially avoidable hospitalizations on both the health care system and the patient.

Implications for Nursing

The availability of a National Cancer Institute managed, large-scale dataset such as SEER-Medicare offers many advantages for nursing inquiry, though claims data are limited by nature, and do not offer the same opportunities to capture factors critical to clinical outcomes such as performance or psychosocial status, nor inform subtleties of the clinical situation that would be available in the narrative or other clinician documentation in an electronic health record. Until more robust, integrated and easily accessible data sources become available to the research community, this study provides a first step towards the identification of patients at elevated risk of unplanned hospitalizations. The ability to recognize high-risk individuals prior to treatment initiation shifts nursing care from a reactive paradigm to one where additional proactive, tailored nursing education, supportive care and monitoring may enable more patients to remain on potentially curative therapies without experiencing toxicity-related interruptions. Future work including additional clinical variables such as performance status, chemotherapy timing, dosing and relationship to symptom incidence and management is needed.

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Knowledge Translation

- Large datasets such as SEER-Medicare offer the opportunity to study patterns of care at the population level outside of traditional clinical trials data, though variables key to nursing inquiry, such as patient performance status and symptom incidence and severity are lacking in claims data.
- More research is needed to understand the impact of specific comorbidities on patterns of adverse events among older adults receiving chemotherapy.
- Further work is needed to identify socioeconomic variables in administrative and claims data that are meaningful at the population level to reveal patterns of risk and potential health care disparities.

FIGURE 1.
Study Cohort Design.

FIGURE 2.
Study Observation Periods.

FIGURE 3.
Formation of the Lung Cancer Cohort.

TABLE 1

Cohort Characteristics

Characteristic	Hospitalized (n = 1479)			Non-hospitalized (n = 978)		
	M	SD	Range	M	SD	Range
Age at diagnosis (yrs)	76.2	5.0	66–92	77.5	5.1	66–95
Education ^a	19.6	12.9	0.8–77	18.5	12.3	0–69.9
	n	%		n	%	
Sex (female)	656	44.4		468	47.9	
Comorbidity score ^b						
0	1149	77.7		443	45.3	
1	149	10.1		323	33.0	
2	86	5.8		135	13.8	
3	95	6.4		77	7.9	
Range (pre-recode)			0–7			0–9
Married (yes)	799	54.0		510	52.2	
Urbanization						
Big metro	823	55.65		483	49.44	
Metro/urban	486	32.86		408	41.76	
Less urban/rural	170	11.49		86	8.8	
SEER Registry Region						
New Jersey	268	18.1		125	12.8	
West ^c	487	32.9		407	41.6	
South ^d	370	25.0		217	22.2	
Mid/Northeast ^e	354	23.9		229	23.4	
Race (White)	1320	89.3		905	92.5	
Income ^f	44661.5		8324–200008	44434		7–200008
Disease stage						
0	234	15.8		143	14.6	
I	108	7.3		57	5.8	

Characteristic	Hospitalized (n = 1479)			Non-hospitalized (n = 978)		
	M	SD	Range	M	SD	Range
II	895	60.5		549	56.1	
III	242	16.4		229	23.4	
Unknown [§]	234	15.8		143	14.6	
Radiation treatment						
External beam	718	50.2		484	51.7	
None [†]	711	49.8		453	48.3	
Chemotherapy						
Platin	1283	86.8		805	82.3	
Taxane	943	63.8		537	54.9	
Gemcitabine	417	28.2		195	19.9	
Pemetrexed	320	21.6		135	13.8	
Topoisomerases	369	25.0		241	24.6	
Monoclonal	209	14.1		134	13.7	
Antibodies						
Vinca Alkaloids	138	9.3		69	7.1	

Note. MAb = monoclonal antibodies.

^{II} Census tract percentage of non-high school graduates.

^{III} Percentages based on column totals.

[§] NCI Combined Index.

[†] California, Hawaii, Seattle.

^{*} Kentucky, Louisiana, Georgia.

[†] Michigan, Connecticut, Iowa, New Mexico, Utah.

[§] Census tract median income.

[†] Not missing.

[†] Includes refused.

Patients generally received more than one drug class during the study period.

TABLE 2

Initial Unplanned Hospitalization in Lung Cancer Treatment: GEE Prediction Models

Variable		Bivariate ^α			Multivariate [□] ‡		
		OR	95% CI	p	OR	95% CI	p
Sex	Female	0.87	[0.75, 1.01]	0.0598			
	Male	1					
Age (year)		0.95	[0.94, 0.97]	<.0001	0.95	[0.94, 0.97]	<.0001
		1.48	[1.07, 2.06]	0.0182	1.59	[1.14, 2.22]	0.0066
Race	Non-white						
	White	1					
Education (%) [†]	Non high school graduates	1.05	[1.03, 1.07]	<.0001	1.10	[1.03, 1.17]	0.0068
	High school graduates	1					
Income (Median) [†]		1.02	[0.96, 1.07]	0.5369	1.08	[1.01, 1.16]	0.0200
Urbanization	Big metro	0.86	[0.58, 1.28]	0.4634	0.77	[0.51, 1.17]	0.2234
	Metro/urban	0.60	[0.46, 0.78]	0.0001	0.59	[0.43, 0.82]	0.0015
Comorbidity [*]	Less urban/rural	1					
	0	1					
	1	0.18	[0.15, 0.22]	<.0001	0.18	[0.15, 0.21]	<.0001
	2	0.25	[0.17, 0.35]	<.0001	0.24	[0.16, 0.35]	<.0001
	3+	0.46	[0.34, 0.66]	<.0001	0.45	[0.32, 0.65]	<.0001
Radiation therapy	Yes	0.95	[0.85, 1.05]	0.3127	0.89	[0.79, 1.01]	0.0691
	No	1					
Marital status	Married	0.93	[0.76, 1.13]	0.4484			
	Not Married	1					

Note. N= 1479. CI = confidence interval; GEE = generalized estimating equations; HS = high school; Mdn = median; NCI = National Cancer Institute; OR = odds ratio; QIC = quasi-likelihood under independence model.

^α Unadjusted models.

[□] Adjusted model.

[‡] QIC = 2849.6012.

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7/ Census tract data.
* NCI Combined Index.

TABLE 3

Number of Unplanned Hospitalizations in Lung Cancer: GEE Prediction Models

Predictor	Unadjusted (bivariate) models			Adjusted (multivariate) model ^{1†}		
	Multiplier	95% CI	P	Multiplier	95% CI	p
Sex						
Female	1.02	[0.95, 1.11]	0.5321			
Male	1					
Age (years)	0.99	[0.98, 1.00]	0.1997			
Race						
Non-white	1.09	[1.00, 1.17]	0.0337	1.08	[1.00, 1.15]	0.0420
White	1					
Education (%) [□]						
Non high school graduates	1.01	[0.99, 1.02]	0.1776	0.99	[0.99, 1.01]	0.8199
High school graduates	1					
Income (Median) [□]	0.99	[0.98, 1.01]	0.3691	0.99	[0.97, 1.02]	0.9443
Urbanization [‡]						
Big metro	0.93	[0.85, 1.02]	0.1570	0.93	[0.82, 1.06]	0.2832
Metro/urban	0.90	[0.86, 0.95]	0.0001	0.90	[0.83, 0.98]	0.0122
Less urban/rural	1					
Comorbidity [‡]						
0	1					
1	1.15	[1.07, 1.24]	0.0003	1.15	[1.07, 1.24]	0.0002
2	1.01	[0.98, 1.04]	0.4666	1.01	[0.97, 1.04]	0.6757
3+	0.96	[0.92, 1.01]	0.1446	0.96	[0.92, 1.01]	0.1309
Radiation therapy						
Yes	1.04	[1.02, 1.07]	0.0002	1.04	[1.00, 1.07]	0.0170
No	1					
Marital status						
Married	1.00	[0.96, 1.04]	0.9768			
Not Married	1					

Note. $N = 1,479$ (2,257 hospitalizations, range 1-9, $M = 1.53$, $SD = 0.92$). Outcome was a count variable. CI = confidence interval; GEE = generalized estimating equations; HS = high school; NCI = National Cancer Institute; QIC = quasi-likelihood under independence model.

¹QIC = 4527.8075.

[□]Census tract data.

[‡]NCI Combined Index.