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Lung Disease Mortality in the United States: The National Longitudinal Mortality Study

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Abstract

SETTING—The National Longitudinal Mortality Study (NLMS) offers the advantage of assessing mortality in a representative population of the United States.

OBJECTIVE—To evaluate health disparities associated with lung cancer and chronic obstructive pulmonary disease (COPD) mortality in the United States and whether these associations are similar between these outcomes.

DESIGN—The NLMS is a prospective study. Data are from NLMS cohort years 1985, 1992, 1993, 1995, and 1996 were included representing nearly 1.5 million person years. Lung cancer and COPD mortality relative risks from Cox regression analysis including residential characteristics, marital status, education, health insurance, and family income were evaluated.

RESULTS—By 1998, 1,273 lung cancer deaths and 772 COPD deaths occurred. Lung cancer mortality rates were approximately two times higher than COPD mortality rates among race and ethnic groups. Cox regression analysis revealed that low education (Relative Risk (RR) = 1.77, significant, p=0.01) and low family income (RR = 1.50, significant, p=0.01) are associated with lung cancer and COPD mortality controlling for age, race/ethnicity, gender and smoking status.

CONCLUSIONS—COPD and lung cancer mortality have similar associations with health disparities indicators in the NLMS data with some differences in the magnitude of the effect.

Keywords

cancer; mortality; lung diseases; health disparities; income; education

Introduction

Death rates from chronic lung diseases including chronic bronchitis, emphysema, and chronic obstructive pulmonary disease (COPD) by smoking status are not readily available. Mortality

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rates from world estimates[1] vary, and may reflect differences in diagnosis, cause of death attribution,[2] or mortality files[3]. Cancer mortality rates may be found through nationally representative registries[4] or those representing smaller, well-described populations. Despite the decreases in smoking[5,6] and decreased lung cancer deaths[7], lung cancer remains among the top five cancer causes of death[4]. Smoking remains a top contributor to COPD disease[8, 9].

This analysis examines health disparities, including socioeconomic factors, adjusted for smoking, associated with death from lung cancer and chronic obstructive pulmonary disease (COPD) using the National Longitudinal Mortality Study (NLMS), a population-based mortality study in the United States. The Surveillance, Epidemiology, and End Results (SEER)-NLMS data were introduced as a unique, population-based research resource that is valuable for health disparity research on cancer burden (10). Although cancer rates have been decreasing (11), a data gap exists in the research of health disparities for cancer and other outcomes. Prompted by Congressional action in 1997 and 2000, the Institute of Medicine (IOM) issued a review of the NIH Strategic Plan, and recommended inclusion of information on racial and ethnic subpopulations and detailed socioeconomic data in population-based studies that evaluate health disparities. Risk estimates from NLMS cohorts, which are followed, offer person-year contributions to the mortality risk estimates, rather than cross-sectional mortality estimates. Results are presented of health disparities factors on the burden of lung cancer and COPD using the NLMS tobacco use cohorts, a subset of the NLMS data. The NLMS tobacco use cohorts include self-declared smoking status that will allow adjustment for smoking as part of the evaluation of health disparities.

Study Population and Methods

The study population includes a subset of the NLMS[12–14], a mortality follow-up of selected cohorts of respondents to the Current Population Survey (CPS) and the 1980 U.S. Census. The CPS is conducted monthly by personal and telephone interview on a national probability sample of about 60,000 households from the civilian non-institutionalized U.S. population by the U.S. Census Bureau for the Bureau of Labor Statistics[15]. Responses are obtained for household members concerning employment status and labor, demographic, economic, and social characteristics. Records were selected from five NLMS cohorts with information on tobacco use: the CPS survey for September 1985, and the March CPS surveys of 1992, 1993, 1995, and 1996. Smoking status (never smoked, current smoker, and former smoker) and other variables are collected only at the time of the survey.

NLMS cohort vital status is followed through the National Death Index (NDI), a national file of death certificate information collected and maintained by the National Center for Health Statistics (NCHS). For this paper, cause of death is defined as the underlying cause of death determined by professional nosologists according to the *International Classification of Diseases, 9th Revision* (ICD-9)[16]. Mortality follow-up is measured from the last day of interview for the source survey until date of death or censoring at the end of follow-up of the study, December 31, 1998. Confidentiality of NLMS data is governed by the U.S. Federal Policy for the Protection of Human Subjects, and is identical to Subpart A or 45 CFR Part 46 of the Health and Human Services regulation.

Data analysis

The ICD-9 underlying lung disease death codes included in the analyses are bronchitis (ICD-9 490), chronic bronchitis (ICD-9 491), emphysema (ICD-9 492), asthma (ICD-9 493), bronchiectasis (ICD-9 494), chronic airway obstruction (ICD-9 496), and lung cancer (ICD-9 162.2–162.9). COPD utilizes the codes for bronchitis, chronic bronchitis, and emphysema (490-492) and CAO (496). While 494 and 495 are included in the NCHS definition of COPD, these conditions are not included. Direct, age adjusted mortality rates per 100,000 person years[17] based on the NCHS year 2000 standard million population are presented with frequency distributions for demographic and smoking characteristics for persons aged 25 years and older. White race was split into Hispanic and non-Hispanic, owing to very low Hispanic ethnicity found among blacks or other race.

Geographic and residential variables in the analysis include urban or rural residence, residence in a standard metropolitan statistical area (SMSA) in a central city, SMSA residence not in a central city, or residence in a non SMSA area, and U.S. Census division. Referent groups for geographic and residential variables are urban residence, residence in an SMSA central city, and Pacific division.

Socio-economic status (SES) included marital status (widowed or divorced, separated, married, and never married), education (less than high school diploma, high school diploma, and education beyond a high school diploma), health insurance (insured/not insured), family income in 1990 U.S. dollars, and percent of poverty level using 1990 standings. Major occupation was analyzed by the 1990 categorization of U.S. occupations[18]. Referent groups for these variables are married, greater than high school education for education, having health insurance, more than $60,000 in family income in U.S. 1990 dollars, and living at greater than or equal to 400 percent of the 1990 U.S. poverty level.

Cox proportional hazards regression models[19] were used to estimate relative risks (RR) and 99 percent confidence intervals for the risk of dying from the underlying cause of death for geographic, residence, and SES variables. Stratified analysis by calendar year was used in consideration of the baseline hazard of each of the CPS cohorts[20]. Cox regression models were adjusted for age in years, gender, race/ethnicity (non-Hispanic white, Hispanic white, black, other). A global test of whether all levels of a categorical variable are equal to zero was conducted using the test statement for the Cox regression models in SAS to address the possibility of a type-1 error[20]. The proportional hazards assumption was verified graphically (results not shown). 189,924 individuals had sufficient data for mortality analysis representing 1,653,653 person years.

Results

Mortality

Of 189,924 individuals at risk of death, 94,027 or 49.51% were never smokers, 49,532 or 26.08% were current smokers, and 46,368 or 24.51% were former smokers. Death rates for lung cancer and COPD by demographic factors and smoking are shown in Table 1. Lung cancer mortality rates were highest among those aged 65 to 74 years, males, and among black individuals (Table 1). COPD mortality rates were highest among 65 to 74 year olds, males, and non-Hispanic whites. Mortality rates by smoking were highest among current smokers followed by former smokers for both lung cancer and COPD.

Smoking and Lung Disease Mortality

The adjusted relative risk for smoking and lung cancer death was 13.24 (99% confidence interval 10.36 to 16.91) and 5.27 (99% confidence interval 4.09 to 6.80) for current and former smokers respectively as compared with non-smokers in a model adjusted for age, gender and race/ethnicity. In a similar model for COPD mortality, the adjusted relative risks were 12.40 (99% confidence interval 8.79 to 17.50) and 6.72 (99% confidence interval 4.77 to 9.47) for current and former smokers respectively as compared with non-smokers (results not shown).

Table 2 presents frequencies and the results of the Cox regression analyses for geographic, residential, and SES factors for time until lung cancer or COPD mortality adjusted for age, race/ethnicity, gender, and smoking. Rural residence and type of SMSA residence did not show increased mortality risk from either lung cancer or COPD relative to those with urban residence or residence in a Central City SMSA. Risk of death from COPD was increased for the Mountain US Census division (RR=1.40, p=0.03, Table 2).

Risk by marital status did not differ from the referent category, married, for lung cancer mortality in the smoking-adjusted models (Table 2). Mortality risk from COPD, however, was increased significantly for those who were widowed or divorced (RR=1.33, p<0.01) and increased, but not significantly, for those who were separated relative to those who were married.

Adjusted mortality risks for lung cancer and COPD were significantly increased for those with less than a high school diploma (RR=1.77, p<0.01 for lung cancer; RR=1.87, p<0.01 for COPD) relative to those with education beyond a high school diploma. Mortality risk was significantly elevated for those with a high school diploma (RR=1.50, p<0.01 for lung cancer and RR=1.40, p<0.01 for COPD) relative to those with an education beyond a high school diploma.

Lung cancer mortality risk was non-significantly increased for those who were not insured relative to those insured (RR=1.35). Access to health insurance did not impact mortality risk for COPD, RR=0.86.

Mortality risk for lung cancer and COPD was significantly increased for lower family income. There is a significant trend for increasing risk of mortality for both lung cancer and COPD with decreasing income (results not shown). Lung cancer mortality risk significantly increased for those with less than a high school education relative to greater than a high school education (results not shown). COPD mortality risk by education and smoking was similar. Significant trend relationships for increased lung cancer and COPD mortality risk and decreasing income were detected among current and former smokers (results not shown).

Discussion

The NLMS data provide mortality rates for outcomes that may not be obtainable otherwise. Mortality rates for lung cancer and COPD are presented by demographic background and by smoking. The Cox regression analysis focuses on potential health disparities factors in a representative sample of the U.S. population, controlling for self-reported smoking.

A primary risk factor for chronic obstructive pulmonary disease (COPD) is smoking[21–23]. In a study of male British doctors, COPD mortality rates were less than half for former smokers compared with current smokers[22]. Our results agree with previous studies that former smokers have a decreased risk of lung cancer mortality compared with current smokers[24]. COPD rates among former smokers in our analysis were slightly more than half the rate among current smokers.

No significant differences for lung cancer mortality risk for urban and rural residence and SMSA residence were found. Non-SMSA dwellers had decreased COPD mortality risk relative to SMSA dwellers may indicate a role for air quality in the risk of COPD death. Fine particulate air pollution has been previously associated with daily mortality[25]. An extension of the Harvard Six Cities Study found total, cardiovascular, and lung cancer mortality positively associated with ambient PM2.5 concentrations; reduced PM2.5 concentrations were associated with reduced mortality risk[25]. SMSA central city residents may be exposed to higher concentrations of particulate matter, reflecting higher risks of mortality. Residents who do not live in these areas have reduced mortality. An airborne particulate matter source apportionment workgroup reported that soil sources and residual oil sources were more consistent in explaining PM2.5 sources and traffic sources were not consistently correlated with PM2.5[26].

The magnitude of COPD mortality risk was slightly higher than that of lung cancer for U.S. Census divisions with an increased risk. Underlying reasons for these differences are unknown; lung cancer mortality is not subject to the reversibility that can be observed with lung diseases where particulate air pollution is a major risk factor[27]. Lung cancer and COPD mortality risk decreased in the West North Central division relative to the Pacific region, perhaps due to better air quality.

Our results concur with increased risk of death from COPD in the Mountain division described previously[28, 29]. Particulate matter is associated with non-malignant respiratory diseases and mortality based on changes in PM 2.5[27]. Many areas of the Mountain region are exposed to dusty industries, including farming and mining. Reduced oxygen concentration in the Mountain division may make lung function more difficult among those with pulmonary challenges. Lifestyle factors, including diet and physical fitness, and environmental factors, including air pollution, particulate matter, and other air toxics specific to the U.S. Census divisions, in consideration of population density would be recommended for further analysis. COPD and lung cancer mortality risk among those widowed, divorced, or separated compared with married individuals, is similar to a finding that unmarried individuals have a higher risk compared with married persons[30]. Lower socio-economic status (lower education and low income) and a higher percentage of households at the poverty level resulted in higher mortality risks for lung cancer and COPD among current and former smokers. Higher incidence and mortality of lung cancer has been associated with socioeconomic disadvantage including working class jobs, lower education, and lower income[31–33].

Lack of health insurance had a greater impact on lung cancer mortality than COPD mortality, as there was a non-significant increased mortality risk for lung cancer for those lacking health insurance. COPD, lung cancer, and heart disease, share inflammation as part of their pathology[34]. Death from COPD may be underreported on death certificates when the ante-mortem symptoms are less severe as opposed to COPD cases that have moderate to severe symptoms[35]. Access to care determines which lung cancer patients receive surgery, which increases their chances for long term survival. Conversely, it is possible for COPD patients to survive with or without care until they become eligible for Medicare. Future studies of health insurance should explore lung cancer and non-cancer lung diseases, interventions and effects on morbidity and mortality to increase our understanding of the role of health insurance.

The strengths and limitations of these data and the analysis should be carefully considered. These data are prospective and mortality rates are based on person years of observation; strengths include self-reported lifestyle factors and self-reported tobacco exposure. Vital status was determined using the NDI after the CPS interviews were conducted. Smoking (never, current and former smoker) was collected only at the time of interview. Cigarettes smoked per day, number of years of smoking and pack years, and time since cessation are not available in the CPS.

A potential limiting factor of the analysis is multiple comparisons. Our concern was whether variables that have more than three or four levels, such as U.S. Census division are associated with mortality risk. Results of the global test of association to address the possibility of type-1 errors indicated that U.S. Census division, income, and education for lung cancer, and income, education, and poverty level for COPD were significant indicating a global association for each level of these variables. The significance of the global test for U.S. Census division for lung cancer ($p=0.03$) and marginal significance for COPD agrees with our relative risk findings. Level of significance is also considered when there is concern of type-1 error; many associations are highly significant ($p<0.01$).

In summary, our analysis agrees with previous associations of self-declared smoking status and mortality from lung diseases. While the same health disparity indicators were often associated with both lung cancer and COPD mortality, the magnitude of the risk differs between the two outcomes. Etiologies of lung cancer and other lung diseases differ, however these results may guide surveillance efforts for cancer and non-cancer lung causes of death, provide information to the public, shape research questions, and focus prevention efforts for respiratory health in various subpopulations. Future research using NLMS and SEER data will ascertain the importance of histologic and staging factors for lung cancer mortality with health disparity indicators.

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Table 1

Mortality rates for lung cancer and COPD by demographic characteristics, National Longitudinal Mortality Study, United States, 1985, 1992, 1993, 1995, 1996

	Lung cancer (n = 1,273)			Chronic obstructive pulmonary disease (n = 772)		
	# Deaths	Person-years	Rate[b]	# Deaths	Person-years	Rate[b]
Baseline Age						
25 to 44	64	941,144.25	12.20	10	941,144.25	2.02
45 to 54	129	243,211.56	19.50	45	243,211.56	10.00
55 to 64	391	217,166.26	49.88	170	217,166.26	26.86
65 to 74	447	162,254.60	52.71	303	162,254.60	36.93
75 to 84	217	75,209.34	26.92	211	75,209.34	25.69
85+	25	14,667.11	4.09	33	14,667.11	5.40
Gender						
Male	795	764,304.43	103.60	433	764,304.43	46.18
Female	478	889,348.67	46.72	339	889,348.67	25.17
Race/Ethnicity[a]						
Hispanic white	14	79,031.09	27.33	7	79,031.09	11.26
Non-Hispanic White	1115	1,343,013.61	72.89	705	1,343,013.61	35.16
Black	104	147,045.28	75.41	36	147,045.28	22.17
Others	19	53,221.51	46.96	8	53,221.51	19.76
Unknown	21	31,341.61	55.16	16	31,341.61	31.92
Smoking Status						
Never	143	837,868.96	15.56	98	837,868.96	9.62
Current	679	466,200.34	184.29	342	466,200.34	106.72
Former	451	349,583.80	84.78	332	349,583.80	63.12

[a]Hispanic ethnicity includes white Hispanic. White, black and other are non-Hispanic.

[b]Mortality rate is direct adjusted per 100,000 person years.

Table 2

Adjusted relative risks for lung cancer and COPD cause of death adjusted for age, race/ethnicity, gender, and smoking status for geographic, residential, and SES factors. National Longitudinal Mortality Study, United States, 1985, 1992, 1993, 1995, 1996

	Lung Cancer # DeathsRR[a]	99% CI[a]	Chronic Obstructive Pulmonary Disease # DeathsRR[a]	99%CI[a]
Urban/Rural Residence				
Rural	3650.91	0.78, 1.07	2250.94	0.77, 1.16
Urban	9081.00		5471.00	
SMSA[b]				
SMSA not Central City	4640.94	0.78,1.14	2660.87	0.68, 1.12
Not an SMSA	4760.90	0.75,1.09	3080.93	0.74, 1.19
SMSA, Central City	3331.00		1981.00	
US Census Division				
New England	1100.92	0.65,1.29	741.00	0.65, 1.54
MidAtlantic	2151.12	0.83,1.50	1020.90	0.61, 1.34
East North Central	2061.09	0.81,1.47	1311.22	0.83, 1.78
West North Central	1120.88	0.63,1.23	700.91	0.59, 1.40
South Atlantic	2491.07	0.80,1.43	1361.04	0.71, 1.51
East South Central	701.10	0.74,1.63	391.13	0.67, 1.89
West South Central	1121.19	0.85,1.67	631.22	0.78, 1.90
Mountain	740.74	0.51,1.08	731.40	0.92, 2.12
Pacific	1251.00		741.00	
Marital Status				
Widowed/Divorced	3410.97	0.81,1.17	2841.33[c]	1.07, 1.66
Separated	261.11	0.66,1.86	151.66	0.84, 3.30
Never Married	490.69	0.47,1.01	220.95	0.59, 1.52
Married	8571.00		4411.00	
Education				
<HS Diploma	5781.77[c]	1.45,2.17	3881.87[c]	1.44, 2.42
HS Diploma	4511.50[c]	1.22,1.84	2451.40[c]	1.07, 1.85
>HS Diploma	2441.00		1391.00	
Health Insurance Status				
No Health Insurance	241.35	0.79,2.32	60.86	0.30, 2.50
Health Insurance	4011.00		2581.00	
Family Income 1990 US$				
<$10,000	2511.50[c]	1.12,2.00	2052.46[c]	1.65, 3.66
$10,000–$20,000	3381.45[c]	1.10,1.90	2512.13[c]	1.45, 3.13
$20,000–$40,000	4221.43[c]	1.10,1.87	2131.61[c]	1.09, 2.37
$40,000–$60,000	1381.33	0.97,1.83	471.08	0.65, 1.80
>=$60,000	801.00		301.00	

[a] RR, relative risk; CI, confidence interval

[b] SMSA, Standard metropolitan statistical area

[c] $p<0.01$