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Rural Disparities in Lung Cancer Mortality: An Ecologic Study in Florida

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RURAL DISPARITIES IN LUNG CANCER MORTALITY: AN ECOLOGIC STUDY IN FLORIDA

by

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ABSTRACT

Lung cancer is the leading cause of cancer death in the United States and worldwide. The higher mortality among patients with lung cancer is related to cases being diagnosed in late stage where treatment is limited. Urban and rural health outcomes are potentially influenced by differences in accessibility to health care services. We are unaware of existing research examining geographic differences in or factors related to lung cancer mortality in Florida. Therefore, this study aims to examine lung cancer mortality differences between urban and rural counties in Florida. We examined all 67 counties in Florida to investigate if a rural disparity exists in lung cancer mortality. We collected data from the National Cancer Institute (NCI) State Cancer Profile. We assigned urban and rural designation using the United States Census Bureau definition based on population density. We then used a t-test for unequal variances to compare the mean lung cancer mortality rate for the urban counties versus rural counties using Microsoft Excel®. We used ArcGIS Pro software to create three maps: one showing urban and rural county designations, one showing lung cancer mortality, and a third bivariate map of urban and rural designations combined with age-adjusted lung cancer mortality rates together to examine the geographic distributions in Florida. We observed a mean age-adjusted lung cancer mortality of 62.7 per 100,000 for rural counties in Florida and a mean of 44.2 per 100,000 for urban counties which was significantly different using a t-test for unequal variances ($p<0.0001$). The counties with the highest lung cancer mortality were grouped geographically in Florida's Big Bend area. Overall, rural counties had a significantly higher average lung cancer mortality than the urban

counties in Florida. Future research should examine factors affecting higher lung cancer mortality in rural counties such as screening locations and access to care.

DEDICATIONS

A special feeling of gratitude to my loving parents, Rita and Moris Amouyal, thank you for always believing in me; reminding me I could do whatever I set my mind to. The two of you always taught me to be a lover of knowledge. Thank you for always setting me high standards for me. I love you both.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE: INTRODUCTION

Lung cancer kills 1.5 million people worldwide per year[1]. Lung cancer, breast cancer, and prostate cancer are the top three causes of cancer deaths in the United States. However, lung cancer is the primary cause for cancer-related death in both the US and worldwide[2]. This higher mortality rate is related to most lung cancer cases being diagnosed in stage 4, where treatment options are limited, thereby decreasing chances of survival[3]. Lung cancer is hard to detect in early stages because of its few clinical symptoms are manifested[19]. Five year survival rates for lung cancer are only 18% nationally[3,10] compared to 85% survival for breast cancer[4], and nearly 100% survival rate for prostate cancer[5].

In 1964, smoking was recognized as a cause of lung cancer[1]. Even though tobacco smoking has decreased since then, smoking remains the leading cause of lung cancer with around 90% of cases diagnosed in current or former smokers[6]. Other than smoking, lung cancer has other risk factors including exposures to chemicals (e.g., asbestos, nickel, arsenic, and chromium) exposure to radiation, outdoor air pollution, and secondhand smoke[7]. Other risk factors for lung cancer are mutations to selected genes as well as a family history of lung cancer[8,9].

For all stages, only 18% of lung cancer cases survive for five years following diagnosis[3,10]. Lung cancer mortality rates in the United States are decreasing but not equally across geographies[7]. Urban and rural residence may play a role in lung cancer mortality

geographical differences[11]. Rural populations have higher all cause mortalities as well as higher late-stage lung cancer incidence compared to urban populations across the overall United States[2]. In some rural areas, lung cancer mortality is up to 20% higher than in metropolitan areas[10]. While improvements in mortality are being made in urban areas, rural areas lag behind[11]. In order for people to have an effective screening and potentially improved survival, access to medical centers is needed, a resource that is often unavailable or limited in rural areas.

In Florida, more research is needed examining potential urban and rural differences in lung cancer mortality. State data from the American Lung Association reports that Florida ranks 15th in states with the highest percentage of lung cancer cases receiving surgery for first-course treatment[3]. The percentage of cases in Florida receiving surgery was 21.3%, slightly higher than the national rate of 21.0%.[3] The report also estimated that the smoking rate in Florida is about 15.8%, slightly lower than the national level at 16.8%. We are unaware of additional research examining geographic differences in or factors related to lung cancer mortality in Florida. Therefore, this study aims to examine lung cancer mortality differences between urban and rural counties in Florida. These results will help us understand the mortality rate difference by rural and urban designation and examine factors driving potential differences in future research.

HYPOTHESES

H_0: Rural counties in Florida will have the same mortality rates for lung cancer as urban counties in Florida.

H_1: Rural counties in Florida will have significantly higher mortality rates for lung cancer than urban counties in Florida.

CHAPTER TWO: METHODS

Data source

We used lung cancer mortality data from the National Cancer Institute (NCI) State Cancer Profiles[12]. The NCI State Cancer Profiles is a system used to characterize the cancer burden in a standardized format to accommodate surveillance for cancer control planning from diagnostic stage to treatment. Moreover, the CDC characterizes areas and demographic groups, and exposures such as smoking for each county in the US. Incidence data for the diagnosis year 2016 was added for state and metropolitan area central cancer registries from data submitted to the National Cancer Institute's Surveillance, Epidemiology, and End Results Program in November 2018. Incidence data for the diagnosis year 2016 were added by the National Program of Cancer Registries Cancer Surveillance System (NPCR-CSS). Updated death data through 2016 were also added for data provided by the National Vital Statistics System[12]. Our research focused on county level mortality in Florida. We have included data for all 67 counties in Florida 5-year period (2012-2016) with age-adjusted mortality rates per 100,000 populations.

Urban and Rural Designation

For urban and rural designation, we used the United States Census Bureau definition which defines rural and urban areas based on population density[14]. Counties with more than 50% of the population living in a rural area were classified as rural. Counties with less than 50% of the population living in rural areas were defined as urban. Rural areas are defined as "Population densities less than 500 people per square mile and place with fewer than 2,500 people."[13]

Mortality by Urban-Rural Designation

We assessed county-level mortality rates in Florida and made a comparison for lung cancer mortality between rural and urban counties in Florida. After assigning urban and rural designations, we calculated the mean age-adjusted lung cancer mortality for urban Florida counties and the mean age-adjusted lung cancer mortality for rural Florida counties. We then tested for differences in the variances using the F-test and tested for differences in the mean using the T-test for unequal variances. We created three maps of our data. The first showed county urban and rural designations while the second map showed tetriles of lung cancer mortality for all Florida counties (low, medium, and high mortality). Finally, we created a bivariate map of urban and rural designations and tetriles of age-adjusted mortality rates for geographic comparison of dissimilar distributions on the same map. The maps were made using ArcGIS Pro software. All statistical analyses were performed using Microsoft Excel®.

CHAPTER THREE: LITERATURE REVIEW

Lung cancer overview

Lung cancer is a massive killer in the US and worldwide because it is hard to detect in early stages when treatment options are most successful in improving survival. Diagnosis of lung cancer is difficult because of its location and late presentation of symptoms. Stages for lung cancer are based on the size and location of the tumor and the involvement of lymph nodes and or other organs. Most cases of lung cancer are diagnosed at stage 4. Lung cancer diagnosed in stage 4 is very hard to treat and has a low probability of survival. At this stage, surgeries are often not recommended or unsuccessful because the cancer has already spread resulting in low survival rates[15].

Overall differences in urban-rural lung cancer survival

Rural areas are defined with low-density populations, remoteness, and long distances from metropolitan areas[18]. Urban-rural residence may play a part in lung cancer mortality. Mortality tends to be higher in rural areas than in urban. In rural areas, access to health care is limited. Urban and rural disparities in health outcomes have been shown to be directly reflected by the differences inaccessibility to health care services[19]. Rural residents face difficulties accessing health care centers with longer drive times than urban residents. For patients to have better survival chances they must have access to medical centers that can provide needed cancer care[16]. In rural areas, availability for cancer care centers is low. Evidence exists for people who lives in rural areas that have destitute of cancer survival[17]. A patient who does not live close by

cancer centers or medical care has a greater chance of being diagnosed in a later stage as well as a lower chances of getting proper treatment resulting in a low rate for survival[17].

Other factors related to lung cancer

Smoking continues to be the most dominant cause of lung cancer. Other than that, lung cancer can have many other factors. Demographic factors such as race, age, sex, in addition to occupational and smoking history will correlate with lung cancer mortality. Traditionally, people with low income tend to live in lower socioeconomic areas, where educational resources and health care centers are limited. Income, education, and wealth have a direct effect on health outcomes[20]. Exposures to chemicals such as asbestos, nickel, arsenic, and chromium during life will lead to a higher risk for lung cancer development. Exposure to radiation, outdoor air pollution, and secondhand smoke have been shown to cause lung cancer as well[7]. Mutations that occur to selected genes over the course of one's life can occur in lung cells[8,9], which can impact the risk for developing lung cancer. Additionally, family history of lung cancer is associated with a greater risk for developing lung cancer due to environmental and genetic factors shared by a family[9].

Lung Cancer in Florida

In Florida, there are very low percentages of the overall cases of lung cancer being diagnosed in an early stage providing a good chance for survival. Sadly, 46.9% are not being captured until the very late stage were survival stands at only 4.5%[3]. The geographic distribution of lung cancer death rates in Florida are highest in counties in The Big Bend area

of the state as shown by the National Cancer Institute's State Cancer Profiles (Figure 1). Lung cancer death rates have not been previously examined in Florida by urban and rural status, therefore more research is needed to assess whether lung cancer mortality differences between urban- rural counties exist in the state of Florida.

CHAPTER FOUR: RESULTS

A mean for lung cancer mortality for the years of 2012- 2016 for all ages, both sexes, and all races, was calculated for Florida counties by rural and urban areas (Table 1). We observed a mean age-adjusted lung cancer mortality of 62.7 per 100,000 for rural counties in Florida and a mean of 44.2 per 100,000 for urban counties. We observed a variance of 64.8 for urban counties and 360.10 for rural counties. The p-value for our F-test was less than 0.0001, indicating unequal variance for our two groups, directing us to use the t-test for unequal variances. The t-test results we observed were statistically significant ($p<0.0001$) indicating a significant difference in the mean lung cancer mortality for urban and rural counties in Florida. The five counties with the lowest mortalities rates from lung cancer were: Collier, Miami- Dade, Broward, Palm Beach, and Osceola. All five are urban counties. The five counties with the highest mortality rates were: Union, Columbia, Putnam, Levy, and Dixie. All five are rural counties. The county with the highest death rate was Union county with 142.8 death per 100,000.

Using the data for urban-rural mortality rates we created three maps. One map for urban rural designation according to the United States Census Bureau definition for urban and rural areas (Figure 1) showed the majority of rural counties were located in north Florida. For the second map, we used data from the National Cancer Institute (NCI) State Cancer Profiles for mortality rates for lung cancer in Florida (Figure 2). Here we observed a clustering of high mortality counties in the Big Bend area of the state. For the third map, we combined both maps into a bivariate map of mortality rates urban-rural designation. The results from the bivariate

map showed high mortality rates in rural areas. The Big Bend region is mainly rural counties with high mortalities rates shown in Figure 3.

Figure 1: Urban- Rural Designation

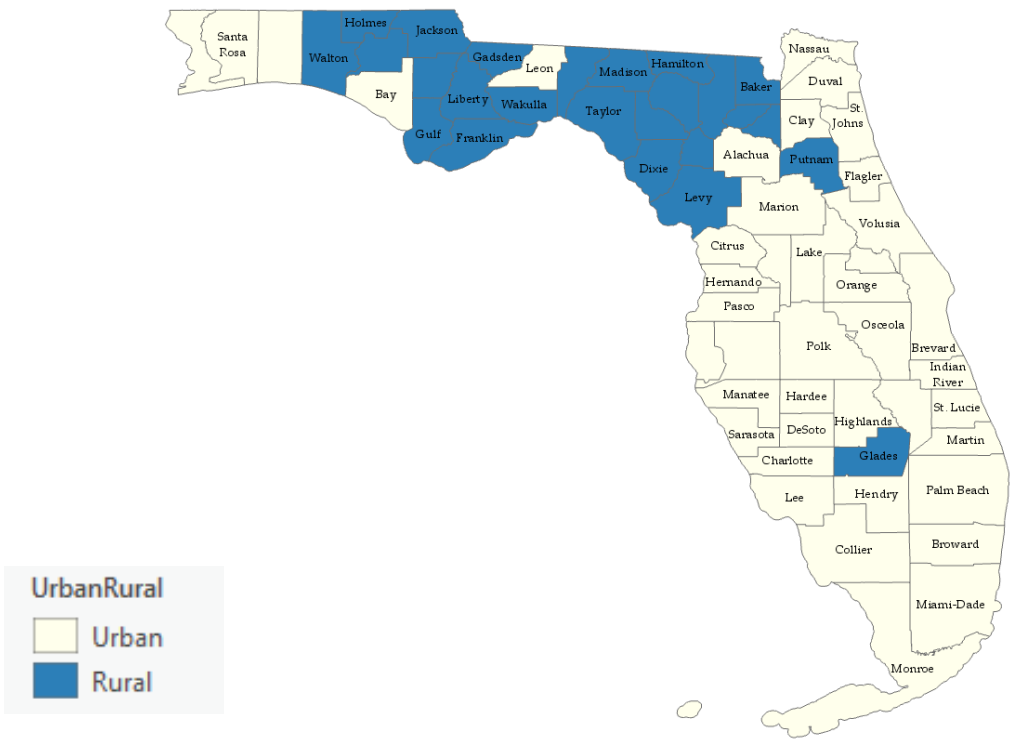


Figure 2: Mortality Rates by County in Florida

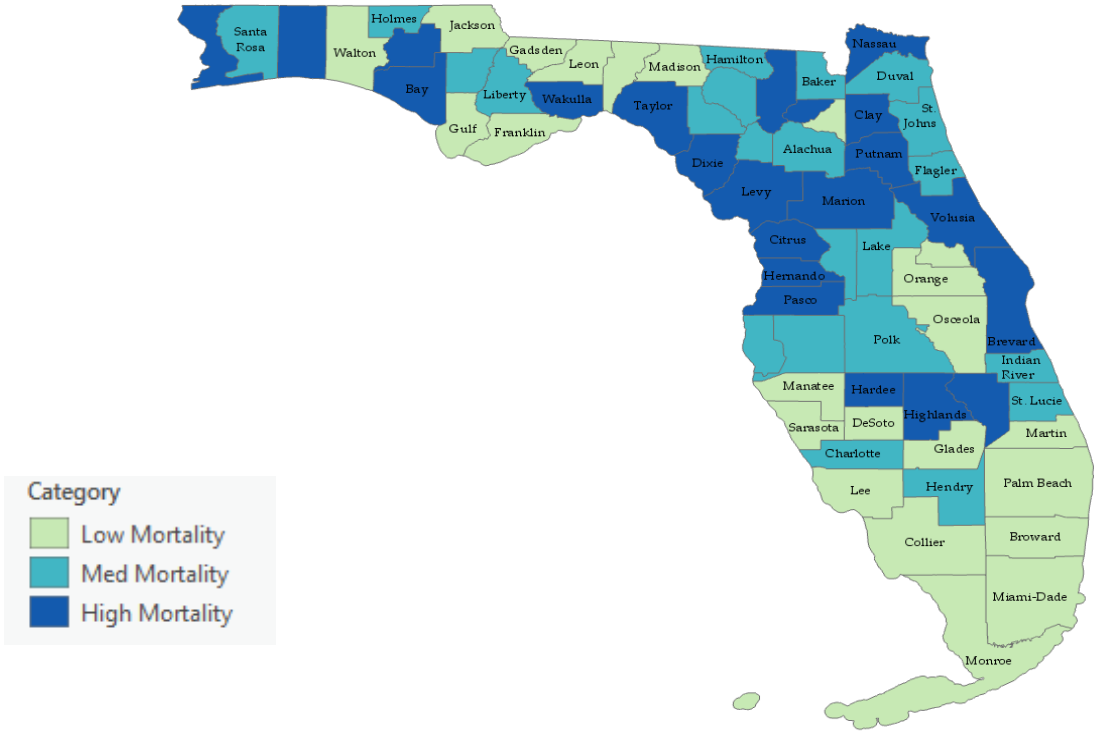
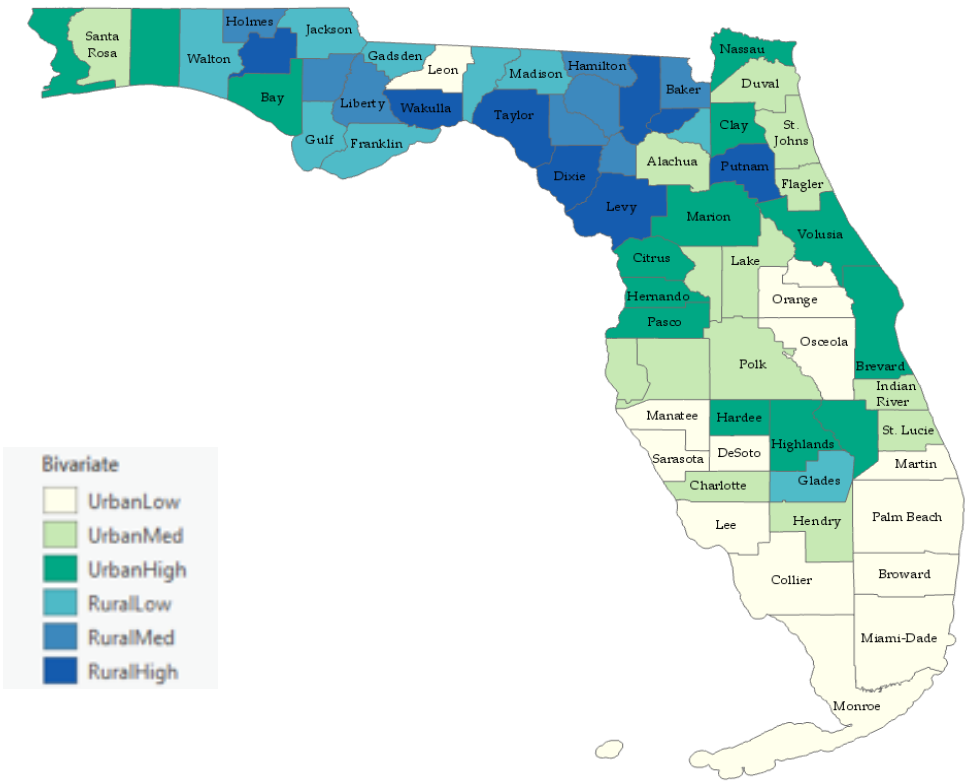


Figure 3: Bivariate Mortality Rate and Urban- Rural Designation in Florida Counties



CHAPTER FIVE: DISCUSSION

A significantly different mean for lung cancer mortality was observed across all Florida state counties with separation of rural and urban areas, with rural counties having a higher lung cancer mortality. This is in line with previously published studies examining urban and rural differences in cancer mortality for states other than Florida[2,10,11]. The counties were grouped geographically in a bivariate map that allowed for visualizing Florida's Big Bend as the area with the highest lung cancer mortality rate among rural counties, a novel finding for geographic clustering of lung cancer mortality in Florida. These results helped us understand the mortality rate differences by rural and urban designation and provide a foundation to examine factors driving potential variations for future research.

The mean mortality rate difference by rural and urban designation observed for Florida counties has been observed in other regions of the United States as well. Urban counties generally have better access to health care centers as well as cancer centers[16,19]. Additionally, rural counties generally have less geographic availability of low dose computed tomography for lung cancer screening that may thereby delay a diagnosis of cancer. Lung cancer has a dependent relation to early diagnosis in terms of treatment options and mortality. Other factors potentially driving higher lung cancer mortality in rural areas include access to health centers as well as limited cancer specialists practicing in rural areas and driving time to health care/cancer care facilities.

Limitations and Strengths

This study is an ecological study solely based on geographic location and mortality rates with data analysis pulling from secondary data sources. The ecologic design does not allow the capability in associating a disease and an exposure factor at the individual level. We also were unable to control for potential confounding variables such as age sex, and race. Our project was limited to Florida. Despite these limitations, our data was updated from reliable sources. We included all 67 counties in the state of Florida. Our data consisted of years 2012-2016, the most up to date data available at the time of our study. We also used bivariate mapping to provide data visualization, a novel approach for identifying geographic trends in epidemiologic outcomes.

Conclusion

Lung cancer is the leading cause of cancer death in the United States and worldwide. We found a higher mean lung cancer mortality for rural counties in Florida compared to urban counties in Florida. The higher mortality among patients with lung cancer has been previously documented outside of Florida and is related to cases being diagnosed in late stage when treatment is limited. Urban and rural health outcomes are reflected by different accessibility to health care services. We also found a geographic clustering in the Big Bend area of Florida. We are unaware of existing research examining geographic differences in or factors related to lung cancer mortality in Florida. Our results provide information needed to examine factors driving higher rural mortality in Florida and identifies the Big Bend as a geographic area in the state potentially in need of greater healthcare resources to reduce lung cancer mortality in the future.

LIST OF TABLES

Table 1: County level Age-Adjusted Lung Cancer Mortality

County Name	Age- Adjusted Lung Cancer Mortality	Urban/ Rural Designation
Union County	142.8	Rural
Columbia County	70.2	Rural
Putnam County	70.1	Rural
Levy County	69.6	Rural
Dixie County	69	Rural
Wakulla County	68.4	Rural
Washington County	68	Rural
Taylor County	66.6	Rural
Liberty County	65.5	Rural
Calhoun County	65.3	Rural
Baker County	65.2	Rural
Hamilton County	63.6	Rural
Holmes County	63.3	Rural
Okeechobee County	61.9	Urban
Gilchrist County	61.3	Rural
Suwannee County	60.7	Rural
Escambia County	56.8	Urban
Citrus County	56.7	Urban
Nassau County	55.2	Urban
Lafayette County	55	Rural
Jackson County	54.5	Rural
Hardee County	54	Urban
Madison County	54	Rural
Clay County	53.9	Urban
Gulf County	53.3	Rural
Okaloosa County	52.9	Urban
Pasco County	52.5	Urban
Franklin County	52.5	Rural
Bradford County	52.2	Rural
Hernando County	51.9	Urban
Brevard County	51.5	Urban
Volusia County	49.5	Urban
Highlands County	49.5	Urban

Walton County	49.4	Rural
Marion County	48.4	Urban
Bay County	48.3	Urban
Duval County	47.8	Urban
Lake County	47.6	Urban
Santa Rosa County	47.5	Urban
Pinellas County	46.3	Urban
Gadsden County	46.2	Rural
Polk County	45.4	Urban
St. Lucie County	44.8	Urban
Indian River County	44.8	Urban
Flagler County	44.5	Urban
Charlotte County	43.4	Urban
Hillsborough County	42.9	Urban
Glades County	42.6	Rural
Hendry County	41.9	Urban
St. Johns County	41.7	Urban
Alachua County	41.3	Urban
Jefferson County	38.9	Rural
Sumter County	38.3	Urban
Sarasota County	38.1	Urban
Martin County	37.7	Urban
Monroe County	37.7	Urban
Leon County	37.6	Urban
DeSoto County	37.5	Urban
Seminole County	37.3	Urban
Manatee County	37.1	Urban
Lee County	37.1	Urban
Orange County	36.1	Urban
Osceola County	35.8	Urban
Palm Beach County	34.3	Urban
Broward County	33.8	Urban
Miami-Dade County	27.5	Urban
Collier County	27.2	Urban

REFERENCES

1. Proctor RN. The history of the discovery of the cigaretteelung cancer link: Evidentiary traditions, corporate denial, global toll. *Tob Control*. 2012;21(2):87-91. doi:10.1136/tobaccocontrol-2011-050338
2. Jenkins WD, Matthews AK, Bailey A, et al. Rural areas are disproportionately impacted by smoking and lung cancer. *Prev Med Reports*. 2018;10:200-203. doi:10.1016/j.pmedr.2018.03.011
3. Florida | American Lung Association. https://www.lung.org/our-initiatives/research/monitoring-trends-in-lung-disease/state-of-lung-cancer/states/FL.html. Accessed September 18, 2019.
4. Breast Cancer: Statistics | Cancer.Net. https://www.cancer.net/cancer-types/breast-cancer/statistics. Accessed November 6, 2019.
5. Prostate Cancer: Statistics | Cancer.Net. https://www.cancer.net/cancer-types/prostate-cancer/statistics. Accessed November 6, 2019.
6. Odahowski CL, Hébert JR, Eberth JM. Regional variation in lung and bronchus cancer survival in the US using mortality-to-incidence ratios. *Spat Spatiotemporal Epidemiol*. 2018;26:107-112. doi:10.1016/j.sste.2018.06.004
7. Alberg AJ, Brock M V., Ford JG, Samet JM, Spivack SD. Epidemiology of Lung Cancer: Diagnosis and Management of Lung Cancer. *Chest*. 2013;143(5):e1S-e29S. doi:10.1378/CHEST.12-2345
8. What Causes Lung Cancer | American Lung Association. https://www.lung.org/lung-

health-and-diseases/lung-disease-lookup/lung-cancer/learn-about-lung-cancer/what-is-lung-cancer/what-causes-lung-cancer.html. Accessed September 24, 2019.

9. Kanwal M, Ding XJ, Cao Y. Familial risk for lung cancer. *Oncol Lett*. 2017;13(2):535-542. doi:10.3892/ol.2016.5518

10. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2016. - PubMed - NCBI. *CA Cancer J Clin*. 2016;66(1):7-30. doi:10.3322/caac.21332

11. Zahnd WE, James AS, Jenkins WD, et al. Rural-Urban differences in cancer incidence and trends in the United States. *Cancer Epidemiol Biomarkers Prev*. 2018;27(11):1265-1274. doi:10.1158/1055-9965.EPI-17-0430

12. About State Cancer Profiles. https://statecancerprofiles.cancer.gov/about/. Accessed October 10, 2019.

13. USDA ERS - What is Rural? https://www.ers.usda.gov/topics/rural-economy-population/rural-classifications/what-is-rural/. Accessed October 10, 2019.

14. Urban and Rural. https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural.html. Accessed November 6, 2019.

15. Amini A, Verma V, Glaser SM, et al. Early mortality of stage IV non-small cell lung cancer in the United States. *Acta Oncol (Madr)*. 2019;58(8):1095-1101. doi:10.1080/0284186X.2019.1599138

16. Loftus J, Allen EM, Call KT, Everson-Rose SA. Rural-Urban Differences in Access to Preventive Health Care Among Publicly Insured Minnesotans. *J Rural Heal*. 2018;34:s48-s55. doi:10.1111/jrh.12235

17. Campbell NC, Elliott AM, Sharp L, Ritchie LD, Cassidy J, Little J. Rural and urban

differences in stage at diagnosis of colorectal and lung cancers. *Br J Cancer*. 2001;84(7):910-914. doi:10.1054/bjoc.2000.1708

18. Measuring Rurality. http://www.incontext.indiana.edu/2007/january/2.asp. Accessed November 7, 2019.

19. Shugarman LR, Sorbero MES, Tian H, Jain AK, Ashwood JS. An exploration of urban and rural differences in lung cancer survival among medicare beneficiaries. *Am J Public Health*. 2008;98(7):1280-1287. doi:10.2105/AJPH.2006.099416

20. Erhunmwunsee L, Joshi MBM, Conlon DH, Harpole DH. Neighborhood-level socioeconomic determinants impact outcomes in nonsmall cell lung cancer patients in the Southeastern United States. *Cancer*. 2012;118(20):5117-5123. doi:10.1002/cncr.26185

21. Interactive Maps. https://statecancerprofiles.cancer.gov/map/map.withimage.php?12&county&001&047&00&0&02&0&1&5&0#results. Accessed November 6, 2019.