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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

BATEL AMOUYAL

A Thesis submitted in partial fulfillment of the requirements
for the Honors in the Major Program in Health Sciences- Pre-Clinical track
in the College of Health Professions and Sciences
and in the Burnett Honors College at the University of Central Florida
Orlando, Florida

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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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CHAPTER ONE: INTRODUCTION

Lung cancer kills 1.5 million people worldwide per year¹. 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 worldwide². 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 survival³. Lung cancer is hard to detect in early stages because of its few clinical symptoms are manifested¹⁹. Five year survival rates for lung cancer are only 18% nationally^{3,10} compared to 85% survival for breast cancer⁴, and nearly 100% survival rate for prostate cancer⁵.

In 1964, smoking was recognized as a cause of lung cancer¹. 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 smokers⁶. 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 smoke⁷. 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 geographies⁷. Urban and rural residence may play a role in lung cancer mortality

geographical differences¹¹. Rural populations have higher all cause mortalities as well as higher late-stage lung cancer incidence compared to urban populations across the overall United States². In some rural areas, lung cancer mortality is up to 20% higher than in metropolitan areas¹⁰. While improvements in mortality are being made in urban areas, rural areas lag behind¹¹. 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 treatment³. 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

H₀: Rural counties in Florida will have the same mortality rates for lung cancer as urban counties in Florida.

H₁: 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 Profiles¹². 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 System¹². 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 density¹⁴. 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 tertiles 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 tertiles 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 rates¹⁵.

Overall differences in urban-rural lung cancer survival

Rural areas are defined with low-density populations, remoteness, and long distances from metropolitan areas¹⁸. 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 services¹⁹. 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 care¹⁶. In rural areas, availability for cancer care centers is low. Evidence exists for people who lives in rural areas that have destitute of cancer survival¹⁷. 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 chance of getting proper treatment resulting in a low rate for survival¹⁷.

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 outcomes²⁰. 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 well⁷. 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 family⁹.

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 where 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

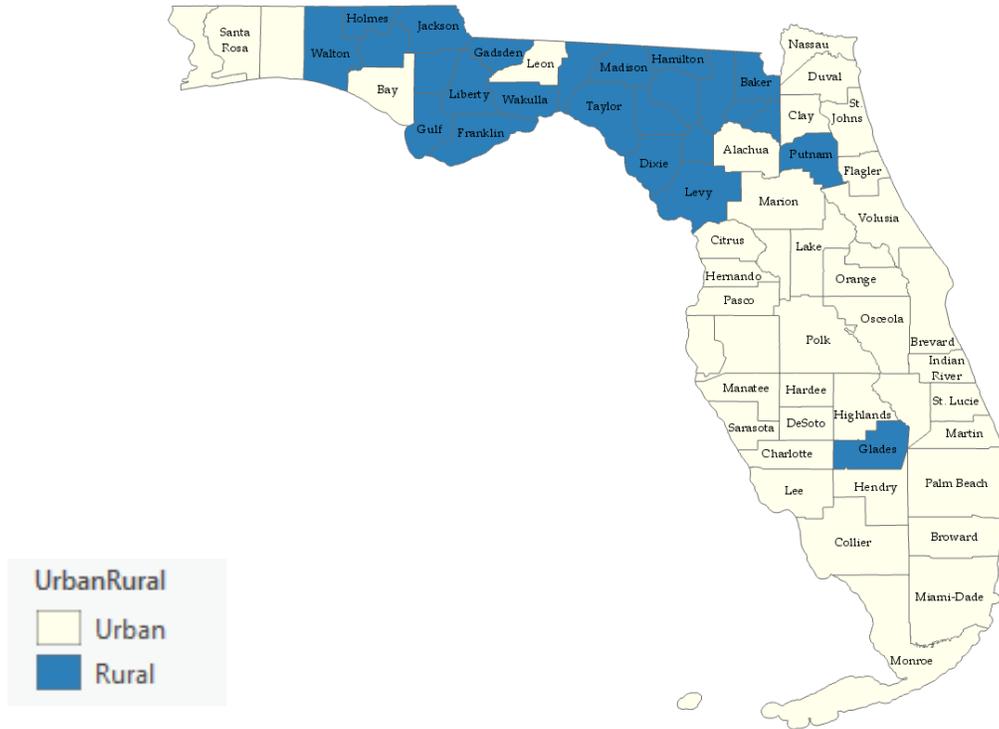


Figure 2: Mortality Rates by County in Florida

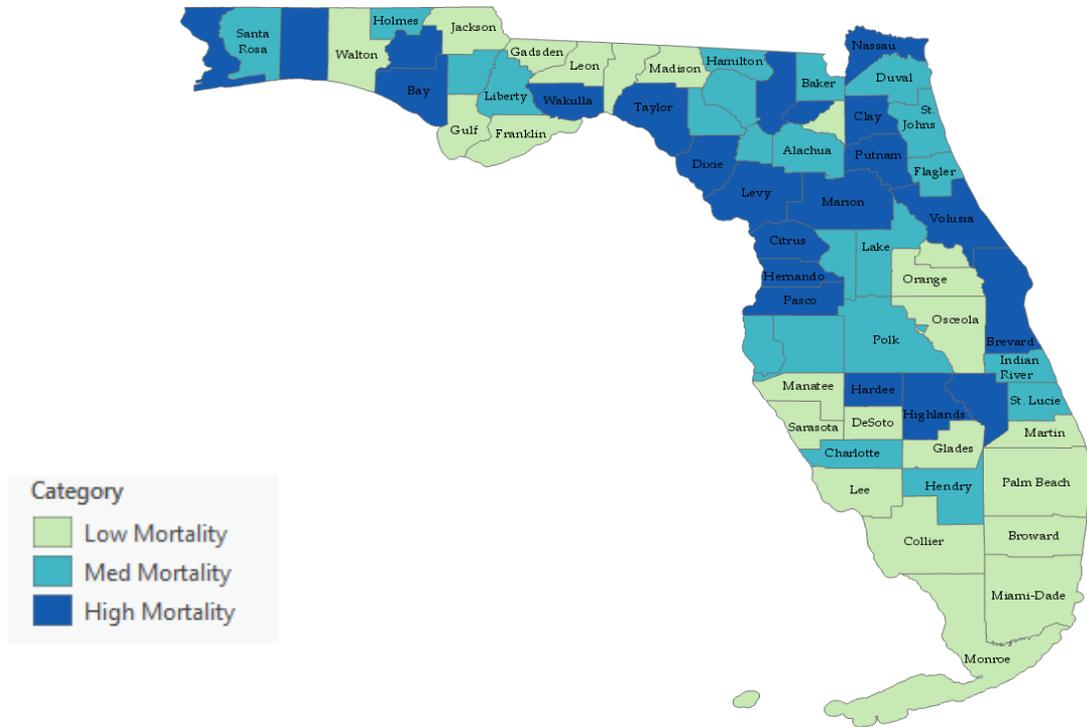
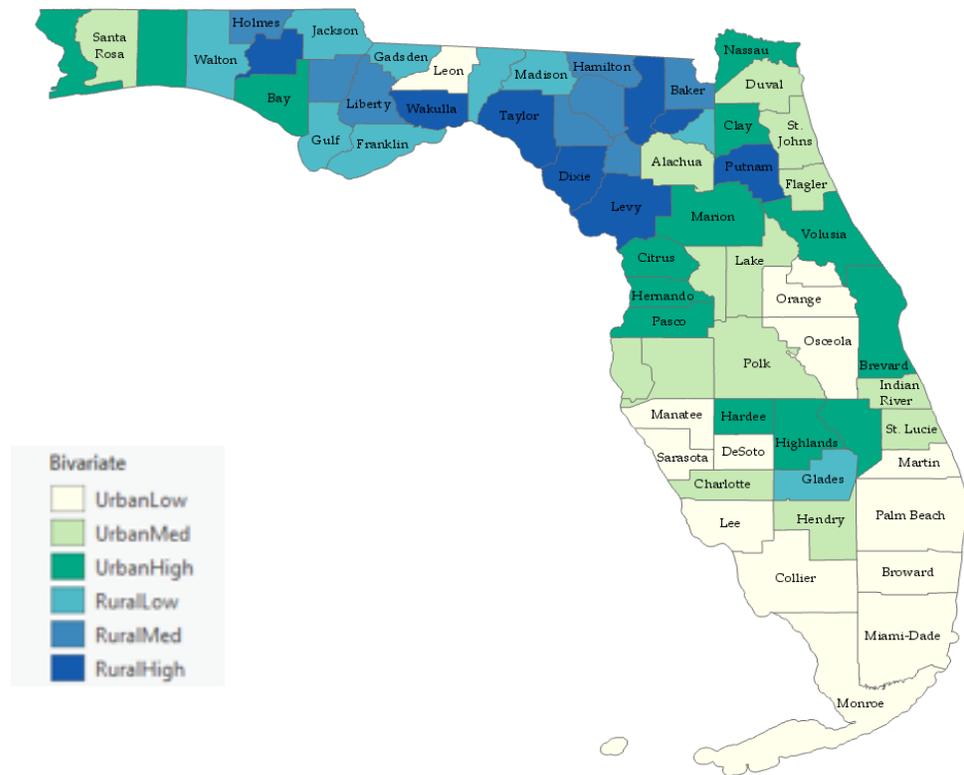


Figure 3: Bivariate Mortality Rate and Urban- Rural Designation in Florida Counties



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 |

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