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Racial and geographic disparities in the patterns of care and costs at the end of life for patients with lung cancer in 2007–2010 after the 2006 introduction of bevacizumab

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ABSTRACT

Objectives: To examine racial/ethnic and geographical disparities in cancer care and costs during the last 6 months of life for lung cancer decedents after the Food and Drug Administration's approval of expensive bevacizumab in October 2006.
Methods: We identified 37,393 cases from the Surveillance, Epidemiology and End Results (SEER) cancer registries and Medicare linked databases who were diagnosed with non-small cell lung cancer of all stages in 1991–2009 and died between July 2007 and December 2010.
Results: Overall, the proportion of patients receiving chemotherapy/targeted therapy (31.0%), bevacizumab (4.6%), growth factors (16.0%), surgery (2.8%), and hospice care (60.9) in the last 6 months of life was higher in whites than in other ethnic populations. Hospitalization rate was higher in blacks (83.2%) than in whites (76.0%) and others (78.0%). Those from metro areas had slightly higher percentages of receiving chemotherapy/targeted therapy, bevacizumab, growth factors, and hospice care, but had a higher hospitalization rate and lower emergency care visit. Mean total health care cost was $42,749 for the last 6 months of life in patients with lung cancer. Adjusted mean health care cost in the last 6 months of life was significantly higher in blacks or other ethnic population as compared to whites.
Conclusion: There were substantial racial/ethnic and geographic disparities in the types of cancer care and costs in the last 6 months of life among lung cancer decedents, regardless of the length of survival times and hospice care status. A clinical guideline may help the appropriate use of costly treatment modalities and minimize racial/geographic disparities.

1. Introduction

Over the past few years, there have been some research reports and debates about overuse of curative therapies and high costs at the end of life care for patients with terminal cancer [1–5]. For example, Emanuel and colleagues reported that 33% of cancer decedents received chemotherapy in the last 6 months of life and 23% did so in the last 3 months in Massachusetts and California [1]. The overuse of curative therapies at the end of life care was also reported in other areas of the United States [6–17] and in other countries as well [18–25]. Warren and colleagues [9] recently compared the end of life care for lung cancer patients between the United States and Canada and concluded that the use of hospital and emergency services were significantly higher in Ontario, Canada. They examined the rates of patients with emergency service visits and hospital admissions and inpatient mortality rate among those hospitalized patients in a large cohort of patients with lung cancer who died at age 65 or older during 1999–2003. One reason for overuse of chemotherapy or other cancer care services at the end of life may be that patients' families wanted to have these medical services regardless of their effectiveness or costs [17,18]. There are calls for stopping overtreatment at the end of life and for cutting cancer costs in the U.S. [26]. There also have been studies on the quality indicators [6,22,27] and some guidelines have been developed for cancer end-of-life care [26,27] in order to help the

Abbreviations: AJCC, American Joint Committee on cancer; CPT, common procedure terminology; FDA, food and drug administration; GLM, generalized linear model; HMO, health maintenance organization; ICD-9-CM, international classification of diseases, 9th revision, clinical modification; SEER, surveillance; SES, socioeconomic status; US, United States.

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care providers, patients and their families make informed decisions and minimize the inconsistencies. Because a new and expensive (that can cost $100,000 per year [28]) antibody, bevacizumab, was approved by the Food and Drug Administration (FDA) for treating patients with lung cancer in October 2006 [29,30], it would be important to know how this costly medication was used towards the end of life care in the U.S. Hence, we undertook this study to examine whether racial/ethnic and geographical disparities exist in cancer care and costs following the introduction of bevacizumab during the last 6 months of life for patients with lung cancer who died between July 2007 and December 2010.

2. Materials and methods

2.1. Data sources

The National Cancer Institute's Surveillance, Epidemiology and End Results (SEER) cancer registries and Medicare linked databases were used for this retrospective cohort study [31–33]. SEER program, supported by the National Cancer Institute, includes population-based tumor registries in selected geographic areas: San Francisco/Oakland, Detroit, Seattle, Atlanta, Rural Georgia, Los Angeles county, the San Jose-Monterey area, and the rest of California; and the states of Connecticut, Iowa, New Mexico, Utah, Hawaii, Kentucky, Louisianan and New Jersey. Medicare Program is administered by the Center for Medicare and Medicaid Services, and covers hospital, physician and other medical services for >97% of persons aged ≥65 years. The Committee for the Protection of Human Subjects at the University of Texas Health Science Center approved this study.

2.2. Study population

The study aimed to identify patients with lung cancer at all stages who died between July 2007 and December 2010 to allow assessment of the end of life care in the last 6 months after the FDA's October 2006 approval of bevacizumab for treating lung cancer. Hence, we identified 41,789 patients who were diagnosed with non-small cell lung cancer of all stages from January 1991 to December 2009 and died between July 2007 and December 2010. The study population inclusion and exclusion flowchart was shown in Appendix-Fig. A majority (85%) of patients were diagnosed in 2006–2009 and a small proportion of patients were diagnosed before 2001 and died between July 2007 and December 2010. Additional 1364 cases that were ascertained from autopsy or death certificate were excluded. To ensure complete information on health care utilization during the last six months of life, cases were included if they were continuously enrolled in Medicare part-A and part-B and were excluded if they were enrolled in a health maintenance organization during the last six months of life ($n = 2968$), leaving 37,457 cases in the final analytical file. The date of death was available from the Medicare enrolment data files, but because the SEER data only provided the month and year of cancer diagnosis, the 15th of each month is arbitrarily chosen as the day of diagnosis. As a result, 64 patients for whom date of death was more than 15 days earlier than the date of diagnosis were excluded. Of the remaining 37,393 cases, 37,387 cases were available for geographic disparity analysis by excluding 6 cases with missing information on geographic areas and 37,363 cases were available for racial disparity analysis by excluding 30 cases with unknown race/ethnicity.

2.3. Study variables

The main exposure variables for the study were race and geographic location. Race was categorized as whites, blacks and others. Geographic location variable in SEER-Medicare database was obtained from the Area Resource File (ARF) from the Bureau of Health Professions of the Department of Health and Human Services [34], was categorized "Big Metro"-metro area counties of 1 million populations or more; "Metro"-metro area counties of less than 1 million populations; "Urban"-urban population of 20,000 or more; "Less Urban"-urban population of 2500–19,999; "Rural"-urban population of less than 2500; and "Unknown"-missing value. In this study, we recoded them into metropolitan area (big metro or metro), urban area and less urban/rural area, and excluded 6 cases with missing value.

The outcome variables included the receipt of chemotherapy/targeted biologic, bevacizumab, radiation, growth factors, surgery, hospitalization and mean number of hospitalization, emergency department care, hospice care, and costs during the last six months before death. Procedure and revenue center codes were used to identify chemotherapy/targeted biologic, bevacizumab, radiation, growth factors, and surgery (see Appendix-Table) [35–38]. Hospitalization, emergency care and hospice use was defined if they initiated at least one inpatient admission or hospice admission during the last six months of life, respectively.

Total health care costs were defined as the sum of amount in dollars paid by the Medicare program for inpatient services, outpatient services, physician services, skilled nursing facility, hospice, and durable medical equipment for each patient for last six months of life, rather than the amount charged by the care providers. Costs were adjusted for geographical location and inflation using county level price adjusters developed by Brown and colleagues [39] because the study included patients across various regions in the U.S. Price adjusters were matched with the patient's county at diagnosis allowing cost adjustment to the 2009 U.S. dollars. Further inflation adjustment to the 2014 U.S. dollars was conducted using the medical care component of the consumer price index [39].

The weighted comorbidity scores from the 18 non-cancer conditions were generated from above Medicare claims in the last 6 months of care. The method was similar to what was reported before [40] . Other variables included age, gender, marital status, American Joint Committee on Cancer (AJCC) stage, historic stage, tumor grade, tumor size, number of positive nodes, SEER areas, year of diagnosis, and socioeconomic status (SES). SES was defined by using the percent of persons living below the poverty line at the census tract level from the 1990 census for cases in 1992–1999 and from the 2000 census for cases in 2000–2009, which were then classified into quartiles for SES.

2.4. Statistical analysis

Descriptive statistics were performed to compare the distribution of patient socio-demographic and tumor characteristics among racial/ethnic groups and geographic location categories. Multiple logistic regression analysis was conducted for each of the outcomes with race and geographic location as the primary independent variables, while adjusting for other socio-demographic and tumor characteristics. These analyses were stratified by the survival times (who survived at least six months after diagnosis and who died within six months of diagnosis) and by hospice care status (who received hospice care and who did not receive hospice care in the last six months). Generalized linear models (GLMs) were used to estimate the total health care cost using log link and gamma distribution, which are often used with cost data [41–43]. GLMs account for heteroscedasticity and skewness that usually occur with cost data [41]. The primary variables of interest for cost analyses were receipt of chemotherapy/targeted biologic, bevacizumab, radiation, growth factors, surgery, hospitalization and hospice care. Separate GLMs were estimated for patients who survived at least six months and who died within six months of diagnosis. All analyses were

Table 1
Distribution of socio-demographicand tumor characteristics by race/ethnicity and geographic location.

Characteristics	Number (column %) by Race				Number (column %) by Urban/rural			
	Whites N = 31,723	Blacks N = 3,245	Others N = 2,395	P-value	Less urban N = 4,650	Urban N = 2,479	Metro N = 30,258	P-value
Age (years)				<.001				<.001
65–69	6,478 (20.4)	911 (28.1)	442 (18.5)		1,225 (26.3)	553 (22.3)	6,054 (20.0)	
70–74	7,604 (24.0)	812 (25.0)	537 (22.4)		1,258 (27.1)	625 (25.2)	7,074 (23.4)	
75–79	7,391 (23.3)	710 (21.9)	569 (23.8)		1,002 (21.6)	595 (24.0)	7,078 (23.4)	
80+	10,250 (32.3)	812 (25.0)	847 (35.4)		1,165 (25.1)	706 (28.5)	10,052 (33.2)	
Gender				<.001				<.001
Male	16,329 (51.5)	1,761 (54.3)	1,416 (59.1)		2,766 (59.5)	1,333 (53.8)	15,416 (51.0)	
Female	15,394 (48.5)	1,484 (45.7)	979 (40.9)		1,884 (40.5)	1,146 (46.2)	14,842 (49.1)	
Marital status				<.001				<.001
Married	15,508 (48.9)	1,017 (31.3)	1,334 (55.7)		2,411 (51.9)	1,233 (49.7)	14,225 (47.0)	
Unmarried	15,111 (47.6)	2,083 (64.2)	992 (41.4)		2,075 (44.6)	1,175 (47.4)	14,954 (49.4)	
Unknown	1,104 (3.5)	145 (4.5)	69 (2.9)		164 (3.5)	71 (2.9)	1,079 (3.6)	
SES (poverty)				<.001				<.001
1st (Low SES)	6,364 (20.1)	1,925 (59.3)	799 (33.4)		2,393 (51.5)	906 (36.6)	5,795 (19.2)	
2nd	8,060 (25.4)	682 (21.0)	601 (25.1)		1,490 (32.0)	840 (33.9)	7,026 (23.2)	
3rd	8,365 (26.4)	409 (12.6)	540 (22.6)		671 (14.4)	488 (19.7)	8,165 (27.0)	
4th (High SES)	8,742 (27.6)	212 (6.5)	426 (17.8)		57 (1.2)	230 (9.3)	9,093 (30.1)	
Unknown	192 (0.6)	17 (0.5)	29 (1.2)		39 (0.8)	15 (0.6)	179 (0.6)	
Tumor AJCC stage				<.001				<.001
Stage I	5,258 (16.6)	448 (13.8)	317 (13.2)		723 (15.6)	380 (15.3)	4,927 (16.3)	
Stage II	1,247 (3.9)	106 (3.3)	76 (3.2)		198 (4.3)	116 (4.7)	1,115 (3.7)	
Stage III	7,213 (22.7)	843 (26.0)	556 (23.2)		1,098 (23.6)	582 (23.5)	6,935 (22.9)	
Stage IV	12,062 (38)	1,322 (40.7)	956 (39.9)		1,735 (37.3)	907 (36.6)	11,709 (38.7)	
Stage occult	462 (1.5)	44 (1.4)	21 (0.9)		93 (2.0)	43 (1.7)	389 (1.3)	
Unknown/missing	5,481 (17.3)	482 (14.9)	469 (19.6)		803 (17.3)	451 (18.2)	5,183 (17.1)	
Historic stage				<.001				0.495
Localized	6,124 (19.3)	527 (16.2)	362 (15.1)		868 (18.7)	465 (18.8)	5,685 (18.8)	
Regional	7,580 (23.9)	770 (23.7)	474 (19.8)		1,115 (24)	602 (24.3)	7,108 (23.5)	
Distant	15,739 (49.6)	1,752 (54)	1,374 (57.4)		2,310 (49.7)	1,226 (49.5)	15,343 (50.7)	
Unstaged/missing	2,280 (7.2)	196 (6.0)	185 (7.7)		357 (7.7)	186 (7.5)	2,122 (7.0)	
Tumor grade				0.002				0.062
Well/Moderately differentiated	5,949 (18.8)	543 (16.7)	423 (17.7)		788 (17.0)	456 (18.4)	5,672 (18.8)	
Poorly/un differentiated	8,401 (26.5)	824 (25.4)	600 (25.1)		1,249 (26.9)	663 (26.7)	7,920 (26.2)	
Unknown/missing	17,373 (54.8)	1,878 (57.9)	1,372 (57.3)		2,613 (56.2)	1,360 (54.9)	16,666 (55.1)	
Tumor size, cm				<.001				0.053
<2.0	2,768 (8.7)	228 (7.0)	143 (6.0)		363 (7.8)	201 (8.1)	2,577 (8.5)	
2.0–<4.0	7,963 (25.1)	704 (21.7)	553 (23.1)		1,112 (23.9)	608 (24.5)	7,506 (24.8)	
4+	10,568 (33.3)	1,274 (39.3)	804 (33.6)		1,673 (36.0)	847 (34.2)	10,134 (33.5)	
Unknown	10,424 (32.9)	1,039 (32)	895 (37.4)		1,502 (32.3)	823 (33.2)	10,041 (33.2)	
Number of positive nodes				<.001				0.027
0	4,149 (13.1)	261 (8.0)	250 (10.4)		514 (11.1)	293 (11.8)	3,855 (12.7)	
1–9	1,942 (6.1)	153 (4.7)	159 (6.6)		279 (6.0)	137 (5.5)	1,838 (6.1)	
10–51	873 (2.8)	88 (2.7)	68 (2.8)		122 (2.6)	65 (2.6)	842 (2.8)	
Unknown	24,759 (78.1)	2,743 (84.5)	1,918 (80.1)		3,735 (80.3)	1,984 (80.0)	23,723 (78.4)	
SEER areas				<.001				<.001
Mid West	4,303 (13.6)	604 (18.6)	48 (2.0)		857 (18.4)	319 (12.9)	3,783 (12.5)	
North East	6,740 (21.3)	611 (18.8)	167 (7.0)		0 (0)	251 (10.1)	7,267 (24.0)	
South	9,095 (28.7)	1,344 (41.4)	74 (3.1)		3,108 (66.8)	927 (37.4)	6,485 (21.4)	
West	11,585 (36.5)	686 (21.1)	2,106 (87.9)		685 (14.7)	982 (39.6)	12,723 (42.1)	
Year of diagnosis				<.001				<.001
1991–1995	241 (0.8)	17 (0.5)	15 (0.6)		19 (0.4)	12 (0.5)	242 (0.8)	
1996–2000	799 (2.5)	55 (1.7)	56 (2.3)		64 (1.4)	50 (2.0)	796 (2.6)	
2001–2005	3,714 (11.7)	305 (9.4)	284 (11.9)		463 (10)	281 (11.3)	3,564 (11.8)	
2006–2009	26,969 (85.0)	2,868 (88.4)	2,040 (85.2)		4,104 (88.3)	2,136 (86.2)	25,656 (84.8)	

conducted using SAS version 9.2 and significance was assessed at α level of 0.05.

3. Results

Table 1 presents the distribution of socio-demographic and tumor characteristics by race/ethnicity and geographical locations. There were some differences in these socio-demographic and tumor characteristics by race/ethnicity and geographical locations. For example, compared to white and other ethnic population, black patients with lung cancer had higher proportions of younger, unmarried, low socioeconomic status, and stages III-IV cases. Patients from less urban areas were a little younger than those from metro areas and were more likely to have low socioeconomic status. The distribution of tumor characteristics was similar among those form different geographic locations.

Table 2 presents the frequencies of patients receiving various types of cancer care in the last 6 months before death by race/ethnicity and geographical locations. These analyses were also stratified by the length of survival times (i.e., those who survived

Table 2
Receipt of cancer care in the last 6 months by race/ethnicity and geographic location.

	Number (%) of patients receiving cancer care, stratified by length of survival times and hospice use							
	Race				Urban/rural			
Types of cancer care[b]	Whites	Blacks	Others	*P*-value	Less urban/rural	Urban	Metro	*P*-value
	Overall							
	N = 31,723[a]	*N* = 3,245	*N* = 2,395		*N* = 4,650[a]	*N* = 2,479	*N* = 30,258	
Chemotherapy/targeted therapy	9,824 (31.0)	905 (27.9)	670 (28.0)	<.001	1,325 (28.5)	745 (30.1)	9,336 (30.9)	0.004
Bevacizumab	1,466 (4.6)	98 (3.0)	82 (3.4)	<.001	180 (3.9)	88 (3.6)	1,380 (4.6)	0.010
Radiation	8,756 (27.6)	897 (27.6)	589 (24.6)	0.006	1,222 (26.3)	675 (27.2)	8,351 (27.6)	0.168
Growth Factor	5,088 (16.0)	448 (13.8)	328 (13.7)	<.001	681 (14.7)	374 (15.1)	4,812 (15.9)	0.062
Surgery	881 (2.8)	56 (1.73)	57 (2.38)	0.001	135 (2.9)	65 (2.6)	795 (2.6)	0.549
Hospitalization	24,118 (76.0)	2,699 (83.2)	1,868 (78.0)	<.001	3,482 (74.9)	1,785 (72.0)	23,434 (77.5)	<.001
Mean (SD number of hospitalizations)[c]	2.34 (1.6)	2.68 (1.9)	2.35 (1.7)		2.46 (1.8)	2.27 (1.5)	2.36 (1.7)	
Emergency department care	10,667 (33.6)	1,185 (36.5)	732 (30.6)	<.001	2,203 (47.4)	1,013 (40.8)	9,377 (31.0)	<.001
Hospice	19,304 (60.9)	1,730 (53.3)	1,139 (47.6)	<.001	2,694 (57.9)	1,384 (55.8)	18,105 (59.8)	<.001
	Survived more than 6 months							
	N = 18,061	*N* = 1766	*N* = 1356		*N* = 2,569	*N* = 1,384	*N* = 17,242	
Chemotherapy/targeted therapy	6,844 (37.9)	632 (35.8)	491 (36.2)	0.119	910 (35.4)	508 (36.7)	6,553 (38)	0.032
Bevacizumab	1,082 (6.0)	79 (4.5)	66 (4.9)	0.011	136 (5.3)	64 (4.6)	1,029 (6.0)	0.061
Radiation	4,438 (24.6)	439 (24.9)	297 (21.9)	0.079	596 (23.2)	352 (25.4)	4,229 (24.5)	0.229
Growth Factor	3,817 (21.1)	348 (19.7)	255 (18.8)	0.058	510 (19.9)	281 (20.3)	3,631 (21.1)	0.324
Surgery	244 (1.4)	16 (0.9)	16 (1.2)	0.266	31 (1.2)	22 (1.6)	224 (1.3)	0.587
Hospitalization	12,656 (70.1)	1,390 (78.7)	959 (70.7)	<.001	1,754 (68.3)	919 (66.4)	12,339 (71.6)	<.001
Mean (SD number of hospitalizations)[c]	2.53 (1.8)	2.89 (2.1)	2.48 (1.8)		2.67 (1.9)	2.42 (1.7)	2.56 (1.8)	
Emergency department care	6,748 (37.4)	730 (41.3)	467 (34.4)	<.001	1,318 (51.3)	605 (43.7)	1,318 (34.9)	<.001
Hospice	11,351 (62.9)	994 (56.3)	668 (49.3)	<.001	1,552 (60.4)	799 (57.7)	10,667 (61.9)	0.005
	Survived less than 6 months							
	N = 13,662	*N* = 1,479	*N* = 1,039		*N* = 2,081	*N* = 1,095	*N* = 13,016	
Chemotherapy/targeted therapy	2,980 (21.8)	273 (18.5)	179 (17.2)	<.001	415 (19.9)	237 (21.6)	2,783 (21.4)	0.308
Bevacizumab	384 (2.8)	19 (1.3)	16 (1.5)	0.000	44 (2.1)	24 (2.2)	351 (2.7)	0.208
Radiation	4,318 (31.6)	458 (31.0)	292 (28.1)	0.061	626 (30.1)	323 (29.5)	4,122 (31.7)	0.142
Growth Factor	1271 (9.3)	100 (6.8)	73 (7.0)	0.000	171 (8.2)	93 (8.5)	1,181 (9.1)	0.389
Surgery	637 (4.7)	40 (2.7)	41 (4.0)	0.002	104 (5.0)	43 (3.9)	571 (4.4)	0.318
Hospitalization	11,462 (83.9)	1309 (88.5)	909 (87.5)	<.001	1,728 (83)	866 (79.1)	11,095 (85.2)	<.001
Mean (SD number of hospitalizations)[c]	2.12 (1.4)	2.46 (1.7)	2.21 (1.5)		2.25 (1.5)	2.11 (1.1)	2.15 (1.5)	
Emergency department care	3,919 (28.7)	455 (30.8)	265 (25.5)	.016	885 (42.5)	408 (37.3)	3,349 (25.7)	<.001
Hospice	7,953 (58.2)	736 (49.8)	471 (45.3)	<.001	1,142 (54.9)	585 (53.4)	7,438 (57.2)	0.014
	No hospice use							
	N = 12,419	*N* = 1,515	*N* = 1,256		*N* = 1,956	*N* = 1,095	*N* = 12,153	
Chemotherapy/targeted therapy	3,834 (30.9)	409 (27.0)	355 (28.3)	0.002	551 (28.2)	330 (30.1)	3,722 (30.6)	0.090
Bevacizumab	582 (4.7)	46 (3.0)	47 (3.7)	0.006	85 (4.4)	35 (3.2)	557 (4.6)	0.100
Radiation	3,260 (26.3)	406 (26.8)	307 (24.4)	0.318	481 (24.6)	296 (27.0)	3,199 (26.3)	0.213
Growth Factor	2,006 (16.2)	206 (13.6)	174 (13.9)	0.006	275 (14.1)	159 (14.5)	1,954 (16.1)	0.040
Surgery	630 (5.1)	43 (2.8)	41 (3.3)	<.001	105 (5.4)	46 (4.2)	564 (4.6)	0.266
Hospitalization	10,589 (85.3)	1,315 (86.8)	1,052 (83.8)	0.078	1,648 (84.3)	885 (80.8)	10,436 (85.9)	<.001
Mean (SD number of hospitalizations)[c]	2.53 (1.8)	2.93 (2.1)	2.52 (1.8)		2.74 (1.9)	2.44 (1.6)	2.56 (1.8)	
Emergency department care	4,320 (34.8)	551 (36.4)	360 (28.7)	<.001	982 (50.2)	498 (45.5)	3,757 (30.9)	<.001
	Hospice use							
	N = 19,304	*N* = 1,730	*N* = 1,139		*N* = 2,694	*N* = 1,384	*N* = 18,105	
Chemotherapy/targeted therapy	5,990 (31)	496 (28.7)	315 (27.7)	0.010	774 (28.7)	415 (30.0)	5,614 (31)	0.049
Bevacizumab	884 (4.6)	52 (3.0)	35 (3.1)	0.001	95 (3.5)	53 (3.8)	823 (4.6)	0.032
Radiation	5,496 (28.5)	491 (28.4)	282 (24.8)	0.026	741 (27.5)	379 (27.4)	5,152 (28.5)	0.445
Growth Factor	3,082 (16.0)	242 (14.0)	154 (13.5)	0.011	406 (15.1)	215 (15.5)	2,858 (15.8)	0.628
Surgery	251 (1.3)	13 (0.8)	16 (1.4)	0.133	30 (1.1)	19 (1.4)	231 (1.3)	0.726
Hospitalization	13,529 (70.1)	1,384 (80.0)	816 (71.6)	<.001	1,834 (68.1)	900 (65)	12,998 (71.8)	<.001
Mean (SD number of hospitalizations)[c]	2.18 (1.5)	2.45 (1.8)	2.13 (1.5)		2.22 (1.5)	2.11 (1.4)	2.21 (1.6)	
Emergency department care	6,347 (32.9)	634 (36.7)	372 (32.7)	.006	1,221 (45.3)	515 (37.2)	5,620 (31.0)	<.001

[a] Of 37,457 cases in the final analytical file, 64 patients for whom date of death was more than 15 days earlier than the date of diagnosis were excluded. Of the remaining 37,393 cases, 37,387 cases were available for geographic disparity analysis by excluding 6 cases with missing information on geographic areas and 37,363 cases were available for racial disparity analysis by excluding 30 cases with unknown race/ethnicity.
[b] Patients may have received more than one of treatment modalities or care.
[c] Mean (SD): mean (standard deviation) number of hospitalizations.

more than 6 months versus those who survived less than 6 months after the diagnosis) and hospice use (i.e., those who received hospice care versus those who did not in the last 6 months). Overall, the proportion of patients receiving chemotherapy/targeted therapy (31.0%), bevacizumab (4.6%), growth factors (16.0%), surgery (2.8%), and hospice care (60.9) in the last 6 months of life was higher in whites than in other ethnic populations. Hospitalization rate was higher in blacks (83.2%) than in whites (76.0%) and others (78.0%). The mean number of hospitalization and emergency department care were also higher in blacks. These patterns by race/ethnicity were similar in analyses stratified by the length of survival times and by hospice care status. In terms of geographic variation, those from metro areas had slightly higher percentages of receiving chemotherapy/targeted therapy, bevacizumab, growth factors, and hospice care. Although they had a higher overall hospitalization rate, they had lower mean numbers of hospitalizations

Table 3
Adjusted odd ratios of receiving cancer cares by race and geographic location.

Race and geographic location	Odds ratio (95% CI)[a] of receiving cancer cares by race and geographic location						
	Chemotherapy/targeted therapy	Bevacizumab	Radiation	Growth Factor	Surgery	Hospitalization	Hospice
Race (whites as reference) for all cases							
Blacks	0.86 (0.79–0.94)**	0.73 (0.59–0.91)**	0.97 (0.88–1.06)	0.88 (0.78–0.98)*	0.77 (0.57–1.04)	1.32 (1.17–1.49)**	0.75 (0.69–0.81)**
Others	0.87 (0.79–0.97)**	0.64 (0.51–0.81)**	0.95 (0.85–1.05)	0.83 (0.73–0.95)**	0.94 (0.69–1.27)	1.41 (1.24–1.59)**	0.67 (0.61–0.73)**
Urban/rural (Less urban/rural as reference) for all cases							
Urban	1.10 (0.98–1.24)	0.86 (0.66–1.12)	1.12 (1.00–1.26)*	1.01 (0.88–1.17)	0.95 (0.69–1.33)	0.85 (0.74–0.96)*	1.02 (0.92–1.13)
Metro	1.13 (1.04–1.23)**	1.07 (0.89–1.28)	1.13 (1.04–1.23)**	1.04 (0.94–1.15)	0.92 (0.73–1.16)	1.15 (1.05–1.27)**	1.31 (1.21–1.41)**
Race (whites as reference) for stage-I							
Blacks	1.06 (0.80–1.39)	1.53 (0.79–2.97)	0.95 (0.71–1.25)	1.03 (0.73–1.46)	0.81 (0.49–1.31)	1.43 (1.05–1.95)*	0.76 (0.62–0.94)**
Others	1.40 (1.04–1.89)*	0.89 (0.40–1.97)	1.04 (0.74–1.46)	1.15 (0.78–1.70)	0.85 (0.50–1.44)	1.54 (1.10–2.17)*	0.57 (0.44–0.74)**
Urban/rural (Less urban/rural as reference) for stage-I							
Urban	1.05 (0.75–1.47)	0.92 (0.33–2.59)	1.34 (0.96–1.85)	0.74 (0.46–1.17)	1.35 (0.81–2.24)	0.84 (0.61–1.17)	0.95 (0.73–1.24)
Metro	1.08 (0.85–1.37)	1.32 (0.65–2.68)	0.99 (0.78–1.26)	0.98 (0.73–1.33)	1.08 (0.74–1.31)	1.04 (0.83–1.32)	1.28 (1.07–1.53)**
Race (whites as reference) for stage-II							
Blacks	1.01 (0.64–1.61)	1.01 (0.29–3.55)	0.87 (0.53–1.43)	0.94 (0.50–1.76)	1.56 (0.66-3.70)	1.21 (0.64–2.27)	0.82 (0.53–1.28)
Others	1.06 (0.62–1.84)	0.67 (0.18–2.37)	0.78 (0.44–1.40)	0.95 (0.47–1.91)	0.84 (0.30–2.34)	1.66 (0.78–3.53)	0.36 (0.21–0.63)**
Urban/rural (Less urban/rural as reference) for stage-II							
Urban	1.03 (0.61–1.76)	0.36 (0.07–1.87)	1.14 (0.66–1.98)	0.95 (0.50–1.81)	0.21 (0.07–0.72)*	0.47 (0.24–0.88)	1.28 (0.78–2.12)
Metro	1.15 (0.78–1.71)	0.78 (0.30–2.06)	1.27 (0.85–1.90)	0.80 (0.50–1.29)	0.57 (0.29–1.09)	1.17 (0.71–0.88)*	1.67 (1.16–2.41)**
Race (whites as reference) for stage-III							
Blacks	0.83 (0.69–0.98)*	0.64 (0.40–1.04)	1.03 (0.87–1.23)	0.85 (0.69–1.06)	0.56 (0.30–1.08)	1.25 (0.99–1.58)	0.77 (0.66–0.91)**
Others	0.85 (0.69–1.04)	0.71 (0.44–1.12)	1.08 (0.88–1.34)	0.94 (0.74–1.20)	0.83 (0.45–1.52)	1.08 (0.84–1.39)	0.79 (0.65–0.95)*
Urban/rural (Less urban/rural as reference) for stage-III							
Urban	1.12 (0.89–1.41)	0.97 (0.55–1.70)	1.06 (0.84–1.33)	0.99 (0.82–1.21)	1.17 (0.60–2.26)	0.85 (0.64–1.12)	1.22 (0.99–1.51)
Metro	1.17 (0.99–1.37)	1.07 (0.72–1.60)	1.15 (0.98–1.36)	0.93 (0.70–1.22)	1.07 (0.67–1.70)	1.07 (0.88–1.31)	1.23 (1.05–1.43)**
Race (whites as reference) for stage-IV							
Blacks	0.78 (0.68–0.89)**	0.60 (0.44–0.82)**	0.96 (0.84–1.09)	0.82 (0.69–0.97)*	0.42 (0.17–1.01)	0.88 (0.71–1.10)	0.72 (0.64–0.82)**
Others	0.76 (0.65–0.88)**	0.54 (0.38–0.77)**	0.86 (0.74–1.00)*	0.72 (0.59–0.88)**	0.77 (0.36–1.62)	1.23 (1.05–1.44)**	0.69 (0.60–0.80)**
Urban/rural (Less urban/rural as reference) for stage-IV							
Urban	1.18 (0.98–1.41)	0.94 (0.66–1.34)	1.11 (0.93–1.32)	1.08 (0.93–1.26)	0.82 (0.34–1.99)	0.85 (0.74–0.96)*	0.87 (0.74–1.03)
Metro	1.13 (0.98–1.28)	1.07 (0.84–1.36)	1.16 (0.93–1.32)	1.14 (0.91–1.41)	0.94 (0.52–1.70)	1.15 (1.05–1.27)**	1.29 (1.14–1.46)**

[a] Adjusted for age, gender, percent below poverty, tumor stage, historic stage, tumor grade, tumor size, number of positive nodes, comorbidity score, SEER areas and year of diagnosis.
* $P < 0.05$.
** $P < 0.01$.

and lower proportions of having emergency department care than those from rural/less urban areas. The receipt of surgery and radiation therapy was similar across patients from different areas. Again, findings were similar in patients who survived more than 6 months versus those with less than 6 months and in patients who received hospice care versus those who did not.

Table 3 presents the multiple regression analyses on the odds ratios of receiving various types of cancer care by race/ethnicity and geographical locations while adjusting for all measured socio-demographic and tumor characteristics, stratified by tumor stage. After adjusting for age, gender, percent below poverty, tumor stage, historic stage, tumor grade, tumor size, number of positive nodes, comorbidity score, SEER areas and year of diagnosis, blacks or other ethnic populations were significantly less likely to receive chemotherapy/targeted therapy, bevacizumab, and hospice care, and more likely to be hospitalized in the last 6 months of life, but were not significantly different in receiving radiation and surgery, as compared to whites. The receipt of growth factor was significantly lower in other ethnic populations but was marginally but not significantly lower in blacks than in whites. Relative to those from rural or less urban areas, patients from metro areas were significantly more likely to receive chemotherapy/targeted therapy and radiation therapy, but were not significantly different in receiving bevacizumab, growth factor, surgery, hospice care and hospitalization, while those from urban areas were significantly more likely to receive hospitalization and hospice care after controlling for other socio-demographic and tumor factors. When these analyses were further stratified by the length of survival times and hospice use, the magnitudes and directions of the odds ratios were similar to the above overall non-stratified analyses, although the confidence intervals were wider due to smaller sample sizes (Table 4).

Table 5 presents the mean total health care costs together with 1st and 3rd quartiles of costs for the types of cancer care and by race/ethnicity and geographical locations. The mean total health care cost was $42,749 for the last 6 months of life in patients with lung cancer, with about $4000 more on average for those who survived beyond 6 months as compared to those who died within 6 months of diagnosis. The costs were higher for surgery, bevacizumab and, growth factor, which were followed by chemotherapy/targeted therapy, radiation therapy, hospitalization, emergency department care, and hospice care. The mean total health care costs were higher in black patients, followed by other ethnic and white patients; and were the highest in those patents from metro areas. After adjusting for other socio-demographic and tumor factors, the mean health care cost in the last 6 months of life was significantly higher in blacks or other ethnic population as compared to whites (Table 6), regardless of the length of survival times. Patients from metro areas also had significantly higher costs

Table 4
Multiple regression on odd ratios of receiving cancer cares, stratified by survival times and hospice use.

Race and geographic location	Odds Ratio (95% CI)[a] of receiving cancer cares by race and geographic location						
	Chemotherapy/targeted therapy	Bevacizumab	Radiation	Growth Factor	Surgery	Hospitalization	Hospice
	Survived more than 6 months						
Race							
Whites	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Blacks	0.85 (0.75–0.96)	0.82 (0.64–1.05)	1.00 (0.88–1.13)	0.88 (0.77–1.01)	0.75 (0.44–1.29)	1.39 (1.20–1.61)	0.76 (0.68–0.85)
Others	0.89 (0.78–1.02)	0.66 (0.51–0.87)	0.90 (0.78–1.04)	0.80 (0.69–0.94)	0.88 (0.51–1.51)	1.42 (1.22–1.65)	0.63 (0.56–0.71)
Urban/rural							
Less urban/rural	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Urban	1.08 (0.93–1.26)	0.80 (0.58–1.09)	1.18 (1.01–1.39)	1.02 (0.86–1.21)	1.30 (0.73–2.32)	0.87 (0.74–1.03)	1.01 (0.88–1.17)
Metro	1.18 (1.06–1.31)	1.01 (0.82–1.24)	1.13 (1.01–1.27)	1.06 (0.94–1.20)	1.02 (0.65–1.59)	1.18 (1.04–1.32)	1.33 (1.20–1.47)
	Survived less than 6 months						
Race							
Whites	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Blacks	0.80 (0.68–0.93)	0.48 (0.30–0.78)	0.91 (0.80–1.04)	0.78 (0.61–0.98)	0.81 (0.51–1.28)	1.28 (1.05–1.57)	0.71 (0.63–0.80)
Others	0.73 (0.61–0.88)	0.48 (0.28–0.80)	0.98 (0.84–1.15)	0.79 (0.61–1.03)	1.20 (0.75–1.93)	1.61 (1.29–2.01)	0.68 (0.59–0.78)
Urban/rural							
Less urban/rural	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Urban	1.18 (0.97–1.43)	1.09 (0.65–1.82)	1.05 (0.88–1.25)	1.05 (0.80–1.39)	0.84 (0.49–1.46)	0.77 (0.62–0.95)	1.04 (0.89–1.21)
Metro	1.12 (0.97–1.28)	1.31 (0.92–1.87)	1.13 (1.00–1.28)	1.02 (0.84–1.24)	0.94 (0.65–1.36)	1.14 (0.97–1.34)	1.30 (1.17–1.45)
	No hospice use						
Race							
Whites	Reference	Reference	Reference	Reference	Reference	Reference	NA
Blacks	0.82 (0.72–0.94)	0.74 (0.53–1.02)	0.99 (0.87–1.14)	0.84 (0.71–0.99)	0.68 (0.48–0.98)	1.02 (0.84–1.25)	NA
Others	0.90 (0.78–1.04)	0.73 (0.53–1.00)	1.01 (0.87–1.17)	0.85 (0.71–1.02)	0.78 (0.54–1.13)	1.14 (0.93–1.39)	NA
Urban/rural							
Less urban/rural	Reference	Reference	Reference	Reference	Reference	Reference	NA
Urban	1.12 (0.94–1.35)	0.65 (0.43–0.98)	1.17 (0.98–1.41)	1.04 (0.83–1.30)	0.87 (0.58–1.31)	0.75 (0.60–0.94)	NA
Metro	1.15 (1.01–1.31)	0.89 (0.68–1.17)	1.13 (0.99–1.29)	1.14 (0.97–1.34)	0.99 (0.74–1.32)	1.19 (0.99–1.41)	NA
	Hospice use						
Race							
Whites	Reference	Reference	Reference	Reference	Reference	Reference	NA
Blacks	0.89 (0.79–1.01)	0.72 (0.53–0.97)	0.95 (0.84–1.08)	0.90 (0.78–1.05)	0.74 (0.41–1.35)	1.40 (1.20–1.62)	NA
Others	0.86 (0.74–0.99)	0.56 (0.39–0.79)	0.91 (0.78–1.06)	0.83 (0.69–0.99)	1.22 (0.70–2.11)	1.41 (1.20–1.65)	NA
Urban/rural							
Less urban/rural	Reference	Reference	Reference	Reference	Reference	Reference	NA
Urban	1.09 (0.93–1.27)	1.05 (0.74–1.49)	1.08 (0.93–1.26)	1.01 (0.84–1.22)	1.33 (0.72–2.44)	0.88 (0.75–1.03)	NA
Metro	1.12 (1.00–1.24)	1.22 (0.96–1.55)	1.12 (1.00–1.24)	0.97 (0.86–1.11)	1.04 (0.67–1.62)	1.23 (1.10–1.38)	NA

[a] Adjusted for age, gender, percent below poverty, tumor stage, historic stage, tumor grade, tumor size, number of positive nodes, comorbidity score, SEER areas and year of diagnosis.

than those from rural or less urban areas, but those from urban areas had almost identical costs than those from less urban or rural areas.

4. Discussion

This study examined racial and geographic disparities in various types of cancer care and costs in the last 6 months of life among lung cancer decedents after the FDA's approval of an expensive bevacizumab since October 2006. We observed substantial racial and geographic disparities in cancer care and costs in these patients. Overall, blacks or other ethnic populations were significantly less likely to receive chemotherapy/targeted therapy, bevacizumab, and hospice care, and more likely to be hospitalized in the last 6 months of life, but were not significantly different in receiving radiation and surgery, as compared to whites, after adjusting for socio-demographic and tumor characteristics. Patients from metro areas were significantly more likely to receive chemotherapy/targeted therapy and radiation therapy, whereas those from urban areas were significantly more likely to receive hospitalization and hospice care than those from rural or less urban areas. The costs of cancer care were higher in black patients than in other ethnic groups and patients from metro areas had significantly higher costs than those from rural or less urban areas.

Over the past 2 decades, numerous studies reported substantial variations in treatment for medical conditions by race/ethnicity and by geographic locations [44–48]. These disparities were observed across different healthcare systems [44] and also observed in populations from the same country with the same health insurance coverage such as Medicare in the U.S. [46–48]. Hence, it is not surprising to observe these disparities in types of cancer care and costs in the last 6 months of life among lung cancer decedents in this study because of the following reasons. First, there is no standard or clear-cut guidelines about what should not be used in the last few months of life for cases with terminal cancer, which is likely leading to substantial variations in choices of types of cancer care by the providers or patients/family members. Second, religious and cultural beliefs played a major role in the end of life care, which may vary significantly in the same area or same ethnic population. For example, African Americans preferred more aggressive treatment

Table 5
Total health care costs by types of cancer care, race and geographic location.

Types of cancer care, race and geographic location	Mean (1st quartile–3rd quartile) of total health care cost (2014 US dollars), stratified by survival times		
	Overall *N* = 37,393	Survived more than 6 months *N* = 21,199	Survived less than 6 months *N* = 16,194
All patients	42,749 (18,569–56,016)	44,707 (20,528–59,002)	40,186 (17,028–52,209)
Patients receiving chemotherapy/targeted therapy	56,643 (32,934–72,868)	56,367 (32,232–72,319)	57,284 (34,487–74,154)
Patients receiving bevacizumab	69,159 (44,992–87,338)	70,453 (46,132–88,583)	65,363 (41,697–85,114)
Patients receiving radiation	53,546 (30,597–68,801)	55,781 (31,690–71,867)	51,264 (29,516–65,845)
Patients receiving growth Factor	61,056 (37,861–77,782)	60,634 (37,376–76,829)	62,347 (39,793–80,235)
Patients receiving surgery	99,412 (51,037–121,171)	111,251 (60,510–136,557)	94,845 (48,544–113,399)
Patients receiving hospitalization	50,562 (25,144–64,289)	55,082 (29,013–70,273)	45,606 (21,838–57,180)
Patients receiving hospice	38,877 (19,357–50,605)	40,894 (22,130–53,031)	36,011 (16,851–47,033)
Patients receiving emergency department care	48,736 (23,335–64,885)	50434 (24,875–66,978)	45,828 (21,068–61,554)
Race			
Whites	41,603 (18,330–54,717)	43,599 (20,252–57,426)	38,964 (16,742–50,948)
Blacks	51,654 (22,081–66,852)	54,239 (24,472–71,830)	48,567 (19,366–60,841)
Others	45,835 (19,131–60,682)	47,017 (19,334–63,456)	44,293 (18,917–56,367)
Urban/rural			
Less urban/rural	39,455 (16,940–52,256)	40,695 (18,465–54,270)	37,924 (16,058–50,219)
Urban	38,560 (16,425–50,824)	40,301 (19,401–52,711)	36,359 (14,080–48,767)
Metro	43,603 (19,023–57,039)	45,665 (20,972–60,284)	40,872 (17,436–52,920)

Table 6
Multiple regression for total health care cost by types of cancer care, race and geographic location.

Types of cancer care, race and geographic location	Adjusted cost Ratio (95% CI)[a]		
	Overall *N* = 37,363	Survived more than 6 months *N* = 21,183	Survived less than 6 months *N* = 16,180
Chemotherapy/targeted therapy (Yes vs. No)	1.24 (1.21–1.26)	1.15 (1.12–1.18)	1.27 (1.23–1.31)
Bevacizumab (Yes vs. No)	1.36 (1.31–1.41)	1.37 (1.31–1.42)	1.31 (1.23–1.40)
Radiation (Yes vs. No)	1.21 (1.19–1.23)	1.15 (1.12–1.18)	1.35 (1.32–1.38)
Growth Factor (Yes vs. No)	1.18 (1.15–1.21)	1.15 (1.12–1.19)	1.18 (1.13–1.23)
Surgery (Yes vs. No)	2.01 (1.91–2.10)	1.99 (1.83–2.18)	1.91 (1.78–2.04)
Hospitalization (Yes vs. No)	2.25 (2.21–2.30)	2.23 (2.17–2.30)	2.89 (2.80–2.99)
Hospice (Yes vs. No)	1.04 (1.02–1.06)	1.05 (1.03–1.08)	1.01 (0.98–1.03)
Race			
Whites	1.00	1.00	1.00
Blacks	1.16 (1.13–1.19)	1.14 (1.10–1.18)	1.16 (1.12–1.21)
Others	1.11 (1.08–1.15)	1.09 (1.04–1.14)	1.11 (1.07–1.16)
Urban/rural			
Less urban/rural	1.00	1.00	1.00
Urban	0.98 (0.95–1.02)	0.99 (0.95–1.04)	0.99 (0.94–1.04)
Metro	1.05 (1.03–1.08)	1.06 (1.03–1.10)	1.04 (1.01–1.08)

[a] Adjusted for age, gender, percent below poverty, tumor stage, historic stage, tumor grade, tumor size, number of positive nodes, comorbidity score, SEER areas and year of diagnosis.

at the end of life care than other ethnic populations [16,17] and desired to provide all possible care in order to prolong life [15], whereas the treatment decisions for whites were more likely to withhold treatment before death [15]. Third, the costs of care were often not taken into consideration in providing and choosing the types of cancer care among Medicare beneficiaries in the U.S., unlike the countries with national health services such as Britain. Therefore, these discretionary choices of medical services are expected to vary by care providers or care receivers, resulting in tremendous variations in the patterns of the end of life care.

Our study is unique because we focused on the time period when the expensive medication 'bevacizumab' for lung cancer was introduced in October 2006. All lung cancer decedents from July 2007 to December 2010 were included, allowing at least 6 months for ascertaining the outcome measure of bevacizumab, related cancer care and costs. Indeed, bevacizumab was the most expensive treatment modality after surgery. Even in patients with Medicare parts A and B coverage, there were still substantial variations in cancer care and costs among beneficiaries. Although previous studies did not include the newer medication bevacizumab, the findings on racial and geographic variations in the end of life cancer care were generally consistent with what we found in this study. For example, the total health care costs (in Table 5) were the highest for blacks and lowest for whites, which was consistent with the previous qualitative interview studies [17–19] that reported that blacks were more likely to prefer all possible care and whites were more likely to withhold care before death, leading to differences in health care costs. It was expected that the National Health Insurance system might help lower the health care costs and perhaps minimize the health disparities as well. Interestingly, the use of hospital and emergency services at the end of life care for lung cancer patients was even higher in Canada than in the US. [9]. Hence, the findings from our study and others [9,17–19] have tremendous policy implications. It appears that the clear guidelines for the end of life care are needed, which should help minimize the overuse of treatment at the end of life care, lower the health care cost, and narrow the disparities by race/ethnicities and geographic areas, regardless of health care systems. The study findings and clinical guidelines should be helpful to care providers and to patients and their families, which would ease their discussion on what may be the best care at this stage of life.

This study has some limitations to be noted. First, the study only included lung cancer decedents, the magnitudes of disparities for the end of life care in patients with other types of cancer are not known. Second, although the study examined multiple healthcare datasets (inpatient, outpatient, physician, home health and hospice care), the Medicare Part-D drug information was not analyzed. As a result, the types of cancer care and costs might be under-estimated, although the inclusion of Part-D data may be unlikely to alter the findings of racial and geographic disparities. Third, the study populations were 65 years or older in SEER areas, the findings may not necessarily be generalizable to younger populations or in other areas.

5. Conclusion

There were substantial racial/ethnic and geographic disparities in the types of cancer care and costs in the last 6 months of life among lung cancer decedents, regardless of the length of survival times and hospice care status. Because of high costs and ineffectiveness in certain types of cancer care at the end of life, there should be a clear guideline and policy in place to minimize the overuse of ineffective but costly types of cancer care and to promote more effective palliative care services to patients and families. By doing this, it is expected that racial/ethnic and geographic disparities in the end of life care will be substantially reduced, if not eliminated.

Conflict of interest

The authors declare that there are no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.lungcan.2015.09.017.

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