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Association Between Altitude and Bronchopulmonary Cancer

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This is to certify that the doctoral dissertation by

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has been found to be complete and satisfactory in all respects,
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Abstract

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

As a validation study, this study addressed an under-researched area of bronchopulmonary cancer mortality and incidence. The association between altitude and bronchopulmonary cancer mortality and incidence was investigated using data from the Centers for Disease Control and Prevention Wide-ranging Online Data for Epidemiologic Research. The theoretical framework for my study was Bronfenbrenner's ecological model. This model emphasizes the relevance of social and physical environments that influence patterns of disease and injury and shape responses to these patterns of disease and injury. The age-adjusted bronchopulmonary cancer mortality and incidence rates per 100,000 people in the highest elevation and lowest elevation states were investigated. The data used in this study spans from 2006 to 2014. In this study, bivariate statistics were used to analyze the data. The relevant technique of performing an unpaired t-test was used. After performing age, gender, and race-stratified analysis, no significant difference in cancer mortality and incidence was found within the following three groups: Black or African American, Asian or Pacific Islander, and American Indian or Alaska Native. This was a new finding, as previous studies did not stratify for race. Cancer mortality and incidence were found to be lower in both the male and female groups for the highest elevation states. Cancer mortality and incidence were also found to be lower in all age categories for the highest elevation states. A positive social change impact of this study is that this research provides the groundwork for future studies to probe what in the environment is lowering the bronchopulmonary cancer mortality and incidence for the White population.

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Dedication

This dissertation is dedicated to my Mother and Father, Mrs. Jui-Yen Ching and Mr. Yun-Han Ching. Mom and Dad sacrificed their established and comfortable way of life in Taiwan back in 1976 to immigrate to the United States, so that my sister and I could have a bigger and brighter future here.

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Table of Contents

List of Tables

Chapter 1: Introduction to the Study

Introduction

Cancer is the second leading cause of both morbidity and mortality in the world (World Health Organization, 2018). In 2012 alone, there were 14 million new cases of cancer worldwide, and in 2015, almost 9 million people died from cancer worldwide (World Health Organization, 2018). Therefore, it is important to pay attention to this disease and learn how to treat it because one out of every six deaths is due to cancer (World Health Organization, 2018).

After reviewing the literature, I did not find any research on cancer mortality for site-specific cancers for people living at different altitudes in the years preceding 1982. However, there are studies dated 1982 and afterwards that show living at higher altitudes is associated with lower cancer mortality (Amsel, Waterbor, Oler, Rosenwaike, & Marshall, 1982; Hart, 2011; Simeonov & Himmelstein, 2015). Amsel et al. (1982) analyzed age-adjusted cancer mortality data from the U.S. Department of Health, Education, and Welfare for 34 site-specific cancers for the period from 1950 to 1969 as well as for all cancer sites as a group. They noted lower cancer mortality statistics for geographic counties characterized by their higher altitudes for tongue and mouth, esophagus, larynx, melanoma, and lung cancers as well as for all cancer sites as a group (Amsel et al., 1982).

Other studies have also shown the connection between location and cancer mortality. Hart (2011) analyzed age-adjusted cancer mortality rates for all cancers from the CDC from 2001 to 2005 for the six highest elevation states versus the six lowest

elevation states in the United States. He found that there was a strong association between low age-adjusted cancer mortality and the highest elevation states for all cancer sites as a group. Additionally, Simeonov and Himmelstein (2015) used 2005 to 2009 cancer incidence data from the Surveillance, Epidemiology, and End Results (SEER) Program at the National Cancer Institute (NCI) to search for an association between cancer incidence and altitude. Simeonov and Himmelstein found an association between lower incidence of lung cancer (lung and bronchus cancers) and living at higher altitudes. Simeonov and Himmelstein also found a weak association between lower breast cancer incidence and living at high altitudes, and they found no association between prostate or colorectal cancers and altitude. This finding for lung cancer is important because lung cancer is currently the number one cancer killer in the United States (American Lung Association, 2017).

Problem Statement

The CDC Wide-ranging Online Data for Epidemiologic Research (WONDER) portal captures information from 1999 through 2014. For example, Hart (2011) explored the age-adjusted cancer mortality data from 2001 through 2005 using CDC WONDER data for all cancers as one single group. Simeonov and Himmelstein (2015) also explored the age-adjusted lung cancer (lung cancer only, no bronchus cancer) incidence data from 2005 to 2009 using NCI data. I investigated the association between age-adjusted lung and bronchus cancer (from here on forward, referred to as bronchopulmonary cancer) mortality rates and altitude by using CDC WONDER data from 2006 to 2014. I also investigated the association between age-adjusted

bronchopulmonary cancer incidence rates and altitude by using CDC WONDER data during the same period.

My study contributes knowledge to a gap in the literature because CDC WONDER data from 2006 to 2014 is the continuation of the research conducted by Hart (2011). In my study, I controlled for three confounders: age, sex, and race. A positive social change impact of this study is that this study provides the groundwork for future studies to research what in the environment is causing differences in bronchopulmonary cancer mortality and incidence rates in the United States.

The quantitative analysis used in my study should help in understanding the nature of the association and the strength of the association between altitude and bronchopulmonary cancer incidence and mortality rates. In order to address the research questions, I measured the age-adjusted *mortality rates* per 100,000 people for bronchopulmonary cancer in the highest elevation and lowest elevation states. I also measured the age-adjusted *incidence rates* per 100,000 people for bronchopulmonary cancer in the highest and lowest elevation states. I used the same sets of highest and lowest elevation states that Hart (2011) had used in his study. This will be explained in detail under the Operational Definitions section of this chapter.

Purpose of the Study

The purpose of my study was to develop the understanding of the association between altitude and bronchopulmonary cancer mortality and incidence by studying the cancer mortality data and cancer incidence data for the lowest elevation and highest elevation states within the United States from 2006 to 2014.

Research Questions and Hypotheses

Research Question 1: Does bronchopulmonary cancer mortality differ with increased altitude?

$H_0$1: There is no association between altitude and bronchopulmonary cancer mortality.

$H_1$1: There is an association between altitude and bronchopulmonary cancer mortality.

Research Question 2: Does bronchopulmonary cancer incidence differ with increased altitude?

$H_0$2: There is no association between altitude and bronchopulmonary cancer incidence.

$H_1$2: There is an association between altitude and bronchopulmonary cancer incidence.

Research Objectives

My first research objective was to answer the first central research question posed in my dissertation, therefore demonstrating the association between altitude and incidence of bronchopulmonary cancer. The second research objective was to answer the second central research question posed in my dissertation, therefore demonstrating the association between altitude and bronchopulmonary cancer mortality. I controlled for three confounders: age, sex, and race. These risk factors were the only ones available on the CDC WONDER health portal.

Theoretical Foundation

The theoretical framework for my study was Bronfenbrenner's (1977) ecological model. This model has been modified to adapt to and be applied to different scenarios (Satariano, 2006). The ecological model emphasizes the relevance of social and physical environments that influence patterns of disease and injury and shape responses to these patterns of disease and injury. The tenets of the ecological model are depicted by the four levels of influence used in this model, and they serve as the four central components of this framework. They are the individual level, social environment, physical environment, and public policy components.

At the individual level, intrapersonal traits that influence behavior are key. The focus is on changing an individual's knowledge and attitudes to influence behavior. Individuals who receive the information on bronchopulmonary cancer incidence and mortality at higher altitudes might move to higher elevation as a prophylactic against bronchopulmonary cancer because of their increased awareness. The second level is the social environment level where interpersonal relationships between friends, colleagues, peers, family members, and members of the community influence behavior.

The third level is the physical environment level whereby the environment can have positive or negative influences. Using the methodology explained in the Nature of the Study section, I studied the age-adjusted rate per 100,000 people for bronchopulmonary cancer mortality in the highest elevation and lowest elevation states. The chosen states where I studied bronchopulmonary mortality represent the physical environment where positive or negative influences might occur. It is at this third central

component of the physical environment that my methods and measures tie into the ecological model. I used a similar methodology to study cancer incidence in the highest elevation and lowest elevation states. Finally, at the public policy level, the focus is on changing policy to influence behavior. Public health strategies may be implemented to increase awareness and understanding. The implementation of public health strategies will further advance the power and the impact of the ecological model.

Nature of Study

I conducted a quantitative study. The research design used in my study is an ecological study design. In an ecological study, the focus is not on the individual level but rather on the population or group level. The ecological study design is useful when measuring prevalence and incidence of disease. It is also both observational and retrospective. I retrospectively analyzed the 2006 though 2014 data from the CDC.

Operational Definitions

I used the same method that Hart (2011) used to determine the highest and lowest elevation states. A table from the U.S. Geological Survey displaying states and their respective lowest and highest elevation points was used. This is key for the internal validity and reliability of my study. The highest elevation points for Delaware, Washington, DC, Florida, Louisiana, Mississippi, and Rhode Island are 448, 410, 345, 535, 806, and 812 feet, respectively (U.S. Geological Survey, 2016). This means that all the other points within each of these lowest elevation states are at an altitude below these noted highest elevation points (448, 410, 345, 535, 806, and 812 feet). Examining the highest elevation points for the other 45 states reveals that their highest elevation points

are higher than those for Delaware, Florida, Louisiana, Mississippi, Rhode Island, and Washington, DC. Therefore, these six states qualify as the lowest elevation states.

A similar methodology was used in identifying the six highest elevation states. The lowest elevation points for Colorado, Montana, New Mexico, South Dakota, Utah, and Wyoming are 3,315; 1,800; 2,842; 966; 2,000; and 3,099 feet, respectively (U.S. Geological Survey, 2016). This means that the other points within each of these highest elevation states are at an altitude above these noted lowest elevation points (3,315; 1,800; 2,842; 966; 2,000; and 3,099 feet). The lowest elevation points for the other 45 states are lower than the lowest elevation points of Colorado, Montana, New Mexico, South Dakota, Utah, and Wyoming. Therefore, these six states qualify as the highest elevation states.

Assumptions

The CDC has a useful public health information portal called Wide-ranging Online Data for Epidemiologic Research (WONDER) (CDC, 2017) that allows the user to interactively request age-adjusted cancer mortality and age-adjusted cancer incidence data for different kinds of cancers. This public health information portal is practical and interactive. It allows someone to input qualifiers such as type of cancer, time frame of interest, and specific state of interest within the United States. The age-adjusted cancer incidence and age-adjusted cancer mortality data in units of number of people per 100,000 can then be requested and obtained online. I assumed that all the data provided by the CDC WONDER portal are accurate, as my research results are based on the data from this public health information portal.

It was also assumed that one of the best methods to perform this study is to use the entire population data set of all the selected highest elevation states and lowest elevation states versus specific population types within the selected states. From a statistical analysis point of view, I was able to harness the most amount of data from the CDC WONDER portal by using the entire population of the selected states. This is the reason why Hart (2011) also chose to collect and analyze the data from the entire population of the same highest elevation and same lowest elevation states.

Scope and Delimitations

The specific parameters used in my study were bronchopulmonary cancer incidence and bronchopulmonary cancer mortality along with altitude. My dissertation was focused on the association between altitude and bronchopulmonary cancer mortality and bronchopulmonary cancer incidence. I closed the gap in the literature by using new data. Moreover, I controlled the data for three confounders of sex, age, and race to observe and verify if there are differences in association for the various combinations of different groups. What the scope of this dissertation does not cover is an entire list of possible environmental factors that may be responsible for the lower rate of bronchopulmonary cancer mortality and incidence in higher altitudes. In addition to behavioral and lifestyle factors, there may be other responsible environmental factors such as better quality of water and food supply and perhaps even decreases in stress levels.

Limitations

Eighty percent of lung cancer deaths are attributed to tobacco smoking (American Cancer Society, 2018), though genetics are thought to be the reason why some people develop particular kinds of cancer. However, genetics alone are not considered to be the cause of that many lung cancers (American Cancer Society, 2018). One of the limitations of this study is that I did not control for smoking status, which is a behavioral and lifestyle factor.

Possible environmental factors such as lower air pollution levels (Pope et al., 2002), lower oxygen levels (Simeonov & Himmelstein, 2015), higher radiation levels (Scott & Di Palma, 2006), and higher vitamin D intake (Hayes, 2010) are suggested to be potential reasons for explaining differences in bronchopulmonary cancer incidence and bronchopulmonary mortality at different altitudes. However, I did not expound on these potential causes of bronchopulmonary cancer incidence and cancer mortality, focusing on the association between altitude and bronchopulmonary cancer incidence and mortality for new data. Another limitation of this study is that an association between altitude and bronchopulmonary cancer incidence and mortality does not imply causality or mean that altitude is a major influencer on bronchopulmonary cancer incidence and mortality. Moreover, my study does not account for lifestyle (such as tobacco use) or higher population densities, which lead to increased air pollution due to increased use of motor vehicles, watercrafts, and aircrafts.

Significance of the Study

My research is a validation study conducted to address an under-researched area of bronchopulmonary cancer mortality and incidence. My research design was useful for the findings of my research inquiry. The results of my study provide insight concerning how living at different elevations is associated with different bronchopulmonary cancer mortality and incidence using new data for the United States. I used the quantitative research design to amass new knowledge for the advancement of this area of study.

My research inquiry is significant because it contributes to the expansion and development of a body of knowledge. This study provides the groundwork for future studies to research what environmental factors cause differences in bronchopulmonary cancer mortality and incidence in the United States. My study also contributes to positive social change through an ecological model. The immediacy of the positive social change is brought about through the relevance of the individual component and social environment component of the ecological model. Both the individual and social circles influence patterns of disease and injury. The individual and social environment both shape responses to these patterns of disease and injury.

At the individual level, the focus is on changing an individual's knowledge and attitudes to influence behavior. Individuals may learn of the information concerning lower bronchopulmonary cancer incidence and mortality at higher altitudes. They may relocate to higher elevation as a prophylactic against bronchopulmonary cancer due to their increased awareness of this issue which may bring about an immediate positive social change.

At the social environment level, interpersonal relationships between friends, colleagues, peers, family members, and members of the community influence behavior. The immediate positive social change, through the web of these interpersonal networks and structures, expands and impacts even more people through this social arrangement and framework.

However, if individuals carry on lifestyles that are correlated with negative health outcomes (e.g., smoking) then the benefits of living at higher altitudes may not be able to counteract against the detriments of these lifestyles. Therefore, lifestyle must be factored for in determining the benefits of moving to a higher elevation.

Summary and Transition

The CDC WONDER data that I analyzed runs from 2006 through 2014. This chapter included the problem statement, purpose of the study, research questions, limitations of the study, and significance of the study. The following chapter demonstrates an extensive review of the literature regarding cancer mortality and incidence and their association with altitude.

Chapter 2: Literature Review

Introduction

This chapter presents an overview of the research that had been done concerning cancer incidence and cancer mortality rates with respect to variations in altitude. The primary purpose of the following literature review was to research previous studies and to determine a research gap in the literature that is appropriate for my study.

Literature Review

Using CDC data from 2001 through 2005, Hart (2011) found that for the six lowest elevation states in the United States, the calculated age-adjusted mean cancer mortality rate for all cancer sites as a group was 205 cancer deaths per 100,000 people, and the calculated age-adjusted mean cancer mortality rate was 171 cancer deaths per 100,000 people for the six states with the highest altitudes. These statistics demonstrated a statistically significant difference for cancer mortality between the six lowest elevation states and the six highest elevation states. Hart did not discuss lung cancer incidence. Burtscher (2014) also indicated that residing at higher elevations is associated with lower mortality from stroke, cardiovascular disease, and bronchopulmonary cancer. Simeonov and Himmelstein (2015) used 2005-2009 cancer incidence data from the NCI, and they found a strong inverse association between lung cancer incidence and altitude. However, Simeonov and Himmelstein did not discuss lung cancer mortality in a similar way that Hart (2011) did not discuss lung cancer incidence.

Hart (2010) also investigated the cancer mortality rates due to all cancers in low elevation counties in the state of Texas and compared them with the mortality rates due to

all cancers in high elevation counties and medium elevation counties within the same state. A county with 75% or more of its terrain in the 0-250 feet above sea level range was classified as a low elevation county. A county with 75% or more of its terrain in the 1,000-2,000 feet above sea level range was classified as a medium elevation county. Finally, a county with 75% or more of its terrain higher than 3,000 feet above sea level was classified as high elevation county. Cancer mortality due to all cancers was found to be statistically significant between the high and low elevation counties with a p-value of 0.003. Cancer mortality due to all cancers was also found to be statistically significant between the high and medium elevation counties with a p-value of 0.010. Cancer mortality due to all cancers was not found to be statistically significant between the low and medium elevation counties with a p-value of 0.05.

The final study by Hart (2013), whose investigation formed the basis of this study, was also focused on the association between cancer mortality and land elevation in American counties and cities but with another method. In this scholarly article, he used median elevation data derived from the U.S. Geological Survey and the U.S. Department of Agriculture. This study was concentrated on three variables that are correlated with elevation. They are natural background radiation, oxygen concentration, and barometric pressure (Hart, 2013). Cities and counties that were at high elevation had higher natural background radiation than their counterparts at low elevation. This study showed an inverse correlation between natural background radiation and cancer mortality as a whole (not site-specific). Cities and counties that were at high elevation had lower oxygen concentration and lower barometric pressure than their counterparts at low elevation.

This study showed direct correlation between natural background radiation and cancer mortality as a whole. Whether it was the higher natural background radiation, lower oxygen concentration, lower barometric pressure, or a combination of the three factors that was responsible for the lower cancer mortality rate, was beyond the scope of this study.

Winkelmayer, Hurley, Liu, and Brookhart (2012) studied the association of altitude with cardiovascular disease for dialysis patients in the United States. Close to one million patients were followed. All of these patients initiated dialysis sometime during the period of time from 1995 to 2006. Compared to similar patients living at or near sea level, patients residing at altitudes greater than or equal to 6,000 feet, experienced a 31% decrease in myocardial infarction, a 27% decrease in strokes, and a 19% decrease in death associated with cardiovascular disease.

Hayes (2010) provided evidence that the enhancement of vitamin D with increasing altitude could explain the observed decrease in cancer rates at higher altitudes. Scott and Di Palma (2006) suggested that elevated diagnostic medical radiation and natural background radiation may lead to lower cancer mortality through the radiation hormesis process. (Increased rock concentration with altitude is associated with increased background radiation.) Sung et al. (2011) were the first to show in a controlled demonstration in mice that lower levels of oxygen delay tumorigenesis. They were able to control for other confounding variables such as radiation exposure and barometric pressure. Tao et al. (2000) researched cancer mortality rates from all cancers in high

background radiation areas of Yangjiang, China, during the period of time from 1979 through 1995 and found that they were generally lower than in the control region.

Danaei et al. (2005) found that the causes of bronchopulmonary cancer are smoking, low fruit and vegetable intake, indoor smoke from household use of solid fuels, and urban air pollution. Pope et al. (2002) found that exposure over time to combustible air pollution can cause cardiopulmonary and lung cancer. Samet et al. (2009) stated that an increased level of outdoor air pollution can be responsible for an increase in lung cancer incidence, however, they cannot provide a reliable estimate of risk based on the available data. Subramanian and Govindan (2007) noted that an increase in cancer risk is associated with air pollution. In Europe, it is estimated that 1-3.6% of lung cancer incidence may be associated with air pollution for the general population, and the data increases to 5-7% for those that never smoked.

Cesaroni et al. (2013) studied chronic exposure to metropolitan air pollution and its effect on mortality. The study used a cohort of greater than one million adult subjects in Rome, Italy. In particular, Cesaroni et al. (2013) investigated the causal relationship between nitrogen dioxide and fine particulate matter to mortality. They were able to assess the concentration-response relationship. The most robust relationship was established for cardiac ischemia. It was then followed by cardiovascular illness and lung cancer. The results of this study will have a profound effect on the next wave of policy changes regarding air quality in the European Union.

Siegel, Ma, Zou, and Jemal (2014) stated that even though cancer mortality has been on the decline for the last two decades, further social positive change can be

accelerated by reinforcing existing cancer control knowledge to the population especially to those with low socioeconomic status.

Information from by the Lung Institute provides biological reasons why it may be beneficial to live at higher altitudes. At higher elevations, the lungs expand compared to lower elevations. The expansion allows the lungs to contribute more to beneficial body functions and processes. The lung expansion enables the body to produce more red blood cells which are essential in promoting good health. More capillaries are produced which allows the lungs to efficiently bring oxygen to the cardiovascular system (Lung Institute, 2016).

Research Gap in the Literature

The CDC WONDER data that I have analyzed runs from 2006 through 2014. I have investigated the age-adjusted cancer mortality phenomenon further by using more current CDC data starting where Hart had left off in 2005. I have investigated the age-adjusted cancer incidence phenomenon by using CDC data to compare with the 2005 to 2009 NCI data used by Simeonov and Himmelstein (2015). These two items that have been investigated comprise the identified research gap in the literature.

Theoretical Foundation

The theoretical framework for my study is Bronfenbrenner's (1977) ecological model. This model has since been modified over time in order to adapt to and be applied to different scenarios (Satariano, 2006). The ecological model emphasizes four components that greatly influence patterns of disease and injury and strongly shape our responses to these patterns of disease and injury. The tenets of the ecological model are

depicted by the four levels of influence used in this model, and they serve as the four central components of this framework. They are the individual level, social environment, physical environment, and public policy components.

At the individual level, intrapersonal traits that influence behavior are key. The focus is on changing an individual's knowledge and attitudes to influence behavior. Characteristics of this first level are personal knowledge, demographics, beliefs, values, aptitude, conduct, self-awareness, and self-respect. Individuals may learn of the information on lower bronchopulmonary cancer incidence and mortality at higher altitudes. On processing the information, they might move to higher elevation as a prophylactic against bronchopulmonary cancer because of their increased awareness. They simply may just want to seek an environment for themselves that are conducive to great health benefits.

The second level is the social environment level where interpersonal relationships between friends, colleagues, peers, family members, and members of the community influence behavior. Characteristics of this second level are social structure, social foundation, family structure, work structure, neighborhood network, friendship network, and peer structure.

The third level is the physical environment level whereby the environment can have positive or negative influences. Characteristics of this third level are climate, habitat, setting, situation, ambiance, elevation, and terrain. I have studied the age-adjusted rate per 100,000 people for bronchopulmonary cancer mortality and bronchopulmonary cancer incidence in the highest elevation and lowest elevation states.

The chosen states where I have studied the bronchopulmonary mortality and incidence represent the physical environment where positive or negative influences might occur. It is at this third central component of the physical environment that my methods and measures tie into the ecological model. Individuals tend to avoid an environment where they may be susceptible to maladies such as cancer. This may possibly include relocating from a low elevation environment to a high elevation environment in order to harness any health benefits.

Finally, at the public policy level, the focus is on changing policy in order to influence behavior. Public health strategies may be implemented to increase awareness and understanding. Characteristics of this fourth level are regulations, protocols, tariffs, government agencies, and codes. Without the implementation of public health strategies, it may be difficult to witness the power and impact of the ecological model. These multi-level interventions are theorized to be very effective in bringing forth a positive social change impact leading to a better tomorrow with positive health outcomes.

Summary

In Chapter 2, I performed the literature review of my research topic and then identified a research gap in the literature. I also described the theoretical foundation of my research. In Chapter 3, I will discuss the research methods and statistical analysis used in my study.

Chapter 3: Research Method

Introduction

This chapter consists of a description of my research methodology. The four main parts of my methodology are research design, sampling, collection of data, and analysis of data. The description of the research design explains why I selected this study design. I illustrate what was involved in the sampling process. Finally, I also delineate the entire data collection process concluding with a comprehensive analysis of the data in my study.

Research Questions

Research Question 1: Does bronchopulmonary cancer mortality differ with increased altitude?

$H_0$1: There is no association between altitude and bronchopulmonary cancer mortality.

$H_1$1: There is an association between altitude and bronchopulmonary cancer mortality.

Research Question 2: Does bronchopulmonary cancer incidence differ with increased altitude?

$H_0$2: There is no association between altitude and bronchopulmonary cancer incidence.

$H_1$2: There is an association between altitude and bronchopulmonary cancer incidence.

Design of the Study

The goal of my research design was to make sure that the data collected allowed me to effectively and systematically answer my research questions. Obtaining data that was specific to my research questions required that I understand the significance of an observable phenomenon, which would justify my study design. The research design used in my study is an ecological study design with a quantitative approach. It is also both observational and retrospective. The quantitative analysis used in my study helped to understand the nature of the association and the extent of the association between altitude and bronchopulmonary cancer mortality and incidence. Being able to better understand the association between altitude and bronchopulmonary cancer incidence and mortality rates is one of the strengths of my study design. This same study design has a weakness in that it does not help establish causality.

Original Study Design

Hart (2011) identified the six highest elevation states in his article to be Colorado, Montana, New Mexico, South Dakota, Utah, and Wyoming. He also identified the six lowest elevation states to be Delaware, Florida, Louisiana, Mississippi, Rhode Island, and Washington, DC. I used the same method that Hart used to determine the highest and lowest elevation states using a table from the U.S. Geological Survey displaying states and their respective lowest and highest elevation points. The highest elevation points for Delaware, Florida, Louisiana, Mississippi, Rhode Island, and Washington, DC are 448, 345, 535, 806, 812, and 410 feet respectively (U.S. Geological Survey, 2016). This means that all of the other points within each of these lowest elevation states are at an

altitude below these noted highest elevation points. The highest elevation points for other states were all higher than the highest elevation points of these six states, making them the six lowest elevation states.

A similar methodology was used in identifying the six highest elevation states. The lowest elevation points for Colorado, Montana, New Mexico, South Dakota, Utah, and Wyoming are 3315, 1800, 2842, 966, 2000, and 3099 feet respectively (U.S. Geological Survey, 2016). This means that all of the other points within each of these highest elevation states are at an altitude above these noted lowest elevation points (3315, 1800, 2842, 966, 2000, and 3099 feet). The lowest elevation points for other states were all lower than the lowest elevation points of these six states, making them the six highest elevation states.

My study contributes knowledge to the research gap in the literature because I analyzed new data from the CDC ranging from 2006 to 2014. I controlled for three possible confounders of age, sex, and race, which had not been done previously.

Sampling

My research involves the entire population of six states that have been selected as highest elevation states and the entire population of six states that have been selected as lowest elevation states. Therefore, the sample population used in my study is the entire population of these chosen states.

Data Sources and Variables

I used secondary data from the CDC in my study. This study was focused on the 2006 through 2014 age-adjusted cancer incidence data and the 2006 through 2014 age-

adjusted cancer mortality rates from the CDC. The independent variables used are the names of the six highest elevation states and the names of the six lowest elevations. The dependent variables are bronchopulmonary cancer incidence rates and bronchopulmonary cancer mortality rates.

Data Collection

The CDC has a very useful public health information portal called WONDER (CDC, 2017) that allows the user to interactively request age-adjusted cancer incidence and age-adjusted cancer mortality data for different kinds of cancers. This public health information portal is very practical and interactive. One can input qualifiers such as type of cancer, time frame of interest, and specific state of interest within the United States. The age-adjusted cancer incidence and age-adjusted cancer mortality data in units of number of people per 100,000 can then be requested and obtained online.

The CDC WONDER portal captures information from 2006 through 2014. Hart (2011) used CDC data from 2001 through 2005 and found a statistically significant difference for cancer mortality between the six lowest elevation states and the six highest elevation states within the U.S. I have investigated the age-adjusted cancer mortality phenomenon further by starting where Hart had stopped in 2005 by researching the CDC bronchopulmonary cancer mortality data from 2006 through 2014. Simeonov and Himmelstein (2015) used 2005-2009 cancer incidence data from the NCI, and they found a very strong inverse association between lung cancer incidence and altitude. I also have investigated the age-adjusted cancer incidence phenomenon by using the CDC lung and bronchus cancer incidence data from 2006 through 2014.

Data Analysis

The purpose of my study is to further develop the understanding of the association between altitude and bronchopulmonary cancer mortality and incidence by studying the bronchopulmonary cancer mortality data and the bronchopulmonary cancer incidence data for the highest elevation and lowest elevation states within the United States from 2006 to 2014. I have controlled for 3 confounders of age, sex, and race as they were the only risk factor that were available on the CDC WONDER. Even the CDC data are all age-adjusted, I still further stratified my analysis by age, using 3 different age groups, to detect any significant differences in cancer mortality and incidence within each age group for the highest and elevation states.

In this study, bivariate statistics were used to analyze the data. The relevant technique of performing an unpaired t-test was used. The independent variables are the names of the six highest elevation states and the names of the six lowest elevations. The dependent variables are bronchopulmonary cancer incidence rates and bronchopulmonary cancer mortality rates.

This test contrasts the disparity between the two selected categories of elevation states. The company GraphPad Software has a software application that is perfectly suitable for analyzing my data (GraphPad, 2018). The software is called "Quick Calcs Online Calculator for Scientists." I used this calculator in this study to calculate the p-value resulting from the comparison between these two groups of data using the t-test. The age-adjusted cancer incidence rates per 100,000 from the six highest elevation states from 2006-2014 were investigated. They were compared to the age-adjusted cancer

incidence rate per 100,000 from the six lowest elevation states during the same period from 2006-2014. I controlled for the 3 confounders age, sex, and race.

The null hypothesis related to my first research question is that there is no difference between the bronchopulmonary cancer mortality rates from the highest elevation states when compared to the bronchopulmonary cancer mortality rates from the lowest elevation states. The alternative hypothesis is that there is a statistically significant difference between the two groups of cancer mortality. If the p-value is less than 0.05, then the null hypothesis should be rejected. With the null hypothesis dismissed, the alternative hypothesis is then applicable to the results of the study. It should be more completely stated as the observed difference between bronchopulmonary cancer mortality from the highest elevation states and the bronchopulmonary cancer mortality from the lowest elevation states, is statistically significant (Gertsman, 2008).

Bivariate statistics were used again to analyze the data for cancer incidence. The age-adjusted cancer incidence rates per 100,000 from the six highest elevation states from 2006-2014 were investigated. They were compared to the age-adjusted cancer incidence rates per 100,000 from the six lowest elevation states during the same period from 2006-2014. I also controlled for the 3 confounders of age, sex, and race.

The null hypothesis related to my second research question is that there is no difference between the bronchopulmonary cancer incidence rates from the highest elevation states when compared to the bronchopulmonary cancer incidence rates from the lowest elevation states. The alternative hypothesis is that there is a statistically significant difference between the two groups of cancer incidence. If the p-value is less

than 0.05, then the null hypothesis should be rejected. With the null hypothesis dismissed, the alternative hypothesis is then applicable to the results of the study. It should be more completely stated as the observed difference between bronchopulmonary cancer incidence from the highest elevation states and the bronchopulmonary incidence from the lowest elevation states, is statistically significant (Gertsman, 2008).

Summary

The research design associated with my study, sampling, collection of data, and analysis of data are described in this chapter. The research design used in my study is an ecological study design. It is also both observational and retrospective. It takes a quantitative approach as data from the CDC WONDER public health information portal is used to further develop the understanding of the association between altitude and bronchopulmonary cancer mortality and incidence by studying the cancer mortality data and cancer incidence data for the lowest elevation and highest elevation states within the United States from 2006 to 2014. The data was controlled for age, sex, and race.

The bivariate statistical technique of conducting an unpaired t-test is used to analyze the data in this study. This test compares the difference between the bronchopulmonary cancer mortality of the two groups of elevation states in order to determine a p-value which allows for the scientific rejection of the null hypothesis if there is a statistically significant difference between the two groups. It also compares the difference between the bronchopulmonary cancer incidence of the two groups of elevation states in order to determine a p-value which allows for the scientific rejection of

the null hypothesis. This brings a conclusion to my proposal. The next section, Chapter 4, deals with data collection and data analysis.

Chapter 4: Results

Introduction

My purpose in conducting this quantitative, observational, retrospective ecological study, was to measure the association between altitude and bronchopulmonary cancer. This study was also undertaken to answer the following two research questions:

Research Question 1: Does bronchopulmonary cancer mortality differ with increased altitude?

Research Question 2: Does bronchopulmonary cancer incidence differ with increased altitude?

In this chapter, I describe the process of collecting secondary data from the CDC. I include an explanation of the sample population that is used in my study. Lastly, I illustrate my data analysis well-defined tables.

Data Collection

I received Walden University's Institutional Review Board (IRB) approval to conduct this study on October 17, 2017 (approval number 10-17-17-0074351). I used the secondary from the CDC public health information portal called WONDER (CDC, 2017). This public health information portal allows the user to interactively request age-adjusted cancer incidence and age-adjusted cancer mortality data for different kinds of cancers. I collected data on bronchopulmonary cancer.

The CDC WONDER portal captures information from 2006 through 2014. Hart (2011) used CDC data from 2001 through 2005 and found a statistically significant difference for cancer mortality between the six lowest elevation states and the six highest

elevation states within the United States. The six lowest elevation states are Delaware, Florida, Louisiana, Mississippi, Rhode Island, and Washington, DC. The six highest elevation states are Colorado, Montana, New Mexico, South Dakota, Utah, and Wyoming. I further investigated the association between altitude and cancer mortality by researching the CDC bronchopulmonary cancer mortality data from 2006 through 2014, which is the time right after the time studied by Hart. Additionally, Simeonov and Himmelstein (2015) used 2005-2009 cancer incidence data from the NCI and found a strong inverse association between lung cancer incidence and altitude. Therefore, I also investigated the association between altitude and cancer incidence by using the CDC bronchopulmonary cancer incidence data from 2006 through 2014.

Sample Population

The sample population used in my study is the entire population of chosen states selected to represent the lowest elevation states and the highest elevation states. My research involves the entire population of six states that have been selected as the highest elevation states and the entire population of six states that have been selected as the lowest elevation states.

Controlling for Possible Confounders

In addition to continuing the work conducted by Hart (2011) and Simeonov and Himmelstein (2015), I elevated this research study by controlling for possible risk factors such as age, sex, and race. I categorized the entire population of each chosen state according the following age range: 44 years and younger, 45-64 years, and 65 years and older. For sex, I divided the entire population of each chosen state into the male and

female genders. Finally, I divided the entire population each chosen state into four categories of race: White, Black or African American, Asian or Pacific Islander, and American Indian or Alaska Native.

Results for Cancer Mortality

Female Cancer Mortality

The age-adjusted cancer mortality rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 1 for the entire female population in those states. They are compared to the entire female, age-adjusted cancer mortality rate per 100,000 for the six lowest elevation states during the same period.

Table 1

Female Bronchopulmonary Cancer Mortality, 2006-2014

	Deaths	Population	Age-adjusted mortality rate per 100,000
Highest elevation states			
Colorado	6,898	22,615,514	29.5
Montana	2,229	4,437,389	38.6
New Mexico	3,006	9,304,585	27.3
South Dakota	1,633	3,671,332	34.8
Utah	1,672	12,342,595	16.3
Wyoming	961	2,472,442	34.4
Totals	16,399	54,843,857	28.3
Lowest elevation states			
Delaware	2,372	4,173,344	44.9
Washington, DC	1,056	2,891,757	34.6
Florida	47,180	87,155,387	37.0
Louisiana	10,054	20,757,395	42.5
Mississippi	6,682	13,712,010	41.5
Rhode Island	2,736	4,905,070	42.2
Totals	70,080	133,594,963	38.5

Male Cancer Mortality

The age-adjusted cancer mortality rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 2 for the entire male population in those states. They are compared to the entire male, age-adjusted cancer mortality rate per 100,000 for the six lowest elevation states during the same period.

Table 2

Male Bronchopulmonary Cancer Mortality, 2006-2014

	Deaths	Population	Age-adjusted mortality rate per 100,000
Highest elevation states			
Colorado	7,442	22,756,887	39.8
Montana	2,483	4,471,606	49.5
New Mexico	3,622	9,095,302	40.5
South Dakota	2,244	3,683,308	58.2
Utah	2,246	12,463,500	25.8
Wyoming	1,120	2,567,794	45.7
Totals	19,157	55,038,397	40.2
Lowest elevation states			
Delaware	2,678	3,919,404	64.3
Washington, DC	1,221	2,596,108	56.1
Florida	59,903	83,366,874	57.5
Louisiana	14,212	19,848,574	76.6
Mississippi	10,884	12,946,292	88.7
Rhode Island	2,970	4,589,221	62.2
Totals	91,868	127,266,473	62.8

Ages 44 and Younger Cancer Mortality

The age-adjusted cancer mortality rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 3 for the entire ages 44 and younger population in those states. They are compared to the entire ages 44 and younger, age-adjusted cancer mortality rate per 100,000 for the six lowest elevation states during the same period.

Table 3

Ages 44 and Younger Bronchopulmonary Cancer Mortality, 2006-2014

	Deaths	Population	Age-adjusted mortality rate per 100,000
Highest elevation states			
Colorado	118	23,382,087	0.5
Montana	27	5,019,498	0.6
New Mexico	45	11,091,784	0.5
South Dakota	20	4,377,849	0.5
Utah	50	17,622,464	0.4
Wyoming	18	3,011,736	0.7
Totals	278	69,505,418	0.5
Lowest elevation states			
Delaware	49	4,723,070	1.1
Washington, DC	22	3,598,013	0.7
Florida	938	95,079,789	1.0
Louisiana	291	24,952,570	1.4
Mississippi	216	16,393,233	1.5
Rhode Island	71	5,498,392	1.4
Totals	1,587	150,245,067	1.1

Ages 45 to 64 Cancer Mortality

The age-adjusted cancer mortality rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 4 for the entire ages 45 to 64 population in those states. They are compared to the entire ages 45 to 64, age-adjusted cancer mortality rate per 100,000 for the six lowest elevation states during the same period.

Table 4

Ages 45 to 64 Bronchopulmonary Cancer Mortality, 2006-2014

	Deaths	Population	Age-adjusted mortality rate per 100,000
Highest elevation states			
Colorado	3,659	11,898,006	28.4
Montana	1,116	2,543,993	38.7
New Mexico	1,480	4,812,297	27.4
South Dakota	941	1,911,295	44.5
Utah	1,101	4,897,551	21.0
Wyoming	511	1,366,558	32.9
Totals	8,808	27,449,700	29.2
Lowest elevation states			
Delaware	1,381	2,178,521	58.2
Washington, DC	769	1,264,262	56.5
Florida	26,826	45,451,086	53.6
Louisiana	7,737	10,553,092	68.0
Mississippi	5,612	6,779,579	76.4
Rhode Island	1,485	2,606,142	53.0
Totals	43,810	68,832,682	58.2

Ages 65 and Older Cancer Mortality

The age-adjusted cancer mortality rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 5 for the entire ages 65 and older population in those states. They are compared to the entire ages 65 and older, age-adjusted cancer mortality rate per 100,000 for the six lowest elevation states during the same period.

Table 5

Ages 65 and Older Bronchopulmonary Cancer Mortality, 2006-2014

	Deaths	Population	Age-adjusted mortality rate per 100,000
Highest elevation states			
Colorado	10,563	5,092,308	216.1
Montana	3,569	1,345,504	272.5
New Mexico	5,103	2,495,806	211.5
South Dakota	2,916	1,065,496	273.4
Utah	2,767	2,286,080	124.3
Wyoming	1,552	641,942	249.8
Totals	26,470	12,927,136	211.1
Lowest elevation states			
Delaware	3,620	1,191,157	312.4
Washington, DC	1,486	655,590	242.1
Florida	79,319	29,991,386	265.6
Louisiana	16,238	5,100,307	325.0
Mississippi	11,738	3,485,490	343.9
Rhode Island	4,150	1,389,757	296.8
Totals	116,551	41,783,687	281.5

White Cancer Mortality

The age-adjusted cancer mortality rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 6 for the entire White population in those states. They are compared to the entire White, age-adjusted cancer mortality rate per 100,000 for the six lowest elevation states during the same period.

Table 6

White Bronchopulmonary Cancer Mortality, 2006-2014

	Deaths	Population	Age-adjusted mortality rate per 100,000
Highest elevation states			
Colorado	13,518	40,787,703	34.1
Montana	4,483	8,138,562	42.9
New Mexico	6,328	15,560,336	34.7
South Dakota	3,635	6,444,469	44.0
Utah	3,766	23,162,746	20.6
Wyoming	2,032	4,769,629	39.5
Totals	33,762	98,863,445	33.7
Lowest elevation states			
Delaware	4,285	5,906,272	54.3
Washington, DC	476	2,316,627	27.6
Florida	97,978	135,813,917	47.5
Louisiana	17,524	26,295,358	56.1
Mississippi	12,663	16,204,647	61.6
Rhode Island	5,495	8,310,100	51.4
Totals	138,421	194,846,921	49.7

Black or African American Cancer Mortality

The age-adjusted cancer mortality rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 7 for the entire Black or African American population in those states. They are compared to the entire Black or African American, age-adjusted cancer mortality rate per 100,000 for the six lowest elevation states during the same period. The data for Montana, South Dakota, and Wyoming are suppressed by the CDC because the absolute number of bronchopulmonary cancer mortality cases for Black or African Americans are extremely low because the Black or African American population in those states are very low. This was done to protect the identity of the people involved since it may be relatively easy to guess who they are (CDC, 2017). Going forward, there will be suppressed data in some more tables for the same reason.

However, the totals in each table reflect the total number of deaths for the entire table, which indicate how many deaths there had been in each of the individual states.

Table 7

Black or African American Bronchopulmonary Cancer Mortality, 2006-2014

	Deaths	Population	Age-adjusted mortality rate per 100,000
Highest elevation states			
Colorado	529	2,219,493	40.1
Montana	Suppressed	68,946	Suppressed
New Mexico	133	519,423	40.9
South Dakota	Suppressed	130,948	Suppressed
Utah	41	379,072	33.9
Wyoming	Suppressed	75,330	Suppressed
Totals	734	3,393,212	38.9
Lowest elevation states			
Delaware	711	1,838,424	49.9
Washington, DC	1,774	2,909.549	53.8
Florida	8,234	28,864,160	37.7
Louisiana	6,570	13,270,198	61.2
Mississippi	4,831	10,022,814	61.0
Rhode Island	151	763,987	33.5
Totals	22,271	57,669,132	48.7

Asian or Pacific Islander Cancer Mortality

The age-adjusted cancer mortality rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 8 for the entire Asian or Pacific Islander population in those states. They are compared to the entire Asian or Pacific Islander, age-adjusted cancer mortality rate per 100,000 for the six lowest elevation states during the same period.

Table 8

Asian or Pacific Islander Bronchopulmonary Cancer Mortality, 2006-2014

	Deaths	Population	Age-adjusted mortality rate per 100,000
Highest elevation states			
Colorado	206	1,553,745	22.1
Montana	Suppressed	76,279	Suppressed
New Mexico	53	342,929	20.9
South Dakota	Suppressed	86,195	Suppressed
Utah	85	854,164	20.1
Wyoming	Suppressed	52,930	Suppressed
Totals	372	2,966,242	21.8
Lowest elevation states			
Delaware	36	291,937	22.9
Washington, DC	24	225,590	20.2
Florida	736	4,945,089	20.2
Louisiana	118	719,583	27.6
Mississippi	50	274,769	34.0
Rhode Island	42	326,711	24.6
Totals	1,006	6,783,679	21.6

American Indian or Alaska Native Cancer Mortality

The age-adjusted cancer mortality rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 9 for the entire American Indian or Alaska Native population in those states. They are compared to the entire American Indian or Alaska Native, age-adjusted cancer mortality rate per 100,000 for the six lowest elevation states during the same period.

Table 9

American Indian or Alaskan Native Bronchopulmonary Cancer Mortality, 2006-2014

	Deaths	Population	Age-adjusted mortality rate per 100,000
Highest elevation states			
Colorado	87	811,460	23.7
Montana	207	625,208	63.9
New Mexico	114	1,977,199	9.5
South Dakota	222	693,028	75.7
Utah	26	410,113	17.6
Wyoming	32	142,347	52.0
Totals	688	4,659,335	28.2
Lowest elevation states			
Delaware	18	56,115	51.4
Washington, DC	Suppressed	36,099	Suppressed
Florida	135	899,095	20.5
Louisiana	54	320,830	25.4
Mississippi	22	156,072	21.7
Rhode Island	18	93,493	34.7
Totals	250	1,561,704	23.5

All non-White Cancer Mortality

Since all of the data for the non-White races demonstrated no significant difference between the highest elevation states and the lowest elevations states, it is imperative that we sum up the cancer mortality data from the three races of Black or African American, Asian or Pacific Islander, and American Indian or Alaska Native, to see if the summed data still show no statistically significant difference between the highest elevation states and the lowest elevations states.

The age-adjusted cancer mortality rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 10 for the entire non-White population in those states. They are compared to the entire non-White, age-adjusted cancer mortality rate per 100,000 for the six lowest elevation states during the same period. As it is

noticeable in the following table, there is no suppressed data, because of the higher cancer mortality statistics collected.

Table 10

All Non-White Bronchopulmonary Cancer Mortality, 2006-2014

	Deaths	Population	Age-adjusted mortality rate per 100,000
Highest elevation states			
Colorado	822	4,584,698	31.1
Montana	229	770,433	58.4
New Mexico	300	2,839,551	16.7
South Dakota	242	910,171	65.0
Utah	152	1,643,349	21.8
Wyoming	49	270,607	34.7
Totals	1,794	11,018,809	29.6
Lowest elevation states			
Delaware	765	2,186,476	46.5
Washington, DC	1,801	3,171,238	52.3
Florida	9,105	34,708,344	34.6
Louisiana	6,742	14,310,611	59.0
Mississippi	4,903	10,453,655	60.0
Rhode Island	211	1,184,191	31.2
Totals	23,527	66,014,515	45.3

Results for Cancer Incidence

Female Cancer Incidence

The age-adjusted cancer incidence rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 11 for the entire female population in those states. They are compared to the entire female, age-adjusted cancer incidence rate per 100,000 for the six lowest elevation states during the same period.

Table 11

Female Bronchopulmonary Cancer Incidence, 2006-2014

	Cases	Population	Age-adjusted incidence rate per 100,000
Highest elevation states			
Colorado	10,068	22,615,514	43.0
Montana	3,177	4,437,389	55.4
New Mexico	4,089	9,304,585	37.2
South Dakota	2,263	3,671,332	49.6
Utah	2,435	12,342,595	23.7
Wyoming	1,265	2,472,442	44.8
Totals	23,297	54,843,857	40.2
Lowest elevation states			
Delaware	3,400	4,173,344	64.7
Washington, DC	1,467	2,891,757	49.0
Florida	68,796	87,155,387	55.1
Louisiana	13,390	20,757,395	56.6
Mississippi	9,052	13,712,010	56.5
Rhode Island	4,054	4,905,070	64.4
Totals	100,159	133,594,963	56.0

Male Cancer Incidence

The age-adjusted cancer incidence rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 12 for the entire male population in those states. They are compared to the entire male, age-adjusted cancer incidence rate per 100,000 for the six lowest elevation states during the same period.

Table 12

Male Bronchopulmonary Cancer Incidence, 2006-2014

	Cases	Population	Age-adjusted incidence rate per 100,000
Highest elevation states			
Colorado	10,024	22,756,887	52.0
Montana	3,313	4,471,606	65.2
New Mexico	4,617	9,095,302	50.2
South Dakota	2,831	3,683,308	72.8
Utah	2,992	12,463,500	33.7
Wyoming	1,349	2,567,794	53.0
Totals	25,126	55,038,397	51.5
Lowest elevation states			
Delaware	3,632	3,919,404	86.0
Washington, DC	1,632	2,596,108	72.4
Florida	79,155	83,366,874	75.7
Louisiana	18,043	19,848,574	94.9
Mississippi	13,575	12,946,292	107.7
Rhode Island	3,955	4,589,221	82.2
Totals	119,992	127,266,473	81.3

Ages 44 and Younger Cancer Incidence

The age-adjusted cancer incidence rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 13 for the entire ages 44 and younger population in those states. They are compared to the entire ages 44 and younger, age-adjusted cancer incidence rate per 100,000 for the six lowest elevation states during the same period.

Table 13

Ages 44 and Younger Bronchopulmonary Cancer Incidence, 2006-2014

	Cases	Population	Age-adjusted incidence rate per 100,000
Highest elevation states			
Colorado	281	28,382,087	1.1
Montana	76	5,019,498	1.7
New Mexico	101	11,091,784	1.1
South Dakota	47	4,377,849	1.3
Utah	117	17,622,464	0.9
Wyoming	30	3,011,736	1.1
Totals	652	69,505,418	1.1
Lowest elevation states			
Delaware	109	4,723,070	2.5
Washington, DC	63	3,598,013	2.1
Florida	1,882	95,079,789	2.1
Louisiana	524	24,952,570	2.4
Mississippi	343	16,393,233	2.5
Rhode Island	122	5,498,392	2.3
Totals	3,043	150,245,067	2.2

Ages 45 to 64 Cancer Incidence

The age-adjusted cancer incidence rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 14 for the entire ages 45 to 64 population in those states. They are compared to the entire ages 45 to 64, age-adjusted cancer incidence rate per 100,000 for the six lowest elevation states during the same period.

Table 14

Ages 45 to 64 Bronchopulmonary Cancer Incidence, 2006-2014

	Cases	Population	Age-adjusted incidence rate per 100,000
Highest elevation states			
Colorado	5,836	11,898,006	45.4
Montana	1,706	2,543,993	59.3
New Mexico	2,307	4,812,297	43.0
South Dakota	1,410	1,911,295	67.3
Utah	1,680	4,897,551	32.1
Wyoming	797	1,386,558	51.4
Totals	13,736	27,449,700	45.8
Lowest elevation states			
Delaware	2,117	2,178,521	89.5
Washington, DC	1,190	1,264,262	87.3
Florida	41,806	45,451,086	83.9
Louisiana	11,068	10,553,092	97.4
Mississippi	7,986	6,779,579	108.9
Rhode Island	2,421	2,606,142	86.5
Totals	66,588	68,832,682	88.7

Ages 65 and Older Cancer Incidence

The age-adjusted cancer incidence rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 15 for the entire ages 65 and older population in those states. They are compared to the entire ages 65 and older, age-adjusted cancer incidence rate per 100,000 for the six lowest elevation states during the same period.

Table 15

Ages 65 and Older Bronchopulmonary Cancer Incidence, 2006-2014

	Cases	Population	Age-adjusted incidence rate per 100,000
Highest elevation states			
Colorado	13,975	5,092,308	284.8
Montana	4,708	1,345,504	358.6
New Mexico	6,298	2,495,806	259.1
South Dakota	3,637	1,065,496	346.0
Utah	3,630	2,286,080	162.2
Wyoming	1,787	641,942	286.2
Totals	34,035	12,927,136	270.7
Lowest elevation states			
Delaware	4,806	1,191,157	413.4
Washington, DC	1,846	625,590	301.2
Florida	104,263	29,991,386	350.7
Louisiana	19,841	5,100,307	394.9
Mississippi	14,298	3,485,490	415.9
Rhode Island	5,466	1,389,757	400.8
Totals	150,520	41,783,687	364.4

White Cancer Incidence

The age-adjusted cancer incidence rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 16 for the entire White population in those states. They are compared to the entire White, age-adjusted cancer incidence rate per 100,000 for the six lowest elevation states during the same period.

Table 16

White Bronchopulmonary Cancer Incidence, 2006-2014

	Cases	Population	Age-adjusted incidence rate per 100,000
Highest elevation states			
Colorado	18,867	40,787,703	46.9
Montana	6,057	8,138,562	57.9
New Mexico	8,272	15,560,336	45.0
South Dakota	4,754	6,444,469	58.4
Utah	5,178	23,162,746	27.9
Wyoming	2,549	4,769,629	48.6
Totals	45,677	98,863,445	45.2
Lowest elevation states			
Delaware	5,926	5,906,272	75.2
Washington, DC	651	2,316,627	36.9
Florida	134,191	135,813,917	66.0
Louisiana	22,724	26,295,358	72.4
Mississippi	16,387	16,204,647	79.3
Rhode Island	7,640	8,310,100	72.6
Totals	187,519	194,846,921	68.0

Black or African American Cancer Incidence

The age-adjusted cancer incidence rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 17 for the entire Black or African American population in those states. They are compared to the entire Black or African American, age-adjusted cancer incidence rate per 100,000 for the six lowest elevation states during the same period.

Table 17

Black or African American Bronchopulmonary Cancer Incidence, 2006-2014

	Cases	Population	Age-adjusted incidence rate per 100,000
Highest elevation states			
Colorado	697	2,219,493	50.7
Montana	17	68,946	77.9
New Mexico	185	519,423	54.1
South Dakota	17	130,948	32.0
Utah	61	379,072	50.6
Wyoming	Suppressed	75,330	Suppressed
Totals	988	3,393,212	50.4
Lowest elevation states			
Delaware	1,008	1,838,424	69.1
Washington, DC	2,358	2,909,549	71.5
Florida	11,343	28,864,160	50.7
Louisiana	8,467	13,270,198	77.0
Mississippi	6,141	10,022,814	76.0
Rhode Island	266	763,987	56.5
Totals	29,583	57,669,132	63.2

Asian or Pacific Islander Cancer Incidence

The age-adjusted cancer incidence rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 18 for the entire Asian or Pacific Islander population in those states. They are compared to the entire Asian or Pacific Islander, age-adjusted cancer incidence rate per 100,000 for the six lowest elevation states during the same period.

Table 18

Asian or Pacific Islander Bronchopulmonary Cancer Incidence, 2006-2014

	Cases	Population	Age-adjusted incidence rate per 100,000
Highest elevation states			
Colorado	348	1,553,745	35.5
Montana	22	76,279	44.0
New Mexico	74	342,929	26.9
South Dakota	Suppressed	86,195	Suppressed
Utah	122	854,164	28.9
Wyoming	Suppressed	52,930	Suppressed
Totals	587	2,966,242	32.9
Lowest elevation states			
Delaware	Suppressed	291,937	Suppressed
Washington, DC	49	225,590	38.5
Florida	1,049	4,945,089	26.6
Louisiana	182	719,583	38.1
Mississippi	70	274,769	43.4
Rhode Island	44	326,711	25.0
Totals	1,453	6,783,679	28.7

American Indian or Alaska Native Cancer Incidence

The age-adjusted cancer incidence rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 19 for the entire American Indian or Alaska Native population in those states. They are compared to the entire American Indian or Alaska Native, age-adjusted cancer incidence rate per 100,000 for the six lowest elevation states during the same period.

Table 19

American Indian or Alaska Native Bronchopulmonary Cancer Incidence, 2006-2014

	Cases	Population	Age-adjusted incidence rate per 100,000
Highest elevation states			
Colorado	102	811,460	25.3
Montana	387	625,208	111.7
New Mexico	154	1,977,199	12.6
South Dakota	311	693,028	101.0
Utah	32	410,113	21.2
Wyoming	43	142,347	55.5
Totals	1,029	4,659,355	39.9
Lowest elevation states			
Delaware	Suppressed	56,115	Suppressed
Washington, DC	Suppressed	36,099	Suppressed
Florida	140	899,095	20.9
Louisiana	50	320,830	22.4
Mississippi	23	156,072	24.5
Rhode Island	Suppressed	93,493	Suppressed
Totals	249	1,561,704	22.7

All non-White Cancer Incidence

Since all of the data for the non-White races demonstrated no significant difference between the highest elevation states and the lowest elevations states, it is imperative that we sum up the cancer incidence data from the three races of Black or African American, Asian or Pacific Islander, and American Indian or Alaska Native, to see if the summed data still show no statistically significant difference between the highest elevation states and the lowest elevations states.

The age-adjusted cancer incidence rates per 100,000 for the six highest elevation states from 2006-2014 are displayed in Table 20 for the entire non-White population in those states. They are compared to the entire non-White, age-adjusted cancer incidence rate per 100,000 for the six lowest elevation states during the same period. As it is

noticeable in the following table, there is no suppressed data, because of the higher cancer incidence statistics collected.

Table 20

All Non-White Bronchopulmonary Cancer Incidence, 2006-2014

	Cases	Population	Age-adjusted incidence rate per 100,000
Highest elevation states			
Colorado	1,147	4,584,698	41.4
Montana	426	770,433	101.7
New Mexico	413	2,839,551	22.0
South Dakota	340	910,171	87.3
Utah	215	1,643,349	30.6
Wyoming	63	270,607	38.8
Totals	2,604	11,018,809	41.0
Lowest elevation states			
Delaware	1,085	2,186,476	64.1
Washington, DC	2,411	3,171,238	69.7
Florida	12,532	34,708,344	46.3
Louisiana	8,699	14,310,611	74.2
Mississippi	6,234	10,453,655	74.7
Rhode Island	324	1,184,191	45.6
Totals	31,285	66,014,515	58.8

Data Analysis for Cancer Mortality

The bivariate statistical technique of conducting an unpaired t-test is used for comparing the bronchopulmonary cancer mortality rates between highest elevation states and the lowest elevation states. The Quick Calcs Online Calculator for Scientists was used to calculate the p-value resulting from the comparison between these two groups of data.

Female Cancer Mortality

The unpaired t-test contrasts the disparity between the female cancer mortality data for the highest elevation states and lowest elevation states. The p-value is calculated

to be 0.0166, which by conventional criteria, indicates that there is a statistically significant difference between these two groups. The female bronchopulmonary cancer mortality is lower in the highest elevation states than in the lowest elevation states.

Male Cancer Mortality

The unpaired t-test contrasts the disparity between the male cancer mortality data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.0051, which by conventional criteria, indicates that there is a very statistically significant difference between these two groups. The male bronchopulmonary cancer mortality is much lower in the highest elevation states than in the lowest elevation states.

Ages 44 and Younger Cancer Mortality

The unpaired t-test contrasts the disparity between the age 44 and younger cancer mortality data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.0006, which by conventional criteria, indicates that there is an extremely statistically significant difference between these two groups. The ages 44 and younger bronchopulmonary cancer mortality is very much lower in the highest elevation states than in the lowest elevation states.

Ages 45 to 64 Cancer Mortality

The unpaired t-test contrasts the disparity between the age 45 to 64 cancer mortality data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.0001, which by conventional criteria, indicates that there is an extremely statistically significant difference between these two groups. The ages 45 to

64 bronchopulmonary cancer mortality is very much lower in the highest elevation states than in the lowest elevation states.

Ages 65 and Older Cancer Mortality

The unpaired t-test contrasts the disparity between the age 65 and older cancer mortality data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.0244, which by conventional criteria, indicates that there is a statistically significant difference between these two groups. The ages 65 and older bronchopulmonary cancer mortality is lower in the highest elevation states than in the lowest elevation states.

White Cancer Mortality

The unpaired t-test contrasts the disparity between the white cancer mortality data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.0434, which by conventional criteria, indicates that there is a statistically significant difference between these two groups. The white bronchopulmonary cancer mortality is lower in the highest elevation states than in the lowest elevation states.

Black or African American Cancer Mortality

The unpaired t-test contrasts the disparity between the white cancer mortality data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.1598, which by conventional criteria, indicates that there is no statistically significant difference between these two groups.

Asian or Pacific Islander Cancer Mortality

The unpaired t-test contrasts the disparity between the Asian or Pacific Islander population cancer mortality data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.2597, which by conventional criteria, indicates that there is no statistically significant difference between these two groups.

American Indian or Alaska Native Cancer Mortality

The unpaired t-test contrasts the disparity between the American Indian or Alaska Native cancer mortality data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.4862, which by conventional criteria, indicates that there is no statistically significant difference between these two groups.

All non-White Cancer Mortality

The unpaired t-test contrasts the disparity between the non-White cancer mortality data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.3461, which by conventional criteria, indicates that there is no statistically significant difference between these two groups. Therefore, we just reconfirmed that the cancer mortality data for three races of Black or African American, Asian or Pacific Islander, and American Indian or Alaska Native, as a group, show no statistically significant difference for the highest elevation states and lowest elevation states.

Data Analysis for Cancer Incidence

The bivariate statistical technique of conducting an unpaired t-test is used for comparing the bronchopulmonary cancer incidence rates between highest elevation states and the lowest elevation states. The Quick Calcs Online Calculator for Scientists was

used to calculate the p-value resulting from the comparison between these two groups of data.

Female Cancer Incidence

The unpaired t-test contrasts the disparity between the female cancer incidence data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.0129, which by conventional criteria, indicates that there is a statistically significant difference between these two groups. The female bronchopulmonary cancer incidence is lower in the highest elevation states than in the lowest elevation states.

Male Cancer Incidence

The unpaired t-test contrasts the disparity between the male cancer incidence data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.0019, which by conventional criteria, indicates that there is a very statistically significant difference between these two groups. The male bronchopulmonary cancer incidence is much lower in the highest elevation states than in the lowest elevation states.

Ages 44 and Younger Cancer Incidence

The unpaired t-test contrasts the disparity between the age 44 and younger cancer incidence data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.0001, which by conventional criteria, indicates that there is an extremely statistically significant difference between these two groups. The ages 44 and younger bronchopulmonary cancer incidence is very much lower in the highest elevation states than in the lowest elevation states.

Ages 45 to 64 Cancer Incidence

The unpaired t-test contrasts the disparity between the age 45 to 64 cancer incidence data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.0001, which by conventional criteria, indicates that there is an extremely statistically significant difference between these two groups. The ages 45 to 64 bronchopulmonary cancer incidence is very much lower in the highest elevation states than in the lowest elevation states.

Ages 65 and Older Cancer Incidence

The unpaired t-test contrasts the disparity between the age 65 and older cancer incidence data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.0178, which by conventional criteria, indicates that there is a statistically significant difference between these two groups. The ages 65 and older bronchopulmonary cancer incidence is lower in the highest elevation states than in the lowest elevation states.

White Cancer Incidence

The unpaired t-test contrasts the disparity between the White cancer incidence data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.0299, which by conventional criteria, indicates that there is a statistically significant difference between these two groups. The white bronchopulmonary cancer incidence is lower in the highest elevation states than in the lowest elevation states.

Black or African American Cancer Incidence

The unpaired t-test contrasts the disparity between the Black or African American cancer incidence data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.1286, which by conventional criteria, indicates that there is no statistically significant difference between these two groups.

Asian or Pacific Islander Cancer Incidence

The unpaired t-test contrasts the disparity between the Asian or Pacific Islander cancer incidence data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.9284, which by conventional criteria, indicates that there is no statistically significant difference between these two groups.

American Indian or Alaska Native Cancer Incidence

The unpaired t-test contrasts the disparity between the American Indian or Alaska Native cancer incidence data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.2518, which by conventional criteria, indicates that there is no statistically significant difference between these two groups.

All non-White Cancer Incidence

The unpaired t-test contrasts the disparity between the non-White cancer incidence data for the highest elevation states and lowest elevation states. The p-value is calculated to be 0.5551, which by conventional criteria, indicates that there is no statistically significant difference between these two groups. Therefore, we just reconfirmed that the cancer incidence data for three races of Black or African American, Asian or Pacific Islander, and American Indian or Alaska Native, as a group, show no

statistically significant difference for the highest elevation states and lowest elevation states.

Summary

In Chapter 4, I presented the findings of my research and data analyses. I also describe the systematic application of my research methods. In Chapter 5, I will summarize my research findings, discuss the implications for practice, explain the social impact, and make recommendations for future research.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The purpose of this study was to develop the understanding of the association between altitude and bronchopulmonary cancer mortality and incidence by studying the cancer mortality data and cancer incidence data for the lowest elevation and highest elevation states within the United States from 2006 to 2014. In this final chapter, I summarize my research findings, discuss the implications for practice, explain the social impact, and make recommendations for future research.

Summary and Interpretation of Findings

Although Hart (2011) and Simeonov & Himmelstein (2015) have pointed out statistically significant differences in cancer mortality and incidence between areas of high elevation and areas of low elevation, my findings refute their findings for certain races. In the following paragraphs, I demonstrate how controlling for a possible confounder such as race led to my findings.

Using CDC data from 2001 through 2005, Hart (2011) found that for the six lowest elevation states in the United States, the calculated age-adjusted mean cancer mortality rate for all cancer sites as a group was 205 cancer deaths per 100,000 people, and the calculated age-adjusted mean cancer mortality rate was 171 cancer deaths per 100,000 people for the six states with the highest elevation. These statistics demonstrated a statistically significant lower cancer mortality rate for the six highest elevation states when compared to the six lowest elevation states. Hart did not discuss cancer incidence.

Simeonov and Himmelstein (2015) addressed the cancer incidence that Hart (2011) did not. They used 2005-2009 lung cancer incidence data from the NCI and demonstrated a statistically significant lower lung cancer incidence rate for areas of high altitude when compared to areas of low altitude. However, Simeonov and Himmelstein did not discuss lung cancer mortality.

My study was a continuation of the work that had been done by Hart (2011) and Simeonov and Himmelstein (2015) using new CDC data to fill the gap in the literature. As a result of controlling for such founders such as sex, age, and race, new findings emerged. The following paragraphs include detailed descriptions of my findings for the bronchopulmonary cancer mortality data when controlled for these three confounders.

Female Cancer Mortality

The p-value is 0.0166, which by conventional criteria indicates that there is a statistically significant difference between the highest elevation states and lowest elevation states. The female bronchopulmonary cancer mortality is lower in the highest elevation states than in the lowest elevation states. Results were similar for males.

Male Cancer Mortality

The p-value is 0.0051, which by conventional criteria indicates that there is a very statistically significant difference between the highest elevation states and lowest elevation states. The male bronchopulmonary cancer mortality is much lower in the highest elevation states than in the lowest elevation states. Both male and female results show lower cancer mortality among high altitude dwellers. Therefore, gender may not be affecting the relationship between cancer mortality and altitude.

Ages 44 and Younger Cancer Mortality

The p-value is 0.0006, which by conventional criteria indicates that there is an extremely statistically significant difference between the highest elevation states and lowest elevation states. The ages 44 and younger bronchopulmonary cancer mortality is much lower in the highest elevation states than in the lowest elevation states. This trend also appeared in other age groups.

Female Ages 45 to 64 Cancer Mortality

The p-value is 0.0001, which by conventional criteria indicates that there is an extremely statistically significant difference between the highest elevation states and lowest elevation states. Similar to the 44 and younger group, the ages 45 to 64 bronchopulmonary cancer mortality is much lower in the highest elevation states than in the lowest elevation states. The final age group also showed similar results.

Ages 65 and Older Cancer Mortality

The p-value is 0.0244, which by conventional criteria indicates that there is a statistically significant difference between the highest elevation states and lowest elevation states. The ages 65 and older bronchopulmonary cancer mortality is lower in the highest elevation states than in the lowest elevation states. All three age categories showed lower cancer mortality among high altitude dwellers. Therefore, age may not be affecting the relationship between cancer mortality and altitude.

White Cancer Mortality

The p-value is 0.0434, which by conventional criteria indicates that there is a statistically significant difference between the highest elevation states and lowest

elevation states. The white bronchopulmonary cancer mortality is lower in the highest elevation states than in the lowest elevation states. This coincides with the findings for age and gender.

Black or African American Cancer Mortality

The p-value is 0.1598, which by conventional criteria indicates that there is no statistically significant difference between the highest elevation states and lowest elevation states. This was first time during the analysis of the bronchopulmonary cancer mortality data where I discovered a new finding. This finding refutes the findings by Hart (2011) because he did not control for confounders such as race. Thus, the interpretation is that for Blacks or American Americans, altitude has no influence on their bronchopulmonary cancer mortality.

Asian or Pacific Islander Cancer Mortality

The p-value is 0.2597, which by conventional criteria indicates that there is no statistically significant difference between the highest elevation states and lowest elevation states. Thus, the interpretation is that for Asians or Pacific Islanders altitude has no influence on their bronchopulmonary cancer mortality. Note that the p-value is slightly higher for Asian or Pacific Islander when compared to Blacks or American Americans. This means that there is even less of a difference found for the Asian or Pacific Islander group.

American Indian or Alaska Native Cancer Mortality

The p-value is 0.4862, which by conventional criteria indicates that there is no statistically significant difference between the highest elevation states and lowest

elevation states. Thus, the interpretation is that for American Indians or Alaska Natives altitude has no influence on their bronchopulmonary cancer mortality. Note that the p-value is the highest for American Indians or Alaska Natives when compared to the other races. This means that there is the least amount of difference found for the American Indian or Alaska Native group.

All non-White Cancer Mortality

The p-value is 0.3461, which by conventional criteria indicates that there is no statistically significant difference between the highest elevation states and lowest elevation states. This reconfirms that the cancer mortality data for three races of Black or African American, Asian or Pacific Islander, and American Indian or Alaska Native, as a group, show no statistically significant difference for the highest elevation states and lowest elevation states. These are unique findings considering that these three groups of races would need to be excluded from groups that would benefit from lower bronchopulmonary cancer mortality at higher altitudes.

Female Cancer Incidence

The p-value is 0.0129, which by conventional criteria indicates that there is a statistically significant difference between the highest elevation states and lowest elevation states. The female bronchopulmonary cancer incidence is lower in the highest elevation states than in the lowest elevation states. These results coincide with the results for cancer mortality and are also seen in the male group for cancer incidence.

Male Cancer Incidence

The p-value is 0.0019, which by conventional criteria indicates that there is a very statistically significant difference between the highest elevation states and lowest elevation states. The male bronchopulmonary cancer incidence is much lower in the highest elevation states than in the lowest elevation states. Both male and female results show lower cancer incidence among high altitude dwellers; therefore, like the results for cancer mortality, gender may not be affecting the relationship between cancer incidence and altitude.

Ages 44 and Younger Cancer Incidence

The p-value is 0.0001, which by conventional criteria indicates that there is an extremely statistically significant difference between the highest elevation states and lowest elevation states. The ages 44 and younger bronchopulmonary cancer incidence is much lower in the highest elevation states than in the lowest elevation states. Similar to gender, the age groups showed similar results for cancer incidence that were shown for cancer mortality.

Ages 45 to 64 Cancer Incidence

The p-value is 0.0001, which by conventional criteria indicates that there is an extremely statistically significant difference between the highest elevation states and lowest elevation states. The ages 45 to 64 bronchopulmonary cancer incidence is much lower in the highest elevation states than in the lowest elevation states. The final age group also showed similar results.

Ages 65 and Older Cancer Incidence

The p-value is 0.0178, which by conventional criteria indicates that there is a statistically significant difference between the highest elevation states and lowest elevation states. The ages 65 and older bronchopulmonary cancer incidence is lower in the highest elevation states than in the lowest elevation states. All three age categories showed lower cancer incidence among high altitude dwellers. Therefore, age may not be affecting the relationship between cancer incidence and altitude, which was also the case for cancer mortality.

White Cancer Incidence

The p-value is 0.0299, which by conventional criteria indicates that there is a statistically significant difference between the highest elevation states and lowest elevation states. The white bronchopulmonary cancer incidence is lower in the highest elevation states than in the lowest elevation states. This coincides with the cancer incidence findings for age and gender.

Black or African American Cancer Incidence

The p-value is 0.1286, which by conventional criteria indicates that there is no statistically significant difference between the highest elevation states and lowest elevation states. Like cancer mortality, this was first time during the analysis of the bronchopulmonary cancer incidence data where I discovered a new finding. This finding refutes the findings by Simeonov and Himmelstein (2015) because they did not control for confounders such as race. Therefore, the interpretation is that for Blacks or American Americans altitude has no influence on their bronchopulmonary cancer incidence.

American Indian or Alaska Native Cancer Incidence

The p-value is 0.2518, which by conventional criteria, indicates that there is no statistically significant difference between the highest elevation states and lowest elevation states. Therefore, the interpretation is that for American Indians or Alaska Natives, altitude has no influence on their bronchopulmonary cancer incidence. Note that the p-value is slightly higher for American Indians or Alaska Natives when compared to Blacks or African Americans. This means that there is even less of a difference found for the American Indian or Alaska Native group.

Asian or Pacific Islander Cancer Incidence

The p-value is 0.9284, which by conventional criteria, indicates that there is no statistically significant difference between the highest elevation states and lowest elevation states. Therefore, the interpretation is that for Asians or Pacific Islanders, altitude has no influence on their bronchopulmonary cancer incidence. Note that the p-value is the highest for Asians or Pacific Islanders when compared to the other races. This means that there is the least amount of difference found for the Asian or Pacific Islander group.

All non-White Cancer Incidence

The p-value is 0.5551, which by conventional criteria, indicates that there is no statistically significant difference between the highest elevation states and lowest elevation states. Therefore, we just reconfirmed that the cancer incidence data for three races of Black or African American, American Indian or Alaska Native, and Asian or Pacific Islander, as a group, show no statistically significant difference for the highest

elevation states and lowest elevation states. These are unique findings considering that these three groups of races would need to be excluded from groups that would benefit from lower bronchopulmonary cancer incidence at higher altitudes.

Social Impact

The association that I had found between altitude and bronchopulmonary cancer incidence and mortality is for the Whites only group. My research inquiry contributes to the expansion and development of a body of knowledge. A positive social change impact of this study is that this study provides the groundwork for future studies to research what exactly in the environment is causing the differences in bronchopulmonary cancer mortality and incidence in the United States.

My study does create an immediate positive social change impact through the very practical Bronfenbrenner's (1977) ecological model. The immediacy of the positive social change is brought about through the relevance of the individual component and social environment component of the ecological model. Both the individual and social circles do greatly influence patterns of disease and injury. The individual and social environment both strongly shape our responses to these patterns of disease and injury. At the individual level, the focus is on changing an individual's knowledge and attitudes to influence behavior. Social impact occurs not only when action is taken, but also when knowledge is learned and when attitudes are changed. Individuals may learn of the information concerning lower bronchopulmonary cancer incidence and mortality at higher altitudes. They may relocate to higher elevation as a prophylactic against bronchopulmonary cancer due to their increased awareness of this issue which may bring

about an immediate positive social change. At the social environment level, interpersonal relationships between friends, colleagues, peers, family members, and members of the community influence behavior. The immediate positive social change, through the web of these interpersonal networks and structures, expands and impacts even more people through this social arrangement and framework.

Implication for Practice

The main aim of this study was to develop the understanding of the association between altitude and bronchopulmonary cancer mortality and incidence by studying the cancer mortality data and cancer incidence data for the lowest elevation and highest elevation states within the United States from 2006 to 2014. I have done so by observing, reporting, and analyzing new data from CDC WONDER.

My study strictly focuses on the association between altitude and bronchopulmonary cancer incidence for new data. It also strictly focuses on the association between altitude and bronchopulmonary mortality for new data. The association that I had found between altitude and bronchopulmonary cancer incidence and mortality for the Whites only group does not imply causality, nor does it mean that altitude is a major influencer on bronchopulmonary cancer incidence and mortality. Moreover, my study does not account for lifestyle (such as tobacco use), nor does my study account for higher population densities, which lead to increased air pollution due to increased use of motor vehicles, watercrafts, and aircrafts.

The theoretical framework for my study is the ecological model. The tenets of the ecological model are depicted by the four levels of influence used in this model, and they

serve as the four central components of this framework. They are the individual level, social environment, physical environment, and public policy components.

At the public policy level, the focus is on changing policy to influence behavior. Public health strategies may be implemented to increase awareness and understanding of the association between altitude and bronchopulmonary mortality and incidence. Without the implementation of public health strategies, it may be difficult to witness the power and impact of the ecological model. Government agencies can promote and distribute my novel finding of the beneficial outcomes for bronchopulmonary cancer mortality and incidence via public health announcements on television, radio, and the internet. The target audience would be only for the Whites only population of the United States. At the same time, these policies and promotions should remind the target audience of the responsibility to live healthy lifestyles such as avoiding tobacco. These policies and promotions encouraging relocation for Whites to higher altitudes would then have a better chance to succeed and lead to positive health outcomes.

Recommendations for Future Research

I believe my study has paved the way for an expanded research into collecting bronchopulmonary cancer mortality and cancer incidence for all 50 states. My study advances opportunities for future research for concept validation and theory reinforcement. More research will be needed to refine and build up on my novel findings. This next phase of research is important because we can rank the various states according to their mean elevations. We can then plot each state's bronchopulmonary cancer mortality data against the mean elevation of each state. The data for each state

should be controlled for age, sex, and race as well just as I had done in my study for the six highest and the six lowest elevation states. There will be 51 data points (including the District of Columbia) for each of the myriads of graphs that can be generated from controlling for age, sex, and race. A linear regression analysis can then be done to see how well the data fits the model. It would be very misleading to do a linear regression fit for the data that I had studied on bronchopulmonary cancer mortality because my data only dealt with the extremes, i.e., my data only dealt with the 6 highest elevation states and the 6 lowest elevation states.

We can also plot each state's bronchopulmonary cancer incidence data against the mean elevation of that state. The data for each state should be controlled for age, sex, and race as well just as I had done in my study for the six highest and the six lowest elevation states. There will be 51 data points (including the District of Columbia) for each of the myriads of graphs that can be generated from controlling for age, sex, and race. A linear regression analysis can then be done to see how well the data fits the model. It would also be very misleading to do a linear regression fit for the data that I had studied on bronchopulmonary cancer incidence because my data only dealt with the extremes, i.e., my data only dealt with the 6 highest elevation states and the 6 lowest elevation states.

My study has also paved the way for future research to find out the reasons behind why the three races, Black or African American, Asian or Pacific Islander, and American Indian or Alaska Native, show no statistically significant difference in

bronchopulmonary cancer mortality and cancer incidence for the highest elevation states and lowest elevation states.

Conclusion

In this final chapter, I summarized my research findings, discussed the implications for practice, explained the social impact, and made recommendations for future research. This study provides the groundwork for future studies to research what exactly in the environment is lowering the bronchopulmonary cancer mortality and incidence specifically for the White population.

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