Published in final edited form as:
Disabil Health J. 2008 April 1; 1(2): 108–115. doi:10.1016/j.dhjo.2008.01.004.

COST DISPARITIES IN LUNG CANCER TREATMENT BY DISABILITY STATUS, SEX, AND RACE

Thomas N. Chirikos, PhD*,
Professor Emeritus, University of South Florida, Tampa, FL (Note: At the time this research was conducted, the author was Professor and Member-in-Residence, H. Lee Moffitt Cancer Center & Research Institute, University of South Florida)

Richard G. Roetzheim, MD, MSPH,
Professor of Family Medicine, Department of Family Medicine and H. Lee Moffitt Cancer Center & Research Institute, University of South Florida, Tampa, FL

Ellen P. McCarthy, PhD, MPH, and
Assistant Professor of Medicine, Harvard Medical School, Division of General Medicine and Primary Care, Beth Israel Deaconess Medical Center, Brookline, MA

Lisa I. Iezzoni, MD, MSc
Professor of Medicine, Harvard Medical School, Institute for Health Policy, Massachusetts General Hospital, Boston, MA

Keywords

Disability; Health disparities; Medicare; Cancer costs; Lung cancer treatment; Cancer care delivery; SEER-Medicare database

The recent literature contains numerous reports of disparities in the diagnosis, treatment and outcomes of lung cancer across a growing list of population subgroups, including race and ethnicity, sex, income, place of residence, and more recently (non-cancer-related) disability (1–13). Health policy makers identify reducing these disparities as a critical priority (14–15). Designing interventions to achieve this end is hampered by limitations in research evidence about causality. Some studies seemingly assume that treatment disparities reflect differential access to the medical care delivery system, e.g., African-Americans have lower levels of income and insurance coverage, which in turn limit their access to appropriate treatment (16–17). Other studies emphasize genetic/ biological variability related to race and ethnicity that leads to differential disease and treatment characteristics, e.g., non-white men metabolize cigarette smoke differently and thus present with more complex squamous cell lung cancers (8,11). To provide policy-relevant results, health disparities studies must account more fully for health insurance coverage as well as actual therapy and follow-up care.

*Address all correspondence to: Thomas N. Chirikos, Ph.D., Professor Emeritus, 9128 Regents Park Drive, Tampa, FL 33647-2406 (Phone: 813-973-1695; tchiriko@health.usf.edu *and* ChirikosTN@aol.com).

Financial Disclosure : The authors have no conflicts of interest, financial or otherwise, to disclose.

This study examines the level and pattern of costs or resource consumption by lung cancer patients covered by Medicare insurance to provide a common metric for judging how much therapy and follow-up care different subgroups actually receive. These findings contribute to determining whether resource differentials are associated with disparities. If disparities in lung cancer outcomes arise uniquely from insurance-related barriers to access, they should not be detected in this sample; other causal pathways may be suggested if they are. We test for cost disparities across eight relevant patient subgroups, white and non-white men and women with and without disabilities, controlling for other plausible cost drivers. Race differences in patterns of lung cancer treatment costs may be detected if biological/genetic factors play a role and/or if provider/patient behavior leads to variations in therapy regimens. Similarly, females are generally expected to use more health care services than men, but whether they do when treated for lung cancer and/or whether there are different cost profiles for men and women divided by race is unclear. Finally, because we draw on the database (18) that links the Surveillance, Epidemiology, and End Results (SEER) cancer registry files to Medicare claims files (hereafter, SEER-Medicare) to conduct our empirical analysis, we also test for disability-related disparities in lung cancer treatment costs. In brief, lung cancer cases that qualified for Medicare benefits because they received a non-cancer-related Social Security Disability Insurance (SSDI) award are compared to those who qualified for Medicare more conventionally through the Social Security retirement program. If disabilities complicate lung cancer treatment, we anticipate relatively higher cost profiles; if they lead to less aggressive care, we anticipate lower ones.

Methods

Study Population and Subgroups

The initial study population was drawn from SEER-Medicare on individuals in 9 (later 11) SEER areas diagnosed with a first primary lung cancer between January 1, 1986 and December 31, 1999, inclusive. Among others, cases who did not have pathologically-confirmed diagnoses, who were younger than 45 or older than 85 years of age at diagnosis, who were diagnosed before January 1, 1991, or who did not have a sufficient number of Medicare claims to trace costs over time were in subsequent steps excluded from this population. These and other sample exclusions are described below and summarized in Table 1. The eight sex, race, and disability subgroups that are at the heart of the empirical work are also spelled out in Table 1. We note that the race variable was originally constructed as a threefold vector of dichotomous variables: white (Caucasian), African-American, and all other race categories. Preliminary analysis suggested that this threefold classification did not produce results appreciably different from those using a twofold classification, white and all other races. In order to simplify the narrative, results corresponding to the twofold classification are reported here. Each of the four race-sex subgroups was then divided by disability status in reference to the “original reason for Medicare entitlement” in the SEER-Medicare denominator file.

Specifically, lung cancer patients who originally qualified for Medicare through an SSDI award were initially categorized as having a disability; all other cases were classified as not having one (without disability). Cases with disabilities attributable to lung cancer were then excluded. Because the Social Security Administration does not release information on causes for disability determination to nongovernmental researchers, we had to infer whether lung cancer was responsible for the SSDI award. This inference was based on the number of elapsed calendar quarters between cancer diagnosis and the award. Only cases diagnosed with lung cancer after at least 10 elapsed quarters were included, because persons awarded SSDI benefits become eligible for Medicare only after waiting at least 29 total months after their disability determination. Disability is thus interpreted as a non-cancer-related medical condition that was sufficiently severe to have precluded gainful employment or to have potentially resulted in

premature death at some point prior to the diagnosis of lung cancer. We acknowledge that the "without disability" classification is not necessarily limited to healthy individuals free of any pre-existing medical condition. Those categorized as without disabilities could have experienced disabling health impairments before age 65, but for whatever reason did not apply for or receive SSDI. For our purposes, the two key attributes of the subgroup with disabilities are: 1) before age 65 they experienced non-cancer-related disability sufficient to prevent employment and recognized by an SSDI award; and 2) after that point, they developed cancer. Persons without disabilities did not have this history.

Finally, the study population was partitioned by age at diagnosis and when the diagnosis occurred. The age "window" provides a means of narrowing the differential in the age at diagnosis across the disability, sex, and race subgroups, particularly disability status. It bears repeating that individuals included in the study population could have developed their lung cancer at any age. Those with disabilities could have been diagnosed after age 65 (on top of their work-limiting medical condition), whereas those who qualified for Medicare because of normal retirement through the Old Age and Survivors Insurance (OASI) program could have been diagnosed at a younger (<65) age. In addition to the age restriction, the study population was limited to lung cancer cases diagnosed after January 1991 (Q21). This restriction provided, among others, a means of constructing control variables for pre-diagnosis Medicare costs.

Cumulative Medicare Costs by Quarter and Treatment Phase

Because they reflect economic opportunity costs better than other variables created from Medicare claims data, we use program reimbursements to quantify the economic value of scare resources used to diagnose and treat lung cancer; for brevity throughout, we call these reimbursed amounts "costs." Costs recorded in each Medicare claims file were compiled for each study subject by calendar quarter over relevant segments of the period January 1, 1986 to December 31, 2001, inclusive. Medicare files included: Part A Inpatient and Skilled Nursing (Medpar); Hospice and Home Health; and Part B Physician/Suppliers, Outpatient and Durable Medical Equipment. Each claim-specific observation was assigned either the sum of current dollar reimbursements for each covered service used over the specific calendar quarter or a zero if no services were used during that quarter. These quarterly cumulative totals were then adjusted for both temporal and geographic variations in medical care prices (19). Temporal price indices were rebased to year 2000, whereas the cross-sectional geographic indices were left to reference the national average in any given year. Thus, the adjusted cumulative cost variables are scaled in constant 2000-year prices; they also reflect the extent to which real outlays in each SEER catchment area deviated from national norms in any year. The adjusted-cumulative amounts of each relevant claim type were then aggregated to create Part A and Part B cost variables for each quarter over the 64-quarter study period.

The next step in constructing dependent cost variables for the statistical analysis was to subset or partition them by when study subjects were diagnosed and treated for lung cancer (treatment phase) and by the type of services they received for treatment (treatment category). Our approach to delineating treatment phases generally paralleled those of other investigators (20). The initial treatment phase is defined as the four-quarter period post-diagnosis, i.e., the quarter when the diagnosis occurred and the three quarters immediately afterward. The death phase encompasses the quarter in which death occurred and the quarter immediately preceding it. The follow-up phase is defined as the (net) number of quarters between the fifth quarter post-diagnosis and the quarter immediately preceding the death-phase for decedents or quarter 64 for survivors. Cumulative costs incurred during each of these phases were then tallied. Cumulative costs corresponding to the treatment phase were further divided four ways: inpatient hospital services, other Medicare Part A services (skilled nursing, hospice, home health), physician services, and other Part B services (outpatient and durable medical

equipment). Death and follow-up costs were divided simply between Part A and Part B services. Since follow-up quarters vary over the study population, cumulative follow-up Part A and Part B costs were standardized by the number of Medicare-eligible quarters observed for each lung cancer case over this treatment phase. Given the high case fatality rates of lung cancer, the (net) number of follow-up quarters is also used as a prime outcome indicator as well.

Regression Model

Multivariate regression techniques were used to estimate the net differentials in cumulative costs, if any, across the disability, sex, and race subgroups. Because of their skewed distributions, each of the cumulative cost dependent variables was first transformed into its natural logarithm (ln). Regressors in each (ln) cost model included seven of the subgroups, the eighth (white men without disabilities) always serves as the omitted or referent subgroup. Each model also included a set of covariates designed to control for cost drivers that potentially confound measured differentials across the subgroups. Table 2 summarizes the key covariates included in the cumulative cost equations, two of which warrant brief comment here. These are the high-expected cost and pre-diagnosis cost variables, which serve to control for the presumptive impact of prior SSDI medical condition on current Medicare costs and, thereby, provides a means of netting-out non-cancer-related reimbursements. High-expected costs are based on predicted values generated from an auxiliary regression analysis of *non-cancer costs* of a 5 percent random sample of Medicare beneficiaries *without cancer* residing in SEER catchment areas. These predicted values indicate what non-cancer spending might be expected had cases with specific age, sex, race and disability characteristics never developed cancer. A dichotomous variable was created from the predicted values indicating whether the case would be expected to have higher than average quarterly Medicare (Part A and Part B) reimbursements in the absence of cancer. Complementing this variable is a measure of Medicare (Part A or Part B depending on the cost category in question) cumulative costs actually incurred by cases in the period prior to the diagnosis of lung cancer. We believe that the combination of these two variables adequately controls for variations in non-cancer health costs across the study sample.

As expected, cumulative cost variables have many zero observations, mostly because Medicare beneficiaries will not have utilized all types of covered services during a given treatment phase equally. For example, whereas a large fraction of cancer cases will incur hospital costs during the 4-quarter treatment phase, a much smaller fraction will incur costs for other Part A services such as skilled nursing or hospice during that phase. However they arise, a major concern with zero cost observations is that they are unlikely to be distributed randomly across the study population. This means that significant (selection) bias may be imparted to the analytic results unless they are otherwise taken into account (21). For this reason, the (ln) cost regression models are estimated in two-parts: the first yields predictions of the likelihood of observing a positive cost for each study subject; the second is the (ln) cost equation per se which includes this predicted value as a covariate.

More formally, the two-part regression model may be summarized as follows: Let D_j represent the *jth* element of the vector of disparity-related disability, sex, and race subgroups; let C_{in} represent the observed *ith* phase/program-specific cost of the *nth* lung cancer case,(I = 1, 2. ., 8; n = 1, 2, . . , **N**); and let y_i* be a dichotomous indicator variable taking the value of one if $C_{in} > 0$, zero otherwise. Suppressing study subject subscripts to simplify the exposition, the regression model is:

$$y_i^* = (\alpha_0 + \sum\nolimits_k \alpha_k Y_k + u) \quad (1)$$

and

$$\ln C_i=(\beta_o+\sum_j \beta_j D_j+\sum_j \beta_j X_j+\lambda_i+\varepsilon) \quad (2)$$

where Y_k is the *kth* selection covariate; ln represents natural logarithm, and X_j is the *jth* cost covariate as discussed previously. The selection model is then set up in general terms following Heckman's method (21–22) First, a Probit estimate of (2) is used to generate "lambda" (inverse Mill's ratio, the selection parameter) which reflects the likelihood that a patient with given socio-demographic and insurance characteristics will be observed having nonzero cumulative costs of the *ith* type. Second, this predicted value λ_i is then incorporated into the cost equation (2) to correct for potential selection bias.

Measuring Cost Disparities

To simplify the narrative, the results of the statistical analysis presented below focus just on the effects of disability, sex, and race subgroups on cumulative costs, net of the other covariates in each (ln) cost equation. Cost differentials are computed by first evaluating each ln cost equation at the subgroup means for the referent (white men without disabilities) subgroup, reevaluating the equation in turn for each of the seven other subgroups, and then exponentiating the results. We use standard smearing techniques to overcome issues arising from the retransformation of *geometric* mean costs to *arithmetic* mean costs in the two-part model (23). To facilitate comparisons across the full set of subgroups, cost differentials are cast as index numbers (percentages) of the costs of white men without disabilities. Index values less than 100 are interpreted as disparities favoring the referent subgroup, whereas values greater than 100 favor the subgroup in question. Statistically insignificant regression coefficients (alpha = .95, two-tailed test) are arbitrarily assigned the value of zero and, correspondingly, an index value of 100. In order to provide an overall summary measure of cost disparities, we also computed the *expected* total cost per case corresponding to each subgroup. These expectations are based upon predicted costs of each type for each subgroup evaluated at subsample mean values of the covariates. These predicted amounts were then scaled by the probabilities of observing nonzero costs of that type in the corresponding subgroup and summed over all eight cost types.

Results

Table 3 summarizes key characteristics of each subgroup of lung cancer cases. As anticipated, the numbers of white men and women without disabilities are much higher than the other subgroups, in part because far fewer persons qualify for Medicare benefits via SSDI than OASI. The racial subgroups had similar mean age at diagnosis, though the subgroups with disabilities were diagnosed at slightly younger ages than persons without disabilities. Stage at diagnosis was similar across the eight subgroups, though relatively fewer women were diagnosed at the most advanced stages, especially compared with disabled men of other races. Roughly similar proportions of each subgroup had non-small cell cancers, surgery, and radiation therapy. In contrast, the subgroups differed substantially in the income, schooling and demographic compositions of the census tracts in which cases resided when diagnosed with cancer. Although not reported here in detail, we note that survival times differed by subgroup based on univariate tests. The same patterns remained following adjustment for sociodemographic and tumor characteristics through multivariate modeling. Briefly, white women had the most favorable outcomes, and persons without disabilities did better than persons with disabilities.

Table 4 shows the main findings from the regression analyses. Three findings stand out. First, more than two-thirds of the cost-related subgroup differentials were statistically different from the referent group at the conventional 5 percent confidence level, and several other coefficients narrowly missed statistical significance at this level. Even if the much more rigorous $p \leq 0.005$ criterion is used to reject the null hypothesis, a plurality of the coefficients differ from zero. Most statistically insignificant coefficients involved subgroups with small numbers of cases. Second, values that differ from zero were often higher than those for white nondisabled men; for instance, costs of treating women of each race and disability status were generally higher than for white men without disabilities. Inpatient hospital costs varied across subgroups more than other Part B service costs. Finally, the estimated cost of treating the average lung cancer case in each subgroup suggests that sex and race subgroups were higher than for white, nondisabled men. Furthermore, with only one exception, white men without disabilities had *lower* cumulative costs per case than the other subgroups. Men and women of other races had the *highest* expected costs.

Discussion

Our analyses offer fairly compelling evidence of sex-related cost differentials in treating Medicare beneficiaries with lung cancer. The health services research literature has repeatedly documented that women utilize more medical care services than men at each point in the life cycle and thus generally have higher costs at each point as well. But the cost differentials detected here may also provide modest, indirect support for the argument that lung cancer in women is a different disease than it is in men (12). Some women actually have lower costs than their male counterparts during the initial year of diagnosis and treatment, but significantly higher costs in the follow-up period and, for decedents, the death phase as well. Since cumulative costs over the follow-up phase are scaled by the (net) number of Medicare-eligible follow-up quarters, this suggests that women receive more intensive or perhaps different follow-up care than men. This might stem from the nature of the disease, though it might also stem from other factors such as better compliance with follow-up regimens. Since women enjoy a slight advantage in being candidates for surgery, it may be that their initial treatment is more cost-efficient, but requires them to be followed more closely after that treatment.

Racial differences in cumulative costs were unanticipated. The general expectation was that non-white men and women would consume fewer treatment resources, because they have lower lung cancer surgery rates (2,6), they appear to be less willing to undergo invasive procedures (3), and, at least for NSCLC, they are less likely to receive “recommended” therapy (6). To be sure, variations in the composition of treatment costs across the four subgroups of non-white men and women were detected: Part B service utilization was presumptively lower for these subgroups than the corresponding white subgroups, though in most cases the lower amounts were offset by much higher use of (Part A) hospital inpatient services. Earle et al (7) found that access to an oncologist differs by race, which may explain differences in referral patterns and the locus of treatment. In view of these cost differentials, it is noteworthy that mostly unfavorable race differences in the length of the (net) follow-up period and survivorship were still detected. This contrasts sharply with a recent finding that outcome disparities disappear when health care access is controlled by examining only patients treated in a single (military) delivery system (11). The present analysis also implicitly controlled for access by investigating lung cancer patients with the same (Medicare) insurance coverage; moreover, other insurance and socio-economic characteristics of these lung cancer cases were also explicitly taken into account. The unfavorable “cost-effectiveness” of treating non-white men documented here warrants substantially more research in the future.

Finally, and perhaps most importantly, disability effects detected in the statistical analysis are of interest from both clinical and policy perspectives. The consistent pattern of low resource

consumption in treating white men with disabilities is most noteworthy. Not only were expected case costs lower for this subgroup than all others, they were consistently lower across all but one of the cost categories. This strongly suggests that the disabling medical condition influences treatment options for this subgroup, which, in turn, may also account for their generally poorer outcomes. In view of these differences, the polar case of non-white women with disabilities is also striking. These women had outcomes generally comparable to all others in the study population. But they also had substantially higher levels of resource consumption, especially more expensive hospital stays for initial therapy and in the 6-months prior to death. The small sample size of this subgroup, however, may have yielded imprecise estimates of cumulative costs. The findings in regard to disability status and lung cancer clearly warrant additional research.

Future studies must overcome several methodological limitations of our empirical analysis. Our estimates of treatment costs were understated because they could be prepared only for services covered by the Medicare benefits package prevailing over the study period. Costs of long-term nursing care and outpatient prescription drugs are notable omissions. To the degree these costs differ across the study subgroups, the measured magnitude and composition of the cost differentials will change. The costs of these omitted services thus warrant further investigation. The cost estimates were also understated because outlays by Medicare beneficiaries in the form of deductibles and co-payments were also excluded from consideration. These outlays require more detailed study as does the costs of some patients who were eligible for other public sector support for their medical care. The empirical analysis here did control explicitly for the patients who had at various points over the study period state “buy-in” arrangements. Yet, the differences in the likelihood of having such an arrangement differs greatly, say, between the race subgroups, and this may have influenced the magnitude of observed outpatient costs. Finally, recall that the overall costs for the patient subgroups are means adjusted for subsample characteristics. These adjusted figures might be higher or lower depending on the characteristics of the sample in respect to stage distribution, socioeconomic, and demographic characteristics. When these differences are factored in, our overall estimates appear to be consistent with the few other studies on lung cancer treatment costs that have been carried out (24). This suggests that the *relative* cost differentials are likely to depend equally on the characteristics of the study population, so reconfirmation of the empirical findings presented here must be obtained by analyzing other populations of lung cancer patients potentially available in other data sets such as the Continuous Medicare History Sample File as well.

Two general conclusions follow from the empirical results. First, resource disparities were detected, albeit not across all of the lung cancer subgroups. The significantly lower level of resource consumption by white men with disabilities is an important case in point, especially in view of their comparatively poorer outcomes. But finding that non-white men had higher levels of resource consumption and equally poor outcomes are also important from a policy perspective. The link between medical care and outcomes is clearly a necessary component of disparities-relating policy, but not a necessary and sufficient one. Moreover, the composition of the services delivered to lung cancer patients may be as important as the level of services. The analysis showed that the pattern of costs varied across the subgroups, generally being higher for Part A services but lower for Part B services. Whether these variations should concern policy makers depends on the degree to which they cancel-out and/or the extent to which care received in different health care settings may lead to outcome differences. If they do, disparity-related programming should target the locus of service delivery, e.g., by means of patient navigation (16). Policies designed to improve physical access and travel to ambulatory setting, especially for patients with disabilities, may also be indicated.

Second, cost differentials were detected in a population fully entitled to Medicare benefits and they involved the type as well as level of service use. Whether access to health care insurance *per se* is the only, or even primary, policy instrument for improving care and outcomes is thus open to some question. The effectiveness of other policy instruments must be examined to ensure that patients and providers use available insurance to diagnose lung cancer as early as possible and treat it in the most cost-efficient manner. The composition or blend of services used to treat and follow cancer patients also warrants additional attention. More disaggregate studies examining treatment costs alongside the specific types of treatment will help clarify the extent to which additional resources might improve cancer outcomes.

Acknowledgments

This research was supported by Grant No. RO1 CA100029 from the National Cancer Institute. The study sponsors were not involved in the study design, in the analysis or interpretation of the data, or in writing and submitting the manuscript for publication. The study used the linked SEER-Medicare database. Approvals from the respective Institutional Review Boards were obtained to analyze these data. The interpretation and reporting of the data here are the sole responsibility of the authors. The authors acknowledge the efforts of several groups responsible for the creation and dissemination of the Linked Database, including the Applied Research Branch, Division of Cancer Control and Population Sciences, National Cancer Institute; the Office of Information Services, and the Office of Strategic Planning, Centers for Medicare and Medicaid Services; Information Management Services, Inc.; and the Surveillance, Epidemiology, and End Results Program Tumor Registries.

References

1. Shavers VL, Brown ML. Racial and ethnic disparities in the receipt of cancer treatment. J Natl Cancer Inst 2002;94(5):334–57. [PubMed: 11880473]
2. Bach PB, Cramer LD, Warren JL, Begg CB. Racial differences in the treatment of early-stage lung cancer. N Engl J Med 1999;341(16):1198–1205. [PubMed: 10519898]
3. Lathan CS, Neville BA, Earle EA. The effect of race on invasive staging and surgery in non-small - cell lung cancer. J Clin Oncol 2006;243(3):413–18. [PubMed: 16365180]
4. Wang SJ, Fuller CD, Thomas CK. Ethnic disparities in conditional survival of patients with non small cell lung cancer. J Thoracic Oncol 2007;2(3):180–90.
5. Smith TJ, Penberthy L, Desch CE, Whittemore M, Newschaffer C, Hillner BE, et al. Differences in initial treatment patterns and outcomes of lung cancer in the elderly. Lung Cancer 1995;13:235–52. [PubMed: 8719064]
6. Potosky AL, Saxman S, Wallace RB, Lynch CF. Population variations in the initial treatment of non-small-cell lung cancer. J Clin Oncol 2004;22:3261–8. [PubMed: 15310770]
7. Earle CC, Neumann PJ, Gelber RD, Weinstein MC, Weeks JC. Impact of referral patterns on the use of chemotherapy for lung cancer. J Clin Oncol 2002;20(7):1786–92. [PubMed: 11919235]
8. Gadgeel SM, Kalemkerian GP. Racial differences in lung cancer. Cancer Metastasis Rev 2003;22(1): 39–46. [PubMed: 12716035]
9. Flenaugh EL, Henriques-Forsythe MN. Lung cancer disparities in African-Americans: health versus health care. Clin Chest Med 200;27(3):431–9. [PubMed: 16880053]
10. Silverstein MD, Nietert PJ, Ye X, Lackland DT. Access to care and stage at diagnosis for patients with lung cancer and esophageal cancer: analysis of the Savannah River Region Information System cancer registry data. South Med J 2002;95(8):900–8. [PubMed: 12190229]
11. Mulligan CR, Meram AD, Proctor CD, Wu H, Zhu K, Marrogi AJ. Unlimited access to care: effect on racial disparity and prognostic factors in lung cancer. Cancer Epidemiol Biomarkers Prev 2006;15 (1):25–31. [PubMed: 16434582]
12. Belani CP, Marts S, Schiller J, Socinski MA. Women and lung cancer: epidemiology, tumor biology, and emerging trends in clinical research. Lung Cancer 2007;55:15–23. [PubMed: 17084482]
13. McCarthy EP, Ngo LH, Chirikos TN, Roetzheim RG, Li D, Drews RE, et al. Cancer stage at diagnosis and survival among persons with Social Security Disability Insurance on Medicare. Health Serv Res 2007;42(2):611–28. [PubMed: 17362209]

14. Edwards BK, Brown ML, Wingo PA, Howe HL, Ward E, Ries LA, et al. Annual report to the nation on the status of cancer, 1975–2002, featuring population-based trends in cancer treatment. J Natl Cancer Inst 2005;97(19):1407–27. [PubMed: 16204691]

15. National Healthcare Disparities Report. Full Report. Agency for Healthcare Research and Quality; Rockville, MD: 2006. http://www.ahrq.gov/qual/nhdr06/report/

16. Freeman HP, Chu KC. Determinants of cancer disparities: barriers to cancer screening, diagnosis, and treatment. Surg Oncol Clin N Am 2005;14(4):655–69. [PubMed: 16226685]

17. Siminoff LA, Ross l. Access and equity to cancer care in the USA: a review and assessment. Postgrad Med J 2005;81:674–9. [PubMed: 16272229]

18. Warren JL, Klabunde CN, Schrag D, Bach PB, Riley GF. Overview of the SEER-Medicare data: content, research applications, and generalizability to the United States elderly population. Med Care 2002;40(8 suppl):3–18.

19. MEDPAC. The Construct of Medicare Price Indices. The Commission; 2002. Report to the Congress, Medicare Payment Policy, Appendix A.

20. Brown ML, Riley GF, Potosky AL, Etzioni RD. Obtaining long-term disease specific costs of care. Med Care 1999;37(12):1249–59. [PubMed: 10599606]

21. Heckman J. Sample selection bias as a specification error. Econometrica 1979;47:153–61.

22. Greene, WH. LIMDEP. Version 8.0, Reference Guide. Plainview; New York: 2002.

23. Duan N. Smearing estimate: a nonparametric retransformation method. J Am Stat Assoc 1983;78:605–10.

24. Kutikova L, Bowman L, Chang S, Long SR, Obasaju C, Crown WH. The economic burden of lung cancer and the associated costs of treatment failure in the United States. Lung Cancer 2005;50:143–54. [PubMed: 16112249]

TABLE 1

DEFINITIONS OF STUDY POPULATION AND SUBGROUPS

Population /Subgroups	Definition; Inclusion/Exclusion Criteria
Study Population	
Includes:	All confirmed cases of first primary lung cancer recorded in the SEER-Medicare database who were diagnosed in the period January 1, 1991- December 31,1999 (inclusive); who were between the ages of 45 and 85 at the time of diagnosis; and who had a sufficient number of Medicare claims to trace cumulative treatment costs over time.
Excludes:	Confirmed lung cancer cases categorized as having a disability (Medicare-eligible for Social Security Disability Insurance benefits, age 64 or younger, and satisfying the 5- and 24-month waiting periods),who were diagnosed before 10 calendar quarters had elapsed from the initial date of SSDI entitlement.
Subgroups	
White Men Without Disability	SEER-coded sex = male, SEER "B" recoded race = Caucasian (white), and Medicare Original Entitlement = Old Age and Survivor (OASI) benefits. This is the referent subgroup against which all other subgroup cost disparities are measured.
White Men With Disability	SEER-coded sex = male, SEER "B" recoded race = Caucasian (white), and Medicare Original Entitlement = SSDI, exclusive of End Stage Renal Disease (ESRD), ESRD plus Disability, or missing Entitlement data.
Men of Other Races Without Disability	SEER-coded sex = male, SEER "B" recoded race = All race categories other than white, and Medicare Original Entitlement = OASI.
Men of Other Races With Disability	SEER-coded sex = male, SEER "B" recoded race = All race categories other than white, and Medicare Original Entitlement = SSDI, exclusive of ESRD, ESRD plus Disability, or missing Entitlement data.
White Women Without Disability	SEER-coded sex = female, and all other characteristics identical to White Men Without Disability.
White Women With Disability	SEER-coded sex = female, and all other characteristics identical to White Men With Disability.
Women of Other Races Without Disability	SEER-coded sex = female; all other characteristics identical to Men of Other Races Without Disability.
Women of Other Races With Disability	SEER-coded sex = female; all other characteristics identical to Men of Other Races With Disability.

TABLE 2

KEY COVARIATES IN THE STATISTICAL ANALYSIS

Selected Covariates	Definitions
Stage at Diagnosis	*A* five-fold vector of SEER-coded post-1987 American Joint Commission on Cancer (AJCC) dichotomous stage variables, with stage IV, stage III, stage II and a residual other stage (unstaged and stage unknown) category gauged against the referent category, stage I disease at diagnosis.
NSCLC	Dichotomous variable indicating whether the histology of the first primary lung cancer was categorized as non- small-cell lung cancer (NSCLC).
Cancer-Directed Surgery	Dichotomous variable indicating whether the patient was known to have had lung cancer-directed surgery.
Radiation Therapy	Dichotomous variable indicating whether the patient was known to have had lung cancer-related radiation therapy.
FFS	Dichotomous variable indicating whether the patient was continuously enrolled in Medicare Fee-For-Service over the study period.
State Buy-In	Dichotomous variable indicating whether the patient had a state-buy-in arrangement covering Medicare Part B at any point over the study period.
High Expected Costs	Dichotomous variables indicating whether the patient is likely to be a high cost Medicare Part A or Part B user based on an auxiliary analysis of cumulative (A and B) costs of Medicare beneficiaries *without cancer* residing in SEER catchment areas by age, sex, race and disability characteristics.
Pre-Diagnosis Costs	Cumulative Part A and Part B Medicare costs of each patient from the beginning of the study period up to the quarter that their lung cancer was diagnosed.
Low Income Census Tract	Dichotomous variable indicating that the patient resided in 2000 in a census tract that was in the *lowest* quartile of all such tracts in terms of per capita income. (SEER-reported results from the 2000 Census based survey).
Low Schooling Census Tract	Dichotomous variable indicating that the patient resided in 2000 in a census tract that was in the *highest* quartile of all such tracts in terms of the percentage of persons 25 and over with *less than* 12 years of schooling.
High Minority Census Tract	Dichotomous variable indicating that the patient resided in 2000 in a census tract that was in the *lowest* quartile of all such tracts in terms of the percentage of the population that was white.

Disabil Health J. Author manuscript; available in PMC 2009 October 30.

TABLE 3

SELECTED CHARACTERISTICS OF THE STUDY POPULATION BY SUBGROUP

Characteristics [a]	White Men		Men of Other Races		White Women		Women of Other Races	
	Without Disability	With Disability	Without Disability	With Disability	Without Disability	With Disability	Without Disability	With Disability
Total Number of Cases	31,643	4,974	7,687	1,720	26,302	2,388	4,990	*717*
Mean Age at Diagnosis (Std. Dev.)	72.7 (5.7)	67.9 (7.7)	72.3 (5.6)	66.8 (8.3)	72.9 (5.9)	68.5 (7.7)	72.4 (5.9)	67.3 (8.0)
Stage Distribution at Diagnosis								
IV (%)	33.8	34.9	32.4	35.1	32.0	32.5	31.8	28.5
III (%)	27.8	26.3	31.2	31.3	26.7	26.0	30.9	32.9
II (%)	4.0	3.9	3.2	3.0	3.8	3.4	3.5	3.4
I (%)	21.5	20.4	20.1	17.0	24.1	24.0	21.4	21.2
Other Stage (%)	12.9	14.5	13.1	13.6	13.4	14.1	12.4	14.2
Disease/Treatment Characteristics								
NSCLC (%)	82.5	81.7	85.1	85.9	77.4	75.8	82.6	78.5
Confirmed Cancer-Directed Surgery (%)	27.7	24.1	23.2	21.0	29.0	24.5	26.0	24.4
Radiation Therapy (%)	44.9	43.1	45.2	46.3	40.6	39.8	41.7	41.8
Insurance/Socio-Economic Characteristics								
Continuous FFS (%)	81.1	81.7	75.3	79.0	78.7	81.8	73.8	79.1
State Buy-In (%)	7.0	20.1	32.3	39.2	11.3	37.8	40.4	56.0
Low Income Census Tract (%)	21.0	27.4	41.5	54.7	18.7	25.3	40.8	54.4
Low Schooling Census Tract (%)	18.0	26.0	50.6	60.3	17.7	25.2	48.1	61.9
High Minority Census Tract (%)	14.5	18.2	66.5	68.8	15.3	19.3	65.2	73.5
Outcomes								
Survivor Q64 (%)	9.7	7.5	9.0	7.4	14.3	10.3	13.5	10.7
Decedent: Lung Cancer (%)	72.4	72.3	72.3	72.8	68.9	70.5	68.6	66.7
Other Causes (%)	17.9	20.2	18.7	19.8	16.8	19.2	17.8	22.6
Mean (Net) Follow-Up Quarters	3.4	2.8	2.9	2.6	4.3	3.6	3.7	3.5

[a] See text and Table 2 for definitions and descriptions.

TABLE 4

NET PROPORTIONAL EFFECT OF SEX, RACE AND DISABILITY STATUS ON CUMULATIVE MEDICARE COSTS BY CATEGORY
(Reference Group = White Men Without Disabilities)

Cumulative Cost Categories	Mean Costs (Adjusted $) (1)	White Men		Men of Other Races		White Women		Women of Other Races	
		Without Disability (% col. 1)	With Disability (% col. 1)	Without Disability (% col. 1)	With Disability (% col. 1)	Without Disability (% col. 1)	With Disability (% col. 1)	Without Disability (% col. 1)	With Disability (% col. 1)
Diagnosis and Treatment (4Q)									
Inpatient Hospital	13,143	100.0	92.0 [b]	131.4 [d]	133.3 [d]	93.2 [d]	100 [a]	121.9 [d]	125.1 [c]
Other Part A Services	1,661	100.0	90.0 [b]	100 [a]	100 [a]	112.0 [d]	100 [a]	114.2 [d]	100 [a]
Physician Services	5,316	100.0	78.9 [d]	95.5 [c]	80.8 [d]	100 [a]	91.9 [c]	100 [a]	100 [a]
Other Part B Services	2,417	100.0	79.1 [d]	105.3 [b]	82.3 [d]	89.3 [d]	71.2 [d]	100 [a]	87.1 [b]
Net Follow-up per Eligible-Quarter									
Part A Services	431	100.0	100 [a]	100 [a]	133.5 [d]	107.5 [c]	135.3 [d]	121.1 [d]	100 [a]
Part B Services	342	100.0	72.9 [d]	89.9 [b]	73.3 [d]	107.9 [d]	100 [a]	100 [a]	100 [a]
D*eath (2Q)*									
Part A Services	10,412	100.0	93.1 [b]	90.7 [c]	100 [a]	126.6 [d]	116.0 [d]	100 [a]	117.4 [b]
Part B Service	3,124	100.0	79.6 [d]	110.2 [d]	100 [a]	92.3 [d]	83.3 [d]	123.4 [d]	115.4 [c]
Expected Case Costs	33,937	100.0	88.2	109.4	108.6	103.0	100.2	110.4	114.9

[a] Cost differential arbitrarily assigned the value of zero, because the regression coefficient was not statistically significant (two-tailed $p > 0.05$).

[b] $0.05 \geq p > 0.01$.

[c] $0.01 \geq p > 0.005$.

[d] $p \leq 0.005$.