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Spatiotemporal Variations in Coexisting Multiple Causes of Death and the Associated Factors

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2018

Abstract

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by

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MSc, University of Hertfordshire, 2015

B Tech., Ladoke Akintola University of Technology, 2008

Dissertation Submitted in Partial Fulfilment

of the Requirements for the Degree of

Doctor of Philosophy

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Abstract

The study and practice of epidemiology and public health benefit from the use of mortality statistics, such as mortality rates, which are frequently used as key health indicators. Furthermore, multiple causes of death (MCOD) data offer important information that could not possibly be gathered from other mortality data. This study aimed to describe the interrelationships between various causes of death in the United States in order to improve the understanding of the coexistence of MCOD and thereby improve public health and enhance longevity. The social support theory was used as a framework, and multivariate linear regression analyses were conducted to examine the coexistence of MCOD in approximately 80 million death cases across the United States from 1959 to 2005. The findings showed that in the United States, there is a statistically significant relationship between the number of coexisting MCOD, race, education, and the state of residence. Furthermore, age, gender, and marital status statistically influence the average number of coexisting MCOD. The results offer insights into how the number of coexisting MCOD vary across the United States, races, education levels, gender, age, and marital status and lay a foundation for further investigation into what people are dying from. The results have the long-term potential of helping public health practitioners identify individuals or communities that are at higher risks of death from a number of coexisting MCOD such that actions could be taken to lower the risks to improve people's wellbeing, enhance longevity, and contribute to positive social change.

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Dedication

To my parents, Mr. Augustine M Salawu and Mrs. Florence B Salawu, who continue to dedicate their lives to teaching in public schools and continue to see the best in all children regardless of their background, race, or religious beliefs.

To my elder brothers, Kayode, Patrick, and Pius, who have a good understanding of hard work, kindness, and fairness.

To my (late) elder sister, Titilade, who showed courage and love of natural and mathematical sciences to her last minute.

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Chapter 1: Introduction to the Study

Introduction

Mortality rates, such as crude mortality rate (which accounts for the entire population) and the more specific mortality rates, such as neonatal mortality rate, infant mortality rate, maternal mortality rate, cause-specific mortality rates, etc. are frequently used as key health indicators (Dwyer-Lindgren et al., 2016; Mackenbach et al., 2015; Nordentoft et al., 2013; Smith et al., 2014; Weber et al., 2013). Since they serve as key health indicators, mortality statistics are useful and of interest in epidemiology and in public health. However, researchers have shown that these forms of mortality metrics alone have limited powers in revealing all the possible and important information about the health of the population and people of interest as well as what the people are dying from (T.-H. Lu & Lin, 2010; Redelings, Sorvillo, & Simon, 2006).

Cause-specific mortality rates (e.g., lung cancer mortality rate, liver cirrhosis mortality rate, etc.) are generally obtained from underlying cause of death (UCOD) data, which is a cause-of-death dataset that identifies a single disease or condition as the UCOD (Piffaretti, Moreno-Betancur, Lamarche-Vadel, & Rey, 2016). Researchers have, however, shown that identifying a single disease or condition as the cause of death makes UCOD an oversimplification of the process/events leading to death and constitutes a major limitation of the UCOD approach (Désesquelles et al., 2010; Piffaretti, Moreno-Betancur, Lamarche-Vadel, & Rey, 2016; Redelings et al., 2006). Furthermore, the UCOD approach has been shown to underestimate the importance of some disease conditions (such as diabetes, sepsis-related conditions, etc.) in the etiology of death (Fedeli, Piccinni, Schievano, Saugo, & Pellizzer, 2016; Hastings et al., 2017). This,

among others, constitutes another major limitation of the UCOD approach (Fedeli et al., 2016; Hastings et al., 2017).

On the other hand, researchers have been able to demonstrate that multiple causes of death (MCOD) data have the capability of providing important information that could not possibly be gathered from other mortality data (T.-H. Lu & Lin, 2010; Redelings et al., 2006). This has been illustrated by the work of Redelings et al. (2006) who compiled MCOD data and identified the most common causes of death in the United States between the year 2000 and the year 2001 and compared the mortality statistics computed from UCOD data and from MCOD data. They showed that the statistics from both the UCOD and the MCOD data are needed for an in-depth and accurate understanding of the mortality information of a population and that UCOD data alone are not enough (T.-H. Lu & Lin, 2010; Redelings et al., 2006). These studies and others supported and proved that UCOD data and MCOD data offer different information that are all important and should be used to complement each other (T.-H. Lu & Lin, 2010; Redelings et al., 2006; Redelings, Wise, & Sorvillo, 2007).

Since MCOD data often contain a list of factors that contributed to the death in additional to the UCOD (Boone-Heinonen, Messer, Fortmann, Wallack, & Thornburg, 2015; Wolfson & Bleich, 2015), the MCOD approach to mortality statistics makes it possible to investigate the relationships between the various causes of death (Redelings et al., 2007). For these reasons, an increasing number of researchers are now suggesting the importance of MCOD data (T.-H. Lu & Lin, 2010; Redelings et al., 2006).

Despite the National Center for Health Statistics' use of resources to routinely collect it, there is still considerable underutilization of MCOD data (U.S. Department of

Health and Human Services, 2009a, 2009b, 2009c, 2009d, 2009e). The underutilization of MCOD data contributes to the gap in mortality knowledge from the MCOD perspective. In this study, I used the MCOD data collected from the year 1959 to the year 2005. The findings of this study help towards bridging the gap and adds to the utilization of the MCOD data.

This study is important and, in addition to adding to the utilization of the MCOD data, offers additional information on the interrelationships between various causes of death in the United States. Through this study, I also investigated the variations in the causes of death over the years for a period of 5 decades, 1959 to 2005, as well as the variations in the causes of death across the states and territories of the United States. My computational and statistical background and my experience offering professional statistical consultation services allow me to have the skills needed for handling this huge dataset. The potential effects of race and education level on the causes of death were also investigated in this study. The insights into what people are dying from and how the causes of death vary across the United States, both in space, from one state to another state, and time, between the year 1959 and the year 2005, (i.e., spatiotemporal) and across races and education levels that the results of this study provided makes it important and urgent. Furthermore, the findings of this study have the potential of promoting positive social change by revealing in the simplest possible forms, to the general public with diverse backgrounds and various education levels, the spatiotemporal, racial, and educational variations in the number of coexisting MCOD. Such information can be used to help people to be more aware of the risks posed by various possible MCOD and how

those risks apply to them as individuals, thereby aiding risk avoidance, longevity, and positive social change.

In this chapter, I will present the background of the study, the problem statement, the purpose of the study, and the research questions and hypotheses of the study. In addition, the theoretical framework for the study will be presented, explaining how the social support theory comes into play as the causes of death are shifting from acute diseases to a combination of chronic diseases that have social aspects. This chapter will also contain information about the nature of the study, the study design, the key study variables, the data sources, and the operational definitions of the most important terms and concepts in the study. I will also present the study assumptions, the scope, and the potential limitations of the study. Furthermore, additional information on how the study will contribute towards positive social change, knowledge advancement, and improvements in health practices will be presented.

Background

Mortality information, such as mortality rates (especially when they are stratified with or adjusted for age, income, etc.), are a set of important public health and population health indicators (Nolte & McKee, 2008). For example, crude mortality rate and specific mortality rates (such as neonatal mortality rate, infant mortality rate, maternal mortality rate, etc.) serve as important indicators for assessing the health status of communities over a given period of time (World Health Organization, 2015; Pearcy & Keppel, 2016). They are also used for assessing the efficiency, quality, and effectiveness of healthcare services and systems in a region and/or population (Organization, 2015; Pearcy & Keppel, 2016). If mortality rates derived from UCOD alone is useful enough in providing

vital information that could be used for a reasonable monitoring of communities' health and healthcare systems' performances, then I expected that a careful analysis and use of MCOD data, which contains more information, would be very valuable. If the leading causes of death that coexist could be carefully articulated for a given community, such information would be valuable and help in guiding decision-making and/or the policy development processes targeted at identifying, designing, planning, and implementing healthcare and/or health promotion programs. This would have the overall benefit of making investments in health programs more cost-effective and more beneficial overall.

There is often more than one disease or cause of death implicated in the majority of deaths. This brings about the importance of looking into MCOD that coexist, so that an individual considers the collective effects of and interactions between all the diseases, conditions, and/or fatal injuries that brought about the death. These can partially explain why the use of MCOD data as a way of assessing and describing mortality patterns is starting to gain popularity (Désesquelles et al., 2010; Gorina & Lentzner, 2008; Redelings et al., 2006, 2007). The gradually increasing interest in MCOD data may also be rationalized based on the ability of MCOD information to give a better understanding of the factors that interact together to give rise to deaths. In fact, researchers have shown that MCOD data are able to provide valuable information and useful insights that could not possibly be gathered from other sources of mortality data (T.-H. Lu & Lin, 2010; Redelings et al., 2006).

Over the past years, more and more researchers have started to suggest the great benefits and importance of MCOD data (T.-H. Lu & Lin, 2010; Redelings et al., 2006), since the information contained in the MCOD often contains a list of factors that

contributed to the death in addition to the root cause of death data (Redelings et al., 2007), such as substance abuse or suicide in people with mental issues (Nordentoft et al., 2013) or diabetes and/or cardiovascular disease in people with obesity (Boone-Heinonen et al., 2015; Klose, Wallace, & Janes, 2010; Wolfson & Bleich, 2015). MCOD data makes it possible to investigate the relationships between a number of reported causes of death (Redelings et al., 2007). It has been shown that MCOD data compliments UCOD data by providing extra information (T.-H. Lu & Lin, 2010; Redelings et al., 2006). For example, when comparing psychiatric disorder mortality between United States and Taiwan based on UCOD and MCOD data, Lu and Lin (2010) found that, according to UCOD data, the mortality rate of psychiatric disorders was 3.6 per 100,000 people in Taiwan, while it was 21.9 per 100,000 people in the United States. However, based on MCOD data, the mortality rate from psychiatric disorders was 10.3 per 100,000 people in Taiwan and 115.4 per 100,000 people in the United States (Lu & Lin, 2010). These and other results supported the fact that UCOD data and MCOD data offer different information that are all important and should be used to complement each other (T.-H. Lu & Lin, 2010; Redelings et al., 2006).

In this study, I used quantitative research methods involving numerical and statistical techniques to analyze and study the coexistence of causes of death and how some independent variables of interest influence the number of causes of death that coexist across the states and territories of the United States from 1959 to 2005 using MCOD data. My principal aim with this study was to explore how the number of MCOD that coexist varies across various independent variables.

The findings of this study help in expanding the current body of knowledge on the coexistence of MCOD and have the potential of providing guidance for public health decision making, health policymaking, and the development of health programs targeted at improving health and enhancing longevity as well as aiding health programs in becoming more cost-efficient and cost-effective.

Problem Statement

Mortality rates, such as crude mortality rate and the more specific mortality rates, such as neonatal mortality rate, infant mortality rate, maternal mortality rate, cause-specific mortality rates, etc., are frequently used as key health indicators (Dwyer-Lindgren et al., 2016; Mackenbach et al., 2015; Nordentoft et al., 2013; Smith et al., 2014; Weber et al., 2013) and are of interest in epidemiology and public health. The cause-specific mortality rates, such as lung cancer mortality rate, liver cirrhosis mortality rate, etc., are generally obtained from UCOD data, which is a cause-of-death dataset that identifies a single disease or condition as the UCOD (Piffaretti et al., 2016). However, researchers have shown that identifying a single disease or condition as the cause of death makes UCOD an oversimplification of the process and/or events leading to death (Désesquelles et al., 2010; Fedeli, Zoppini, et al., 2015; Piffaretti et al., 2016; Redelings et al., 2006), thereby suggesting the need for examining MCOD data. Furthermore, the UCOD approach has been shown to underestimate the importance of some disease conditions, such as diabetes, sepsis-related conditions, etc., in the etiology of death (Fedeli et al., 2016; Hastings et al., 2017). This, among others, is a major limitation of the UCOD approach (Fedeli et al., 2016; Hastings et al., 2017). On the other hand, in the MCOD approach of gathering mortality information, all the conditions reported on the

death certificate, which could be up to 20 conditions and not just the UCOD alone, are treated as been relevant and important (Désesquelles et al., 2010; Fedeli, Zoppini, et al., 2015; Piffaretti et al., 2016; Redelings et al., 2006).

The benefits of the information that coexisting multiple causes of death (CMCOD) data can offer have never been extensively and systematically explored and tapped into, despite the fact that data on the MCOD that coexist are continuously collected by the National Center for Health Statistics (U.S. Department of Health and Human Services, 2009a, 2009b, 2009c, 2009d, 2009e). If well-articulated, information on the coexistence of MCOD can be useful to both clinical and public health practitioners as well as decision makers in the public health sector. Such information could help in improving the practice of evidence-based decision-making towards preserving health, restoring health, and/or enhancing longevity in the United States by guiding the better prioritization and allocation of available resources towards the most important diseases (Mokdad, Marks, Stroup, & Gerberding, 2004; Scallan et al., 2011). In addition, well-articulated and analyzed MCOD data can also be a useful guide to healthcare practitioners by helping them identify the potentially important *secondary* disease conditions that require attention when a patient is diagnosed with or is being treated for a primary condition. This is especially true if the secondary disease is known to often coexist with the primary disease from which the patient currently suffers.

The limited nature or lack of adequate information on the coexistence of MCOD, as suggested by previous research (e.g., Fedeli et al., 2016; Haneuse, 2017; Piffaretti et al., 2016) in addition to the lack of information and knowledge on the disparities in the coexistence of MCOD across the United States amounts to a gap in the literature. Please

note that the limited nature or lack of adequate information on the coexistence of MCOD does not mean that there is lack of MCOD data; rather, there is abundance of unanalyzed and uninterpreted raw MCOD data. This suggests a disturbingly shallow nature of our current understanding of what influences our health and sickness and ultimately our wellbeing and longevity, which are all of fundamental interest in the fields of epidemiology and public health. For example, it is currently not known whether the odds of dying from a combination of Alzheimer's disease, heart failure and renal failure is higher than or lower than the odds of dying from a combination of diabetes, stroke, and hypertension. How the odds of dying from Alzheimer's disease, heart failure, renal failure, and colorectal cancer that coexist compare to or differ from the odds of dying from lung cancer, diabetes, stroke, and hypertension that coexist is not known. How likely it is for these conditions (and other combinations of these and other disease conditions) to coexist remains unknown. How their coexistences may vary by place of residence, by differences in educational attainment, and/or by race are also not known. All these, despite their relevance to epidemiology, which deals with the incidence, distribution, and possible control of diseases and health-related conditions, and public health, cannot be found in the existing literature. The results of this study provide information, in the form of both descriptive and inferential statistics, that can be further expanded towards providing some of these needed facts.

Purpose of the Study

Improving the understanding of coexistence of MCOD in ways that may ultimately, although, perhaps indirectly, help in improving health and in enhancing longevity was the overall purpose of this study. Through this quantitative study, I wished

to provide a comprehensive numerical description of the coexisting MCOD in the form of relative frequencies, identify possible disparities in the number of coexisting MCOD per death case across the states and territories of the United States (i.e., the spatial dimension) and across the years of 1959 to 2005 (approximately five decades; i.e., the temporal dimension). In other words, with this study, I intended to provide information on the interrelationships between various causes of death in the United States. Through this study, I also investigated potential variations in the causes of death across the states and territories of the United States as well as the variations in the causes of death over a period of 5 decades (i.e., 1959 to 2005). Furthermore, the potential effects of race and education level on the coexistence of MCOD were also investigated in this study. Race was considered in this study because race often has important and persistent effects on health, sickness, and longevity (see Beydoun et al., 2016; Curtin & Hoyert, 2017; Garcia-Alexander & Woo, 2015; Yu, Norris, Cheung, & Yan, 2017). This is also true for educational attainment, which is believed to have effects on an individual's wellbeing, health, sickness, longevity, and death (see Benito-León, Contador, Mitchell, Domingo-Santos, & Bermejo-Pareja, 2016; Fedeli, Avossa, et al., 2015; Kulhánová, Hoffmann, Eikemo, Menvielle, & Mackenbach, 2014; Mackenbach et al., 2015).

Research Questions and Hypotheses

I developed the following research questions and hypotheses to guide this study:

Research Question 1: Is there any relationship between the number of coexisting multiple causes of death per death case and the state or territory of residence in the United States?

$H_0$1: There is no relationship between the number of coexisting multiple causes of death and the state or territory of residence in the United States.

$H_1$1: There is a relationship between the number of coexisting multiple causes of death and the state or territory of residence in the United States.

Research Question 2. Are there variations in the number of coexisting multiple causes of death per death case in the United States from 1 year to another?

$H_0$2: There are no variations in the number of coexisting multiple causes of death in the United States from 1 year to another.

$H_1$2: There are variations in the number of coexisting multiple causes of death in the United States from 1 year to another.

Research Question 3. Is there any relationship between the number of coexisting multiple causes of death per death case and race in the United States?

$H_0$3: There is no relationship between the number of coexisting multiple causes of death and race in the United States.

$H_1$3: There is a relationship the number of coexisting multiple causes of death and race in the United States.

Research Question 4. Is there any relationship between the number of coexisting multiple causes of death per death case and education level in the United States?

$H_0$4: There is no relationship between the number of coexisting multiple causes of death and education level in the United States.

$H_1$4: There is a relationship between the number of coexisting multiple causes of death and education level in the United States.

Theoretical Framework for the Study

The theory of persistent income inequality (Durlauf, 1996) and the social support theory (Durkheim, 1897; House, Landis, & Umberson, 1988) were vital to the core of my study. How the coexistence of MCODs are becoming increasingly important was addressed by the social support theory (see Durkheim, 1897; House et al., 1988). The social support theory forms a framework for how stress and psychosocial factors are increasingly contributing more to illnesses and death because chronic diseases that coexist, and which have stress and psychosocial elements, are steadily replacing acute and/or infectious diseases as the major causes of death (House et al., 1988). The theory of persistent income inequality, on the other hand, explains how it is difficult to ascend in economic status and how perpetually low economic status hinders good health (Durlauf, 1996), which may increase susceptibility to various illnesses/various causes of death.

Social Support Theory

In the book titled, *Expression of the Emotions in Man and Animals*, Darwin (1872), who is popularly considered as the Father of Evolution, weighed in on the important contributions and influences of social support on and health, stating

> … my father told me of a careful observer, who certainly had heart-disease and died from it, and who positively stated that his pulse was habitually irregular to an extreme degree; yet to his great disappointment it invariably became regular as soon as my father entered the room. (p. 340)

The social support theory has subsequently been postulated (Durkheim, 1897). The social support theory states that the amount and/or quantity of and the quality of social relationships have a causal impact on health and that people with a low quantity of and

low quality social support consistently show increased risk of death (Durkheim, 1897; House et al., 1988). Early independent research has supported this theory and shown that social support is a moderator of life stress and that people with better social support can better withstand life's various stresses and stay healthy while people with poorer social supports are susceptible to life's stresses and the various associated illnesses (Cobb, 1976). Social environment also contributes immensely to host resistance (Cassel, 1976). The theory essentially puts forward that less socially integrated individuals or more socially isolated individuals are less healthy, psychologically and physically, and they are more likely to die from a variety of causes, while the opposite is true for the people who are more socially integrated (House et al., 1988).

The social support theory is becoming increasingly important as stress and psychosocial factors are increasingly contributing more to illnesses and death because chronic diseases that coexist are steadily replacing acute and/or infectious diseases as the major causes of death, especially in industrialized countries (House et al., 1988). This is the main reason why theories of disease etiology and morbidity and mortality have shifted from those wherein a single factor (e.g., a germ) causes a single disease and consequently morbidity and/or mortality, to those in which multiple factors and diseases act together, especially over an extended period of time, to cause morbidity and/or mortality (House et al., 1988). This is the main reason social support theory was relevant to this study on the MCOD was because it suggests that people with poorer social supports are susceptible to life stress and the various associated illnesses (Cobb, 1976) that could ultimately lead to death from multiple causes, which include MCOD that the

individuals could have been resistant to had they had the proper social environment that has been shown to contribute immensely to host resistance (Cassel, 1976).

The Theory of Persistent Income Inequality

Durlauf (1996) postulated the theory of persistent income inequality through the successful study of income inequalities and their dynamics by examining families' neighborhood choices and how those choices influence the families' evolution of human capital investment. Based on Durlauf's theory of persistent income inequality, parents' choice of the neighborhood where the whole family lives influences the conditional probability distribution of the incomes of the children. Children's neighborhood affects children via a combination of both the local public finance of education and the sociological effects of parents' income and/or access to financial resources (Ellen & Turner, 1997; Friedrichs, Galster, & Musterd, 2003; Galster, 2012) . The theory establishes that the effects of neighborhoods on children shapes their future to the extent of dictating what their earning potentials and income are when they become adults (Durlauf, 1996). These effects work together in making circumstances that enhance neighborhoods' segregations into economically homogeneous segments, such that poor families and wealthy families live within physically separate neighborhoods (Durlauf, 1996). The joint effects of neighborhood-wide feedback and economic stratification favor and often enforce the transmission of economic and social statuses across generations and essentially cause persistent income inequality (Durlauf, 1996). Such income inequalities lead to disparities in health outcomes and disparities in longevities (Ellen & Turner, 1997; Friedrichs et al., 2003; Galster, 2012).

This theory was important to the aspects of this study that focused on how income inequality, educational attainment, and/or the distribution of public health resources and funds that may vary across places of residence may influence the coexistence of MCOD. The theory of persistent income inequality (Durlauf, 1996) helped me in explaining the possible effects of inequalities in people's incomes, educational attainment, and disparities in people's neighborhood may have on their access to public health financing and public health resources as well as how these mayaffect people's health, illnesses, longevity, and the cause of death. For instance, studies have shown that living in disadvantaged neighborhoods leads to health problems (Ross & Mirowsky, 2001).

Nature of the Study

Study Design

This research was an analytic study, and I made use of quantitative methods (see Creswell & Creswell, 2017; Schools, 2010). This allowed me to have numerical quantities for describing my study parameters and the relationship between them. The study was based on a secondary data set for the years 1959 to 2005 that I obtained from the National Center for Health Statistics (see U.S. Department of Health and Human Services, 2007e, 2007c, 2007g, 2008d, 2008b, 2008f, 2008l, 2008c, 2008h, 2008j, 2008a, 2008e, 2007i, 2008k, 2008g, 2008i, 2009e, 2009a, 2009d, 2009c, 2009b, 2007h, 2007a, 2007j, 2007d, 2007f, 2007k, 2007b). The years in the references for the datasets do not in any way indicate the years that the datasets represent. The years in the references merely show the years that the 1959 to 2005 datasets were published and released to the public. For example, the dataset from the year 1959 was published and released to the public

through the Inter-University Consortium for Political and Social Research (ICPSR) database in the year 2009, so its reference has the year 2009.

In the first aspect of this quantitative study, I explored the distribution of the CMCOD across the United States. In the subsequent aspects of the study, I explored the relationships between the number of coexisting MCOD and various independent variables using inferential statistical techniques to test whether there are statistically significant relationships between the dependent and the independent variables of interest and to assess the extent and degree of the relationships, if they exist.

This study contains elements of cross-sectional analytic study design, wherein the dependent and the independent variables are measured at the same point in time. To identify the causes of death that most frequently coexist and to identify the specific group of people among which such coexisting MCOD are the most common, I used clustering statistical techniques such as k-means clustering and hierarchical clustering (see Hartigan & Wong, 1979; Johnson, 1967).

For the inferential statistics, I used multiple/multivariate linear regression analysis so as to be able to control the effects of other variables/potential confounders, such as gender, age, and marital status, while focusing on some specific independent variables of highest interest. Using this approach, I was able to statistically measure and assess the separate effects of each of the independent variables of interest on the dependent variable. The *F* test was used to assess the statistical significance of any model fitted in this study, while the *t* test was used to assess the statistical significance of each of the regression coefficients present in each of the fitted regression models. I also carried out multiple comparison post hoc analysis with Fisher's LSD, and wherever appropriate, Cohen's *d*

(see Cohen, 1988, 1992; Kelley & Preacher, 2012; Sawilowsky, 2009) was used as a measure of effect size for differences between two groups.

Key Study Variables

The dependent variable in the study was the number of MCOD that coexist, which was treated as a continuous variable. The causes of death in the secondary dataset had been obtained from death certificates and had been coded based on International Statistical Classification of Diseases and Related Health Problems (ICD; WHO, 2010). An explicit list of the causes of death considered are based on the list documented in the reports from the National Center for Health Statistics (U.S. Department of Health and Human Services, 2007e, 2007c, 2007g, 2008d, 2008b, 2008f, 2008l, 2008c, 2008h, 2008j, 2008a, 2008e, 2007i, 2008k, 2008g, 2008i, 2009e, 2009a, 2009d, 2009c, 2009b, 2007h, 2007a, 2007j, 2007d, 2007f, 2007k, 2007b).

The key independent variables were education level, race, place of residence, and year. The education level was an ordinal variable and reflected the number of years of formal education that the deceased person had. Race was a categorical variable measured at the nominal level of measurement. The categories were White, Black, American Indian (including Aleuts and Eskimos), Chinese, Japanese, Hawaiian (including part-Hawaiian), Filipino, Asian Indian, Korean, Samoan, Vietnamese, Guamanian, Other Asian or Pacific Islander, and Combined Other Asian or Pacific Islander.

The place of residence was also a categorical variable measured at the nominal level of measurement. The place of residence was based on the state or territory of the United States where the deceased person had been a resident. The year of death independent variable was a categorical variable measured at the ordinal level of

measurement so that the trends and variations in the coexisting causes of death over the years spanning 1959 to 2005 could be investigated.

The main covariates considered in the study were gender, age, and marital status. Gender was a categorical variable measured at the nominal level of measurement. The relevant categories were female and male. The age was measured at the interval level of measurement and was the number of years lived for each of the deceased people. Marital status was treated as a categorical variable measured at the nominal level of measurement. The valid categories were never married, single; married; widowed; and divorced.

Source of Data and Concise Methodology

I used MCOD data collated by the U.S. Department of Health and Human Services, National Center for Health Statistics (2008a) in this study. The secondary dataset contains information about the causes of all recorded deaths occurring in the United States, American Samoa, Guam, Northern Marianas, Puerto Rico, and the Virgin Islands (U.S. Department of Health and Human Services, 2007e, 2007c, 2007g, 2008d, 2008b, 2008f, 2008l, 2008c, 2008h, 2008j, 2008a, 2008e, 2007i, 2008k, 2008g, 2008i, 2009e, 2009a, 2009d, 2009c, 2009b, 2007h, 2007a, 2007j, 2007d, 2007f, 2007k, 2007b). I provide a list of the datasets and the years that each of the datasets covers in Table 1.

Table 1

The Datasets and the Years That Each of the Datasets Covers

Datasets*	Years Covered	References**

MCOD Data, 1959-1967, ICPSR 20680	1959-1967	(US-DHHS, 2009a)
MCOD Data, 1968-1973, ICPSR 3905	1968-1973	(US-DHHS, 2007b)
MCOD Data, 1974-1978, ICPSR 3906	1974-1978	(US-DHHS, 2007c)

(table continues)

Datasets*	Years Covered	References**
MCOD Data, 1979, ICPSR 3895	1979	(US-DHHS, 2007d)
MCOD Data, 1980, ICPSR 3897	1980	(US-DHHS, 2007e)
Mortality Detail and MCOD Data, 1981, ICPSR 3874	1981	(US-DHHS, 2007a)
MCOD Data, 1982, ICPSR 9880	1982	(US-DHHS, 2007f)
MCOD Data, 1983, ICPSR 9879	1983	(US-DHHS, 2008a)
MCOD Data, 1984, ICPSR 9811	1984	(US-DHHS, 2008b)
MCOD Data, 1985, ICPSR 9812	1985	(US-DHHS, 2008c)
MCOD Data, 1986, ICPSR 9723	1986	(US-DHHS, 2008d)
MCOD Data, 1987, ICPSR 9724	1987	(US-DHHS, 2008e)
MCOD Data, 1988, ICPSR 6299	1988	(US-DHHS, 2008f)
MCOD Data, 1989, ICPSR 6257	1989	(US-DHHS, 2008g)
MCOD Data, 1990, ICPSR 6319	1990	(US-DHHS, 2009b)
MCOD Data, 1991, ICPSR 6320	1991	(US-DHHS, 2009c)

(table continues)

Datasets*	Years Covered	References**
MCOD Data, 1992, ICPSR 6546	1992	(US-DHHS, 2008h)
MCOD Data, 1993, ICPSR 6799	1993	(US-DHHS, 2008i)
MCOD Data, 1994, ICPSR 2201	1994	(US-DHHS, 2008j)
MCOD Data, 1995, ICPSR 2392	1995	(US-DHHS, 2009d)
MCOD Data, 1996, ICPSR 2702	1996	(US-DHHS, 2009e)
MCOD Data, 1997, ICPSR 3085	1997	(US-DHHS, 2008k)
MCOD Data, 1998, ICPSR 3306	1998	(US-DHHS, 2007g)
MCOD Data, 1999, ICPSR 3473	1999	(US-DHHS, 2007h)
MCOD Data Public Use Files, 2000-2002, ICPSR 4640	2000-2002	(US-DHHS, 2007i)
MCOD Data Public Use Files, 2003, ICPSR 20540	2003	(US-DHHS, 2007j)
MCOD Data Public Use Files, 2004, ICPSR 20623	2004	(US-DHHS, 2007k)
MCOD Data Public Use Files, 2005, ICPSR 22040	2005	(US-DHHS, 2008l)

* Multiple Causes of Death is abbreviated as MCOD
** United States Department of Health and Human Services is abbreviated as US-DHHS

To identify the causes of death that most frequently coexist and the specific group of people among which such coexisting MCOD are most common, I used clustering such as k-means clustering and hierarchical clustering (see Hartigan & Wong, 1979; Johnson, 1967). For the inferential statistics, to control the effects of other variables, the covariates, and potential confounders (such as gender, age, and marital status) while focusing on the specific independent variables of highest interest, I used multiple/multivariate regression analysis. This approach allowed me to be able to statistically assess the separate effects of the individual independent variables on the dependent variable.

The ICD has undergone many revisions since its first adoption. A number of versions of the ICD have been adopted over the years and my study period spans years during which ICD-7 to ICD-10 were being used: ICD-7 (1958–1967), ICD-8 (1968–1978), ICD–9 (1979-1998), and ICD-10 (1999–present). I handled the variations in the ICD as follows.

Even though the NCHS tries to use consistent ways of representing the diseases and conditions listed in the ICDs (e.g., by having 258RECODE, that groups and represents the diseases and conditions in an internally consistent manner on all NCHS's records/documents), I found that the approach was still not consistent enough and varied slightly when the adopted ICD changed. Therefore, it was suboptimal and not ideal to rely on the NCHS's 258RECODE for ensuring that the diseases and conditions were represented consistently across the study period. However, since my dependent variable was a count or continuous variable, namely the number of multiple causes of death that coexist, the hypothesis testing did not suffer in any way whatsoever from the changes in

the ICDs. So, for the inferential statistics part, wherein a count of the number of multiple causes of death that coexist was needed, it did not matter how the disease was coded because only the count or number of the diseases mentioned was needed. Nonetheless, for the more in-depth descriptive statistics where a person may want to present the exact names of the diseases or conditions for the causes of death, it would be ideal to employ ICD-based stratification of the dataset. This was, however, not within the scope of this study.

Definitions

Age: The age at which the subject died, measured in years. It was treated as a continuous variable measured at the interval level of measurement. The effect of age was controlled for in this study because previous researchers have shown that health outcomes, morbidity, and mortality are affected by age (Gabet, Chatignoux, Ducimetière, Danchin, & Olié, 2016; MacDorman, Declercq, & Thoma, 2017a; Orosco et al., 2015; Taneja, Mitnitski, Rockwood, & Rutenberg, 2016; Tate et al., 2016).

Education level: The education level of each of the deceased people reflects the number of years of formal education that the deceased person went through. In this study, education level could be viewed as a proxy to socioeconomic status because socioeconomic status was not present in the secondary dataset being used. The education level was measured at the ordinal level of measurement and has levels such as eighth grade or less; ninth to 12th grade, no diploma; high school graduate or GED completed; some college credit, but no degree; associate degree; bachelor's degree; master's degree; and doctorate or professional degree.

Gender: A categorical variable measured at the nominal level of measurement. It has female and male as the possible values. The effects of gender were controlled for in this study because it has been previously shown that gender has the tendency of influencing mortality (see Acciai & Firebaugh, 2017; Falasinnu, Chaichian, & Simard, 2017; Ni & Xu, 2016; Ogundipe, Kodadhala, Mehari, & Gillum, 2018).

Marital status: This variable contains information regarding the marital status of the subject at the time of death. It was a categorical variable measured at the nominal level of measurement. The valid categories were never married, single; married; widowed; divorced; and marital status unknown. The effect of marital status was controlled for in this study. This was important because previous studies have shown that marital status influences health outcomes (see Inverso et al., 2015; Kravdal, 2017; Li, Gan, Liang, Li, & Cai, 2015; Marchioni et al., 2017).

Multiple causes of death (MCOD): In the MCOD approach to gathering mortality information, all the conditions reported in the death certificate, which could be up to 20 conditions and not just the UCOD alone, are treated as relevant and important because identifying a single disease as the UCOD has been shown to be an oversimplification of the process and/or events leading to death (Désesquelles et al., 2010; Fedeli, Zoppini, et al., 2015; Piffaretti, Moreno-Betancur, Lamarche-Vadel, & Rey, 2016; Redelings, Sorvillo, & Simon, 2006). The MCOD variable was the dependent variable of interest. It was mainly be treated as a continuous variable with its value being the number of causes of death that coexist for each death case (such as one if only one cause of death is reported, two if two causes of death are reported, and so on).

Place of residence: This variable was based on the states and territories in the United States where the subject resided while alive as stated on the record or death certificate. It was treated as a categorical variable measured at the nominal level of measurement.

Race: A categorical variable measured at the nominal level of measurement with the following categories: White, Black, American Indian (including Aleuts and Eskimos), Chinese, Japanese, Hawaiian (including part-Hawaiian), Filipino, Asian Indian, Korean, Samoan, Vietnamese, Guamanian, Other Asian or Pacific Islander, and Combined Other Asian or Pacific Islander.

Year of death: This was the year that the subject died. It was treated as a categorical variable measured at the ordinal level of measurement with values between the years 1959 to 2005.

Assumptions

I assumed that the reported MCOD were accurate accounts of the causes of death for each of the death cases in the dataset. This assumption was necessary because this study was based on the data collated by the National Center for Health Statistics of the U.S. Department of Health and Human Services from death certificates, which is a secondary dataset. Therefore, I did not have any control over the collection of the original/primary dataset.

In addition, I assumed that the changes in the reporting mechanism for the causes of death over the 5 decades were minimal and could be accounted for by proper linking of the previous ICDs to the current ICD-10. It was further assumed that any nontraceable differences in the ICDs were random and not systematic and would not result in any

significant loss of information across the years. This assumption was necessary because the datasets are for many years spanning five decades, and the ICD have changed slightly over the years.

Scope and Delimitations

Scope

This study was limited to the U.S. population. The dataset was from the death cases recorded in the states and territories of the United States, including American Samoa, Guam, Northern Marianas, Puerto Rico and the Virgin Islands. Furthermore, I focused on the death cases reported between the years 1959 and 2005 alone in this study.

Potential Generalizability

The results of the study generalize well for the population of the United States because the entire data set comes from the United States. However, the results of this study may not be generalizable to other populations. Nonetheless, the results of the study might offer some, although, minimal insights about the MCOD in other developed nations that are similar to the United States in a number of ways. Furthermore, although the results of this study may find and/or identify trends in the MCOD over the period of years under study, the results may not be generalizable to many years before the study period and/or to many years after the study period.

Limitations

Potential Limitations

Lack of socioeconomic status variable. In health science and social science research studies, it is often of interest to know the effects of socioeconomic status on the dependent variable. The same is true for this; namely, it is generally of interest to know

the potential effects of socioeconomic status on the coexistence of MCOD. However, the secondary data set that I used for this study did not specifically contain a socioeconomic status variable. This was a limitation because there is no way to go back in time and collect the socioeconomic status variable for each of the death cases reported in the dataset. Consequently, socioeconomic status could not be directly accounted for in this study.

Changes in the ICD. The ICD serves as the foundation for the identification of health trends and statistics around the world. It is the international standard for reporting diseases and health conditions as well as for reporting causes of death (U.S. Department of Health and Human Services, 2009a, 2009b, 2009c, 2009d, 2009e). The ICD has gone through a number of revisions since its first creation in 1893, when it was titled, International List of Causes of Death. Later, in 1948, it was entrusted to the WHO which published its sixth edition, ICD-6 (CITE). ICD-10 was the current version at the time of writing this work. The changes to the ICD over the years suggest that there are differences in how the causes of death were reported between the year 1959 and the year 2005. This was a limitation because such variations could introduce problems in the comparison of the MCOD across the years if the causes of death are not reported uniformly.

Potential misreporting of the causes of death. It was possible that, in some cases, the reported causes of death were not the exact diseases or events that caused the death. Such misreporting of the causes of death was another potential limitation of this study and the dataset used. There was no way of going back in time and ensuring that the

causes of death information reported on the death certificate for each of the death cases was indeed accurate and correct.

Ways of Addressing the Potential Limitations

Using the highest level of education attained as a potential proxy for socioeconomic status. Socioeconomic status is a broad concept and generally includes a number of factors such as educational attainment, income, and occupation (Andrew, 2010; Miner et al., 2014; Yang & Leveille, 2013). In other words, educational attainment is an important component used for measuring an individual's socioeconomic status (Andrew, 2010; Miner et al., 2014; Yang & Leveille, 2013). Being an important component of socioeconomic status, education level could be viewed as a proxy to socioeconomic status, making it possible to somewhat approximate the potential effects socioeconomic status on the coexistence of MCOD. However, I exercised caution to not refer to the variable as socioeconomic status but as education level because the two are not the same despite being related.

Possibility of interconversion between the ICDs. One possible way of addressing the limitation regarding the changes in the ICDs was linking the previous ICDs to the current ICD-10 using an interconversion table that maps the previous ICDs to the current ICD-10. For such an approach to be appropriate, it must be assumed that any nontraceable differences in the ICDs were random and not systematic and would not result in any significant loss of information across the years. This is assumed in the current study.

Stratification of the dataset by ICD. A better approach to addressing the limitation than the interconversion between the ICDs would be the stratification of the

dataset based on the ICDs. I explained this approach earlier. Please, refer to the section titled Handling the Variations in the International Classification of Diseases Over the Years.

Significance

The results of this study have the potential to contribute to knowledge advancement in this field, make improvements in health practices, and promote longevity. They also have the potential to promote social change. These make this study to be important.

Knowledge Advancement

The results of this study help improve the understanding of the coexistence of MCOD. They provide numerical descriptive statistics on how causes of death coexist and offer an understanding of the factors that influence the coexistence of MCOD. The spatial and temporal disparities in the number of coexisting MCOD that I identified in this study add to the existing body of knowledge and constitute a significant contribution towards this field of epidemiology.

Improvements in Health Practices and Longevity Enhancement

The factors that influence and/or cause variations in the number of coexisting MCOD that I identified in this study shed light on the potential ways of preventing untimely death. The new knowledge may also help in enhancing longevity. Furthermore, the potential of the findings of this study to create new information, which are currently unavailable in the literature and are useful to public health practitioners and epidemiologists, make this research important and significant.

Contributions to Social Change

The results of this study offer insights into how the number of coexisting causes of death vary across the United States and across races and education levels as well as lay a foundation for the further investigation of what people are dying from. The findings of this study reveal in the simplest possible forms to the general public with diverse backgrounds and various education levels the spatiotemporal, racial, and educational variations in the number of coexisting MCOD. Such information can help people to be more aware of the risks posed by various possible MCOD and how those risks apply to them as individuals, thereby aiding risk avoidance, longevity, and positive social change.

Summary

Mortality rates are routinely used as important health indicators; however, the mortality metrics derived from UCOD alone have limited powers in revealing all the possible and important information about the health of the population and what the people are dying from (CITE). Furthermore, researchers have demonstrated that MCOD information are able to provide important information that cannot possibly be extracted from other mortality data, making MCOD information important (CITE). Nonetheless, there is a considerable underutilization of MCOD data, despite the fact that the National Center for Health Statistics, U.S. Department of Health and Human Services spends a lot of money and other resources to routinely collect it. I targeted this study at bridging the gap and adding to the utilization of the MCOD data, thereby generating useful and actionable information. The insights that the results of this study provide into what people are dying from and how the causes of death vary across the United States, both in space, from one state to another, and time, between the years of 1959 and 2005 (i.e.,

spatiotemporal), and across races and education levels make this study important and urgently needed. The information that the findings of this study make available has the potential of helping people to be more aware of the risks posed by various possible MCOD and how those risks apply to them as individuals, thereby aiding risk avoidance, longevity, and positive social change.

In the next chapter, I will provide a detailed review of the literature on the various aspects of this study. The aspects reviewed will range from vital statistics and mortality data and information on the importance of mortality data. I will also provide information on ICD versions and causes of death reporting as well as information on the importance and the applications of MCOD data.

Chapter 2: Literature Review

Introduction

While some mortality rates, such as crude mortality rate, neonatal mortality rate, infant mortality rate, maternal mortality rate, etc., are frequently used as key health indicators (Dwyer-Lindgren et al., 2016; Mackenbach et al., 2015; Nordentoft et al., 2013; Smith et al., 2014; Weber et al., 2013), the valuable information that coexisting MCOD data can offer have rarely been carefully or systematically explored. This suggests an underutilization of the MCOD data (T.-H. Lu & Lin, 2010; Redelings et al., 2006) that are routinely collected by the National Center for Health Statistics (U.S. Department of Health and Human Services, 2009a, 2009b, 2009c, 2009d, 2009e).

Researchers have successfully demonstrated that MCOD data provides important information that cannot be obtained otherwise (T.-H. Lu & Lin, 2010; Redelings et al., 2006). This has been illustrated by the work of Redelings et al. (2006) who compiled MCOD data and found the most common mortality causes in the United States between the year 2000 and the year 2001 and also compared the statistics obtained from UCOD and MCOD. The researchers showed that for some of the diseases and conditions, there are only subtle differences between the statistics from UCOD and the mortality statistics from MCOD, but for some other diseases and conditions, large inconsistencies exist between the mortality statistics from UCOD and the statistics from MCOD. This encouraged the researchers to conclude that because the leading causes of death appear to differ between the two datasets, the statistics from both UCOD and MCOD should be presented (Redelings et al., 2006). Furthermore, while comparing psychiatric disorder mortality between the United States and Taiwan based on UCOD and MCOD data, T.-H.

Lu and Lin (2010) observed that the two types of data offer different information that are all important and should be used to complement each other (Redelings et al., 2006).

The limited nature or lack of adequate information, as contrasted with the abundance of unanalyzed and uninterpreted raw data, on the coexistence of MCOD as suggested by previous researchers (e.g., Fedeli et al., 2016; Haneuse, 2017; Piffaretti et al., 2016) in addition to the lack of information and knowledge on the disparities in the coexistence of MCOD across the United States amounts to a gap in the literature. This suggests a disturbingly shallow nature of our current understandings of what influences our health and sickness and ultimately our wellbeing and longevity, which are all of fundamental interests in the fields of epidemiology and public health.

Improving the understanding of the coexistence of MCOD in ways that may ultimately help in improving health and in enhancing longevity was the overall purpose of this study. In addition, with this study, I intended to provide information on the interrelationships between various causes of death in the United States, the potential variations in the causes of death over a period of 5 decades (i.e., 1959 to 2005), the variations in the causes of death across the states and territories of the United States, and the potential effects of race and education level on the coexistence of MCOD.

In this chapter, I will present information on the databases and search engines that were used for the literature review for this study. The search strategies I used will be presented in a way that is detailed enough to allow reproducibility by independent researchers. These will be followed by the list of the search terms and combinations of search terms that were used. The scope of the literature review will also be presented. I will then discuss the important theories for this study, the origins of the theories, their

major propositions, their previous applications, how they relate to this study, and my rationale for choosing them. Furthermore, previous work that made use of the key variables of interest will be reviewed, and I will present the rationale for my selection of the variables.

Literature Search Strategy

Databases and Search Engines Used

The databases and search engines that I used for this literature review were MEDLINE/PubMed, EMBASE, Cochrane CENTRAL Trials Register, Centers for Disease Control and Preventions WONDER, CINAHL, FDSys, Google Scholar, and Web of Science. Proquest Dissertations and Theses Online, Networked Digital Library of Theses and Dissertations, and Open Access Theses and Dissertations were also used.

Key Search Terms and Combinations of Search Terms

Some of the key search terms that I used while searching the databases for relevant literature are *vital Statistics, mortality data, causes of death information, International Statistical Classification of Diseases and Related Health Problems, ICD, variations in causes of death, multiple causes of death, applications of multiple causes of death, social support theory,* and *theory of persistent income inequality*. I also searched appropriate combinations of these terms. For example, *multiple causes of death* AND education level, multiple causes of death AND race, *multiple causes of death* AND *residence*, *multiple causes of death* AND *year* OR *time*, *multiple causes of death* AND *gender*, *multiple causes of death* AND *age*, *multiple causes of death* AND *marital status*, etc.

Scope of the Literature Review

Overall, except for my attempts to limit the retrieved literature to those published in the past 5 years, there was no strict restriction on the type of data or sources. Essentially, any peer-reviewed journal article, book, thesis, and dissertation that was published in the past 5 years was in the scope of this literature review as long as it addressed one or more of the subject matter of this study. This made it possible for me to have enough previous literature to review.

Theoretical Foundation

The Important Theories for This Study and Their Origins

The two important theories for this study were the theory of persistent income inequality (Durlauf, 1996) and the social support theory (Durkheim, 1897; House et al., 1988). How the coexistence of MCODs are becoming increasingly important was addressed by the social support theory (see Durkheim, 1897; House et al., 1988). The social support theory forms a framework for how stress and psychosocial factors are increasingly contributing more to illnesses and death because chronic diseases that coexist, and which have stress and psychosocial elements, are steadily replacing acute and/or infectious diseases as the major causes of death (House et al., 1988). The theory of persistent income inequality, on the other hand, explains how it is difficult to ascend in economic status and how perpetually low economic status hinders good health (Durlauf, 1996), which may increase susceptibility to various illnesses and various causes of death.

Theoretical Framework for MCOD

The social support theory was postulated by Durkheim (1897) and has four constructs: emotional supports, instrumental supports, informational supports, and

appraisal. Emotional supports are constituted of the expressions of love, empathy, trust, and care from the people in an individual's network of family and friends (Morelli, Lee, Arnn, & Zaki, 2015). Instrumental support is made up by the tangible aid and service that an individual may receive from their social support (Morelli et al., 2015). Informational supports are the suggestions, the pieces of advice, and the information that the individual may receive from their network of family and friends, while appraisal is the information from the social support that the individual may find useful for self-evaluation (Morelli et al., 2015).

It is worthy of note that earlier concepts referring/related to the social support theory (most especially the emotional supports aspect of the social support theory) can be found in Charles Robert Darwin's book titled *'Expression of the Emotions in Man and Animals'* where he wrote

> … my father told me of a careful observer, who certainly had heart-disease and died from it, and who positively stated that his pulse was habitually irregular to an extreme degree; yet to his great disappointment it invariably became regular as soon as my father entered the room. (Darwin, 1872, p. 340).

This statement is relevant to the emotional support construct of the social support theory (in which the sick person gets/feels better in the company of those who are important to his/her social supports network), and the context of Charles Darwin's book focusing on emotional supports reinforces the relevance of this statement to the social support theory. The social support theory has become even more relevant nowadays because coexisting chronic diseases that have social aspects are replacing acute diseases in most societies.

Major Propositions of the Theory of Fundamental Causes

The social support theory states that the amount/quantity of and the quality of social relationships have a causal impact on health and that people with low quantity and low quality social support consistently show increased risk of death (Durkheim, 1897; House et al., 1988). Indeed, early independent research has supported this theory and shown that social support is a moderator of life stress and that people with better social support can better withstand life's various stresses (Cobb, 1976) and stay healthy while people with poorer social supports are susceptible to life's stresses and the various associated illnesses (Cobb, 1976). It has also been shown that social environment contributes immensely to host resistance (Cassel, 1976). The theory essentially puts it forward that less socially integrated individuals or more socially isolated individuals are less healthy, psychologically and physically, and they are more likely to die from a variety of causes, while the opposite is true for the people who are more socially integrated (House et al., 1988).

Previous Applications of the Social Support Theory

In their study, which was based on social support theory, Holt-Lunstad, Smith, Baker, Harris, and Stephenson (2015) investigated loneliness and social isolation and found that both actual and perceived social isolation increases an individual's risk for early mortality. Their results show that living alone is capable of increasing an individual's likelihood of mortality by about 32% (i.e., *OR* = 1.32), and that social isolation is capable of increasing an individual's likelihood of mortality by about 29% (*OR* = 1.29), while loneliness increases an individual's likelihood of mortality by 26%

(*OR* = 1.26). These result were found to be consistent in both males and females, such that deficiencies in social integration lead to increase in the risk of mortality.

Inspired by the social support theory, Hill, Uchino, Eckhardt, and Angel (2016) attempted to study Mexican American population to see whether or not social integration and social support tend to favor longevity in the Mexican American population the same way that it does for the non-Hispanic Whites and the Blacks. In their study, the researchers examined the association between all-cause mortality risk and the perceived social support trajectories of older Mexican Americans (Hill et al., 2016). The result suggests that the older Mexican American men that are in the low level support trajectory tend to exhibit a higher mortality risk than their counterparts in the high support trajectory (Hill et al., 2016).

In another study, Cao, Burton Jr, and Liu (2018) assessed whether or not the nature and strength of an individual's social support network influence the individuals risk of using illegal drugs. They found that social support metrics (such as lack of timely counseling, strength of ties within communities, and residential mobility, etc.) have statistically significant relationship with the odds of being involved in illicit drug use (Cao et al., 2018).

Relevance of the Social Support Theory to this Study

The social support theory is becoming increasingly important as stress and psychosocial factors are increasingly contributing more to illnesses and death because chronic diseases that coexist are steadily replacing acute and/or infectious diseases as the major causes of death most especially in the industrialized countries (House et al., 1988). This is the main reason why theories of disease etiology and morbidity and mortality

have shifted from those wherein a single factor (for example, a germ) causes a single disease and consequently morbidity and/or mortality, to those in which multiple factors (and diseases) act together (most especially over an extended period of time) to cause morbidity and/or mortality (House et al., 1988). This is the main reason why this theory is relevant to my current study on the MCOD as the social support theory suggests that people with poorer social supports are susceptible to life stress and the various associated illnesses (Cobb, 1976) that could ultimately lead to death from multiple causes. These include MCOD to which the individuals could have been resistant had the individuals had proper social environment which has been shown to contribute immensely to host resistance (Cassel, 1976).

The Theory of Persistent Income Inequality: How Persistent Income Inequality Affects Health Outcomes

Durlauf (1996) postulated the theory of persistent income inequality. Durlauf successfully studied income inequalities and their dynamics by examining families' neighborhood choices and how those choices influence the families' evolution of human capital investment (Durlauf, 1996). The constructs of this theory include inequalities in income levels and low intergenerational mobility across income levels, family transmission of wealth across generations and inheritance of the persistent inequality, as well as local segregation and unequal neighborhoods wherein poor people and rich people live in different neighborhoods resulting in inequalities in local public finance of education and infrastructures (Durlauf, 1996; Piketty, 2000).

Major Propositions of the Theory of Persistent Income Inequality

Based on the theory of persistent income inequality, parents' choice of the neighborhood wherein a whole family lives influences the conditional probability distribution of the incomes of the children (Durlauf, 1996). The neighborhood of children affects children via a combination of both the local public finance of education and the sociological effects of parents' income and/or access to (financial) resources. The theory establishes that the effects of neighborhoods on children shapes their future, to the extent of dictating what their earning potentials and income when they become adults (Durlauf, 1996). These effects interact in making circumstances that enhance the segregation of neighborhoods into economically homogeneous segments, in a way that poor families and wealthy families live within physically separate neighborhoods (Durlauf, 1996). The joint effects of neighborhood-wide feedback and economic stratification favor and often enforce the transmission of economic and social statuses from one generation to another. These essentially result in the persistence of income inequality (Durlauf, 1996), and such income inequalities lead to disparities in health outcomes and disparities in longevities.

Previous Applications of the Theory of Persistent Income Inequality

Many studies have been based on or inspired by the theory of persistent income inequality (Akee, Jones, & Porter, 2016; Akinyemi & Potokri, 2016; Aliprantis & Carroll, 2015; Becker, Kominers, Murphy, & Spenkuch, 2015; Butler, 2016; Chakraborty & Das, 2005; Islam, 2016; Mitnik, Cumberworth, & Grusky, 2016). Some previous applications of the theory of persistent income inequality in the literature are discussed next.

Aliprantis and Carroll (2015) were motivated by the work of Wilson (1987, 1991, 2012) who showed/claimed that policies that are put in place to end racial discriminations would not necessarily eradicate inequality without properly addressing neighborhood externalities and residential sorting. This view is also supported by other researchers (Becker et al., 2015; Chakraborty & Das, 2005) whose works are discussed below. Aliprantis and Carroll (2015), therefore, studied a related counterfactual policies using a model of residential sorting and intergenerational human capital accumulation. In their model, each household chooses where to live as well as the amount invested in the production of the human capital of their children, and the return on parents' investment on the children is modelled as been dependent partly on the human capital of their neighborhood, and partly by the ability of each of the children. Aliprantis and Carroll (2015) found that income inequality persistence does result from allowing residential mobility, and that equalizing technologies across neighborhoods only equalizes opportunity only in neighborhoods that were originally segregated when high-income households reside in such neighborhoods. These findings led the researchers into suggesting that the efforts and policies targeted at improving outcomes in the impoverished areas should consider making available incentives that would encourage high-income households to migrate to and stay in those segregated/impoverished neighborhoods. Their results suggest the importance of place of residence on health outcomes making it very relevant to the current study and suggesting the need to consider place of residence in the current study.

In their study, Akee et al. (2016) examined income inequality and income level/status mobility across various ethnic and racial groups in the United States using the

U.S. tax filers data from the year 2000 to the year 2014. While they observed that within-group income inequality increased across the years for all groups, it is of special interest to know that within-group inequality is highest among the Whites and Asians (which are the groups with the highest incomes). The within-group income status/level mobility is also lowest among these groups which have the highest incomes. The reverse holds true for the Blacks, Hispanics, and American Indians, which are the lowest-income groups: they have lower within-group inequality and higher income level/status mobility. The researchers also observed persistent income differences across race and ethnicity. Akee et al. (2016) adds to the body of evidences that racial segregation persists and have long-term effects of career and incomes. They show that income structure is very rigid with the American Indians, Blacks, and Hispanics restricted to the bottom while the Asians and the Whites are confined to the top (Akee et al., 2016). The results from Akee et al. (2016) reinforce the importance of considering the effect of race in social and health-related research and suggest the need to consider race as an important intendent variable in the current study.

Becker et al. (2015) developed a model of intergenerational resource transmission which focuses on the link between cross-sectional inequality and intergenerational mobility. In their study they showed that, on the average, wealthy parents invest a lot more in their children than the poor parents even if there is no difference in the innate abilities of the children, which helps the children to have better potentials of been better off and richer than the children of the poor parents (Becker et al., 2015). The researchers further found that economic status is more persistent at the top of the income spectrum than in the middle, and that efforts by the government to lower inequality may indeed be

hindering intergenerational mobility (Becker et al., 2015). Other researchers studied the relationship between the persistence of disparities in health status and persistence of economic disparities (Chakraborty & Das, 2005).

Chakraborty and Das (2005) used a model that defined two generations over two periods that overlap and study the probability of surviving across the two periods. They found that people with private health investments have higher probability of surviving from the first period of life to the next period of life, and (together with education) it enhances an individual's productivity. They further claim that poorer parents develop poor health, and they are unable to invest enough in reducing their mortality risks and the mortality risks of their children. Chakraborty and Das (2005) are also unable to invest enough in improving their human capital and those of their children. These make their children poor and unhealthy when they become parents, and the cycle often continues perpetually (Chakraborty & Das, 2005). These studies reinforce the non-subtle influences of socioeconomic status on health outcomes and the need to consider socioeconomic status in the current study (Becker et al., 2015; Chakraborty & Das, 2005).

Montez, Zajacova, and Hayward (2017) have also shown the existence of considerable disparities in health across the United States. They showed that differences in disability by education is very large across the United States with a 20% point disparity in the state of Massachusetts and a 12-point disparity in the state of Wyoming. From their study, it became known that the variations across the states mainly result from the differences in the prevalence of disability among the low educated adults which varies very widely across states (Montez et al., 2017). These suggest that the efforts targeted at reducing disparities in the disability by education would benefit from

considering the possibility of using state and local strategies to help reduce poverty among the people with low education.

Relevance of the Theory of Persistent Income Inequality to this Study

This theory is important to the aspects of this study that focus on how income inequality, socioeconomic status, and/or the distribution of public health resources/funds may influence the coexistence of MCOD. This theory of persistent income inequality (Durlauf, 1996) helps me in explaining the possible effects inequalities in people's incomes and disparities in people's neighborhood may have on their access to health infrastructure and public health resources, and how these may essentially affect people's health, illnesses, longevity, and cause of death. For example, studies have shown that living in disadvantaged neighborhoods leads to health problems (Ross & Mirowsky, 2001).

Literature Review Related to the Key Variables and Construct

The key variables of this study are the MCOD that coexist, education level, race, place of residence, year of death, gender, age, and marital status. In the following sections, I will discuss the main construct of coexistence of MCOD, and some of the most important previous work on MCOD. I also present a review of some of the most important previous works that made use of the same variables that are being used in this study.

Coexistence of MCOD

MCOD variable examines any mention of a disease in death certificates because identifying a single disease as the UCOD has been shown to be an oversimplification of the process/events leading to death (Désesquelles et al., 2010; Fedeli, Zoppini, et al.,

2015; Piffaretti et al., 2016; Redelings et al., 2006). In the MCOD approach to gathering mortality information, all the conditions reported in the death certificate, which could be up to 20 conditions (and not just the UCOD) alone are treated as been relevant and important (Désesquelles et al., 2010; Fedeli, Zoppini, et al., 2015; Piffaretti et al., 2016; Redelings et al., 2006). The number of coexisting MCOD is the dependent variable of interest. The listed causes of death are based on ICD-10 (WHO, 2010), which is the 10th and the latest version of the ICD.

Researchers (Redelings et al., 2006) compared MCOD and UCOD for the deaths reported in the United States between the year 2000 and the year 2001 and found that leading causes of death differ when calculated from UCOD and from MCOD data, suggesting the need for presenting the data and statistics from both UCOD and MCOD data whenever possible (Redelings et al., 2006). A number of other previous works have also suggested the great importance of MCOD data and the need to be extracting useful information from the data. For example, Hastings et al. (2017) have shown that the disease burden for diabetes is under-reported and that the under-reporting becomes obvious/evident through MCOD analysis. In a similar way, researchers (Piffaretti et al., 2016) have shown that cause-related/cause-specific mortality can be better quantified by weighting MCOD data.

Furthermore, researchers (Fedeli et al., 2016) have shown that sepsis-related mortality might be better assessed and its burden could be better estimated through MCOD analysis. Other researchers have also showcased how well the MCOD analysis performed when used to assess mortality from systemic sclerosis (de Rezende et al., 2017), mortality from rheumatoid arthritis (Pinheiro, Souza, & Sato, 2015), the

relationship between airborne arsenic exposure and mortality among Anaconda Copper smelter workers (Keil & Richardson, 2017), assessing mortality from hepatitis C and hepatitis B virus infection (Fedeli & Schievano, 2016), among others.

Education Level

Previous studies have suggested the importance of education level in individuals wellbeing, health, sickness, and other aspects of life, longevity, and death (Benito-León et al., 2016; Fedeli, Avossa, et al., 2015; Kulhánová et al., 2014; Mackenbach et al., 2015). Fedeli et al. (2015) showed the effect of education on the etiology of chronic liver disease. Benito-León et al. showed the effect of performance on specific cognitive domains and cause of death (Benito-León et al., 2016). Kulhánová et al. (2014) showed how educational inequalities affect mortality by cause of death in the Netherlands. Sasson (2016) has shown that differences in educational attainment introduces diverging trends in cause-specific mortality and the number of life years lost. In similar ways, Schiltz et al. (2018) have shown that cognitive impairment (which is related to influence educational attainment) has a statistically significant effect on the leading causes of death, and Calvin et al. (2017) (through their 68-year prospective population study) have shown that Childhood intelligence (which influences educational attainment) does affect the major causes of death. These and other evidence showing how educational attainment (as well as cognitive abilities) influences life and death (and everything in between) are why it is important to consider the effects of education on the dependent variable of interest in this study.

Race

The important and persistent effects of race on health, sickness, and longevity have been of interest to many researchers (Beydoun et al., 2016; Curtin & Hoyert, 2017; Garcia-Alexander & Woo, 2015; Yu et al., 2017). There have been many studies on the racial disparities in various mortality measures including the crude mortality rate and the cause-specific mortality rates (Beydoun et al., 2016; Curtin & Hoyert, 2017; Garcia-Alexander & Woo, 2015; Yu et al., 2017). For example, Garcia-Alexander and Woo (2015) investigated the effects of race on infant mortality and documented the effects of race on the how maternal complications, low birth weight, and other factors lead to infant mortality. In a similar way, using data from birth and death certificates, Curtin and Hoyert explored the maternal morbidity and mortality and found statistically significant differences in maternal morbidity and mortality across ethnic groups/races (Curtin & Hoyert, 2017).

Furthermore, a nationwide study of cause-specific mortality among the patients who require maintenance dialysis in the United States show that there is racial disparity in the risk of mortality from infection that is not related to their dialysis (Yu et al., 2017). The researchers show the risk of mortality from infection that is not related to their dialysis is particularly higher in the younger black patients as compared to the other subgroup of patients (Yu et al., 2017). In a similar way, Beydounet al. (2016) have shown that race does directly and indirectly (through mediating and moderating factors) influence all-cause and cause-specific mortality among adults in the United States.

The evidence presented here and other pieces of evidence showing that race affects health outcomes (Beydoun et al., 2016; Yu et al., 2017) form the rationale for its

importance in this study. Race has the tendency of affecting the coexistence of MCOD (which is the dependent variable of interest in this study) hence the inclusion of race as one of the independent variables of interest. In this study, race has categories that include, White, Black, American Indian (includes Aleuts and Eskimos), Chinese, Japanese, Hawaiian (includes Part-Hawaiian), Filipino, Asian Indian, Korean, Samoan, Vietnamese, Guamanian, Other Asian or Pacific Islander, and Combined other Asian or Pacific Islander.

Place of Residence

Over the years, researchers (Foreman, Li, Best, & Ezzati, 2017; Martins-Melo et al., 2015; Martins-Melo, Ramos Jr, Alencar, & Heukelbach, 2016; Meyers, Hood, & Stopka, 2014; Zhao, Tu, & Law, 2017) have repeatedly shown that the place of residence does have effects on individuals wellbeing, morbidity, and mortality. In their study of the trends and spatial clusters of HIV and hepatitis C virus (HCV) from the year 2002 to the year 2011 in Massachusetts using multiple cause of death data, Meyers et al. (2014) showed that HIV and HCV disease burdens and mortalities are not uniform across all places of residence suggesting that there is a relationship between place of residences and morbidity and mortality. In a similar way, Martins-Melo et al. (2015) showed in their study titled "Spatiotemporal Patterns of Schistosomiasis-Related Deaths, Brazil, 2000–2011" that mortality from schistosomiasis varies across places of residence and across time.

The study conducted in Shanghai, China, and in Hong Kong (which is considered a province of China, but using a difference system of government) titled "The incomparability of cause of death statistics under ‘one country, two systems’: Shanghai

versus Hong Kong" showed that the place of residence does affect the risk of death from the various possible causes of death (Zhao et al., 2017). In a similar way, Gordon et al. (2017) have shown that mortality and causes of death varies in Israel across regions/places of residence. Furthermore, in a separate and independent study conducted in Brazil, the researchers found that spatial patterns exist in the mortality from the neglected tropical diseases in Brazil meaning that mortality from the neglected tropical diseases varies across various places of residence (Martins-Melo et al., 2016). These and other evidence, which show that the place of residence does affect health outcomes and the cause of death form the rationale for the inclusion of the place of residence in this study.

Year of Death

In their study, Martins-Melo et al. (2015) looked into the patterns of schistosomiasis-related deaths between the year 2000 and the year 2011 in Brazil. They show that schistosomiasis-related deaths were not constant over time (Martins-Melo et al., 2015). This suggest the need to account for the effect of year when studying mortality over a long period of time. Indeed, most research that have focused on the trend of some forms of events have the implicit assumption that the event of interest may not be constant over a long period of time, hence the need to study the trend of the events.

This could explain why researchers are interested in the trends of mortality due to visceral leishmaniasis in Brazil (Martins-Melo, da Silveira Lima, Ramos Jr, Alencar, & Heukelbach, 2014), non-AIDS cancer mortality in San Francisco, California (Hessol, Ma, Scheer, Hsu, & Schwarcz, 2018), maternal mortality in the United States (Joseph et al., 2017), excess mortality in Northern Italy (Fedeli, Capodaglio, Schievano, Ferroni, &

Corti, 2017), rising mortality associated with HCV in the United States (Ly, Hughes, Jiles, & Holmberg, 2016) and so on. These show that mortality information varies from year to year. It is for these reasons that the year of death is also considered in this study.

Gender

While studying HIV/AIDS in San Francisco and the death that result from HIV/AIDS, researchers found the existence of gender differences in causes of death among the people with HIV/AIDS (Hessol, Schwarcz, Hsu, Shumway, & Machtinger, 2018). Indeed, other studies have also shown gender differences in health, sickness, and mortality. For example, researchers (Ogundipe et al., 2018) have shown that sepsis mortalities differ by gender. Furthermore, it has been shown that gender has a tendency of affecting premature mortality resulting from systemic lupus erythematosus-related causes (Falasinnu et al., 2017), that gender influences life expectancy in the United States (Acciai & Firebaugh, 2017), and that gender influences COPD-related mortality (Ni & Xu, 2016). These and other evidence that support the fact that gender does influence health outcomes make it important to consider the effects of gender in this study.

Age

Age has effect on many things in life. Various previous research have shown that health outcomes, morbidity, and mortality are affected by age (Gabet et al., 2016; MacDorman et al., 2017a; Orosco et al., 2015; Taneja et al., 2016; Tate et al., 2016). For example, MacDorman, Declercq, and Thoma (2017b) have shown that in their study that maternal mortality is significantly affected by maternal age, while Taneja et al. (2016) have shown dynamic relationships between age and health defects and between age and mortality. It is also been shown that sex ratios of mortality is influenced by age

(Wheldon, Raftery, Clark, & Gerland, 2015). In a similar way, Orosco et al. have shown that thyroid cancer-specific mortality is influenced by age (Orosco et al., 2015). Age, having the potentials of influencing health outcomes (as shown above), is therefore important when considering/studying MCOD. This is why age is included as one of the independent variables in this study.

Marital Status

The research work published by Kravdal (2017) shows that there are large and growing social inequality in mortality in Norway. More importantly, it was observed that marital status (as well as the spouse's educational attainment have considerable effects on the mortality and on the inequality in mortality in Norway (Kravdal, 2017). Another independent study conducted in California, United States, also concludes that there is a relationship between marital status and mortality (Martinez et al., 2016). Furthermore, Inverso et al. have shown that there is a relationship between marital status and head and neck cancer outcomes (Inverso et al., 2015). These also hold true for renal cell carcinoma (Marchioni et al., 2017). Specifically, it has been shown that marital status (as well as gender) is capable of affecting the tumor grade, the cancer stage, and cancer specific mortality in renal cell carcinoma (Marchioni et al., 2017). In a similar way, Li, Gan, Liang, Li, and Cai (2015) showed in their study that marital status is capable of influencing both the stage at which colorectal cancer is diagnosed, and the survival of patients with colorectal cancer.

Furthermore, marital status (as well as living condition) has been shown to be an important predictor of heart failure readmissions as well as mortality from heart failure among African Americans (M. L. R. Lu et al., 2016). All these make marital status to be

an important factor to consider when study health and sickness, longevity and death. These are why marital status is considered as one of the independent variables in this study.

Critical Appraisal of the Most Relevant Articles

Critical Appraisal of the Research Article by Piffaretti, Moreno-Betancur, Lamarche-Vadel, and Rey (2016)

One of the highly relevant articles to my study is the work of Piffaretti et al. (2016) titled "Quantifying cause-related mortality by weighting multiple causes of death". It was published in the *Bulletin of the World Health Organization*, which is a peer-reviewed international journal. The researchers set out to explore a new way of calculating cause-related standardized mortality statistics in a manner that accounts for each of the causes of death reported on death certificates by assigning weights to each of the causes (Piffaretti et al., 2016). Their study is, indeed, important and addresses a problem that is becoming increasingly important -- namely, getting more insights from the mortality data by making more use of the MCOD data. Their work is relevant to my study because the they (Piffaretti et al., 2016) made use of MCOD data and they examined new approaches of estimating cause-related mortality rates from MCOD by applying weights to the causes of death listed on the death certificates.

Focusing on the population of France, the researchers derived cause-based standardized mortality rates from death certificate data for the deaths recorded in the year 2010 (Piffaretti et al., 2016). They used three different approaches in addition to the conventional approach which is solely based on the UCOD. The first and the second approach assigned non-zero weights to each of the causes of death mentioned on the

death certificate, while the third approach assigned non-zero weights only to UCOD and to the contributing causes of death that are not in the main morbid process (Piffaretti et al., 2016). Overall, the weights for all the causes for each death case sum to 1.0. This allowed each death case to have equal influence as every other death case on the overall death statistics (Piffaretti et al., 2016).

The results of their study show that on the average, about 3.4 causes of deaths are reported for each of the death cases (Piffaretti et al., 2016). Overall, the number of causes of death reported per death case is fairly consistent and has a standard deviation of 1.92, a median of 3, and an interquartile range of 2 to 4. Out of the three approaches designed by the authors for weighing the causes of death, they find the third approach to be the most interesting (as compared to the conventional method) and the easiest to interpret. Their results show that the conventional method of estimating mortality statistics from only the UCOD underestimates the role of some important diseases in causing death (Piffaretti et al., 2016). Some of the categories of diseases that the conventional approach/classic method underestimates but that the authors' new approach found to be important causes of death are mental disorders, skin diseases, blood diseases, endocrine and nutritional diseases, and genitourinary diseases (Piffaretti et al., 2016).

The new approach developed by these researchers in which MCOD data are weighted have the potentials of improving the amount and the quality of insights obtainable from mortality data in ways that are not possible with the classic method (Piffaretti et al., 2016). Furthermore, the new approach is more capable to identifying under-recognized causes of death. These make the new MCOD-based to be better than the UCOD-based approach.

The authors clearly stated the targeted population, which is the residents of France (Piffaretti et al., 2016). All the documented deaths of the residents of France during the period of interest, which is the year 2010, were taken into account (Piffaretti et al., 2016). They used ICD-10 codes for identifying each of the causes of death.

The study design/approach used by the researchers is appropriate for the goal of the study. Furthermore, the researchers demonstrated a good understanding of statistics and made appropriate use of weighing techniques. Their account of the weighing method used are correct and are detailed enough to allow the replication of their work by independent researchers (Piffaretti et al., 2016). The interpretations of their results are reasonable and the conclusions they reached are consistent with their results, with each statement made supported by the data or the results of their analyses.

Their study and its findings constitute an important contribution to this field, and add to the existing body of knowledge on mortality (Piffaretti et al., 2016). Furthermore, the findings of their study reinforces the need for more use of MCOD dataset when computing mortality statistics. This is in line with the evidences from other studies (Fedeli & Schievano, 2016; Hastings et al., 2017; Meyers et al., 2014).

One of the limitations of their study is related to the possibility of issues with the quality of the data used (Piffaretti et al., 2016). Indeed, this issue could not have been totally eliminated and issues with the quality of data recorded on death certificate are understandable and are not new (Cheng, Lu, & Kawachi, 2012; D'amico, Agozzino, Biagino, Simonetti, & Marinelli, 1999; Mant et al., 2006; Speizer, Trey, & Parker, 1977; Stallard, 2002).

Furthermore, the researchers did not, in any rigorous way, estimate the statistical variance of the mortality metrics they computed in their study. This is not good enough, and this make it impossible to be able to critically compare the mortality data they obtained to those obtained from other studies or from other populations. Another limitation of their study is related to the design of some of the weighting approaches examined. For example, the design of the third weighting approach appears is bound to involve some subjectivity and it based on how well the researchers were able to correctly identify a contributing cause of death as been or not been in the main morbid process of the underlying cause of death (Piffaretti et al., 2016).

Nonetheless, the authors showed that although the UCOD data is valuable, the contributions of the other causes of death listed on the death certificate are equally important and should not be neglected (Piffaretti et al., 2016). Their MCOD weighting approaches for computing mortality statistics are interesting and promising. They have the potentials of better capturing the burden of cause-specific mortality. Their work is very relevant to my study as they made use of MCOD data and estimated mortality statistics. My study focused on the U.S. population and made use of dataset from wider range of years.

Critical Appraisal of the Research Article by Meyers, Hood, and Stopka (2014)

Another highly relevant article to my study is the work of Meyers, Hood, and Stopka (2014) titled *HIV and hepatitis C mortality in Massachusetts, 2002–2011: spatial cluster and trend analysis of HIV and HCV using multiple cause of death*. It was published in the peer-reviewed *PloS one* journal. Their work is highly relevant to this

study because they made use of MCOD data and they examined the spatial distribution of causes of death while focusing mainly on HIV and hepatitis C (Meyers et al., 2014).

The researchers had noticed that most of the previous analyses of mortality from infectious disease were based on UCOD without considering the contributing causes of death obtainable from MCOD data (Meyers et al., 2014). Such approach may be unable to capture the full extent of mortality trends for some diseases including infectious diseases (e.g. HIV and HCV). This observation motivated the researchers to carry out the study with the aim of using MCOD to better capture the spatial distribution and the current trends of the causes of death in the State of Massachusetts (Meyers et al., 2014).

The article carefully addressed and clearly stated the targeted population, which is the residents of Massachusetts (Meyers et al., 2014). All the documented deaths of the residents of commonwealth of Massachusetts during the period of interest (i.e. between the year 2002 and the year 2011) were taken into account regardless of where the death occurred (Meyers et al., 2014). They identified spatial clusters of diseases, carried out a mortality trend analysis, and assessed infectious disease mortality, as well as spatial-temporal clustering trends in the States of Massachusetts between the year 2002 and the year 2011 (Meyers et al., 2014). The researchers found big clusters of infectious disease mortality in Worcester, Springfield, the Merrimack Valley, South Boston, and New Bedford as well as smaller clusters in other parts of the state (Meyers et al., 2014).

The study has new findings and adds to the existing body of knowledge. For example, the researchers were able to identify the regions with big and small clusters of infectious disease mortality in Massachusetts (Meyers et al., 2014). Furthermore, the researchers found that the infectious disease mortality rates obtained from the MCOD

dataset are higher than those obtained from UCOD dataset. This is in agreement with other studies which concluded that UCOD dataset underestimate the mortality from some causes of death (Fedeli & Schievano, 2016; Hastings et al., 2017; Piffaretti et al., 2016).

The design of the study and the dataset used in the study align well with the goal of the study. Furthermore, the researchers made use of the appropriate statistical software such as SAS (for the overall statistical analysis), Esri ArcGIS (for spatial clustering), SatScan (spatial-temporal clustering), etc. The analysis appears to have been carried out diligently. For example, the researchers used yearly population estimates while calculating annual mortality rates (rather than merely using a flat estimate of the population throughout the studied years). The authors also adjusted for the effect of age by calculating age-adjusted mortality rates (Meyers et al., 2014). The inferences and the conclusions drawn by the researchers are appropriate and based on the dataset and are backed by the results they have obtained from the study. The insights yielded by their study as regards the patterns and trends of infectious disease mortality in Massachusetts are appropriate and commensurate with the analysis carried out (Meyers et al., 2014).

Although the study was mostly properly designed and carefully carried out, there are a number of issues that were not addressed or limitations that could not possibly be eliminated. One of such limitations is the possibility of misclassification in some of the causes of death recorded on the death certificates which may lead incorrect underlying and/or contributing causes of death in some cases. Another similar limitation is related to the possibility of racial misidentification especially when the race of the deceased person is guessed in the absence of his/her relatives. Such misidentification may be more likely for smaller racial groups such as Asians, American Indian, and Hispanics. Overall, their

study constitutes an important contribution to this field and adds to the existing body of knowledge especially regarding the importance of making more use of MCOD dataset (Meyers et al., 2014). Furthermore, their approach of spatial clustering of infectious disease mortality could serve as guide for my study which would examine spatial variations in the coexistence of MCOD (Meyers et al., 2014).

Although the research work leading to their article made use of MCOD data and investigated spatiotemporal clusters of mortality causes which are highly relevant/related to this study, their work mainly focused on HIV-related and HCV-related mortality (Meyers et al., 2014). Furthermore, their research only focused on the State of Massachusetts and used the dataset for the year 2002 to the year 2011 (Meyers et al., 2014). These made their work to be very narrow in scope. My research work is broader in score. It is not limited to HIV-related and HCV-related mortality alone. It is also not limited to the state of Massachusetts alone, and the data that were used span more years than the number of years covered in their study. These allow my study to make more contributions to this field and add valuable information to the existing body of knowledge.

Summary and Conclusions

In this chapter, I have presented a review of the relevant literature for this study in a manner (e.g., by mentioning the databases searched and the search strategies used) that allows independent researchers to be able to reproduce the work. A list of the search terms used, how the search terms were combined, and the scope of the literature review have also been presented. The important theory for this study (namely the theory of persistent income inequality), the origin of the theory, its major propositions, its previous

applications, how it relates to this study, and the rationale for choosing it have been discussed. Previous work that made use of the key variables of interest have been reviewed and presented. The rationale for the selection of the variables have also been presented.

Although a number of researchers have made use of MCOD data and contributed to the body of knowledge through their work, the valuable series of information that coexisting MCOD data can offer have not been adequately explored (Piffaretti et al., 2016) as most of the previous mortality-related studies were based on UCOD. This suggests the need for more studies in this area so as to improve our understanding of the coexistence of MCOD in ways that may ultimately help in improving health and in enhancing longevity. This constitutes the overall goal of this study, which intends to provide information that are currently lacking in the literature. For example, this study provides new information on the inter-relationships between various causes of death in the United States, the potential variations in the causes of death over a period of about five decades (i.e. 1959 to 2005), the variations in the causes of death across the states and territories of the United States, as well as the potential effects of race and education level on the coexistence of MCOD.

In the next chapter, Chapter 3, I will present the numerical and statistical techniques that were used in this study. The numerical and statistical methods help in estimating the inter-relationships between various causes of death in the United States and in answering the research questions posed in this study. These make them important.

Chapter 3: Research Method

Introduction

Even though mortality rates, such as crude mortality rate, neonatal mortality rate, infant mortality rate, maternal mortality rate, etc., are frequently used as key health indicators (Dwyer-Lindgren et al., 2016; Mackenbach et al., 2015; Nordentoft et al., 2013; Smith et al., 2014; Weber et al., 2013), the valuable information that coexisting MCOD data can offer have never been carefully or systematically explored, despite the fact that data on the MCOD that coexist are continuously collected by the National Center for Health Statistics (U.S. Department of Health and Human Services, 2009a, 2009b, 2009c, 2009d, 2009e). If well-articulated, the information on the coexistence of MCOD can be useful to both clinical health practitioners and public health practitioners as well as decision makers in the public health sector. Such information can help in improving the practice of evidence-based decision-making towards preserving health, restoring health, and/or enhancing longevity (Reidpath & Allotey, 2003). The limited nature or lack of adequate information, which otherwise could be extracted from the large unanalyzed and uninterpreted raw data that is routinely collected, on the coexistence of MCOD in addition to the lack of information and knowledge on disparities in the nature of the coexistence of MCOD across the United States suggest that there may not be enough known about what influences humans' health, sicknesses, and ultimately our longevities.

Improving the understanding of the coexistence of MCOD in ways that may ultimately help in improving health and enhancing longevity was the overall purpose of this study. With this study, I intended to provide information on the interrelationships

between various causes of death in the United States, the potential variations in the causes of death over a period of 5 decades (i.e., 1959 to 2005), the variations in the causes of death across the states and territories of the United States, and the potential effects of race and education level on the coexistence of MCOD. The assessment of the variations in the MCOD across the states and territories of the United States (i.e., the spatial dimension) and the potential variations in the causes of death over a period of 5 decades (i.e., the temporal dimension) justifies the use of the term *spatiotemporal* in title of this study. The term, spatiotemporal, is not new and is actively used in this field of study (Martins-Melo et al., 2015).

In this chapter, I will present information on how I conducted this study. My presentation will be detailed enough to allow reproducibility of this study by any independent researcher. The research design and rationale will be presented first. The key variables of the study will be presented next, and then the targeted population will be defined. I will also present the details of how the original data set was collected by the National Center for Health Statistics, followed by my process of gaining access to the MCOD data set as an independent researcher. The chapter will also include operational definitions of the study variables and a description of how each of the study variables was measured. Furthermore, I will provide the data analysis plan including the software and statistical computing platform that was used and the data cleaning and data transformation strategies. The descriptive statistics and the inferential statistics approaches that were used in the study will be explained. Lastly, I will discuss the potential threats to internal, external, and construct validity and the applicable ethical considerations.

Research Design and Rationale

Key Study Variables

The dependent variable in the study was MCOD that coexist. I used the MCOD variable to examine any mention of a disease in death certificates because identifying a single disease as the UCOD has been shown to be an oversimplification of the process and events leading to death (see Désesquelles et al., 2010; Fedeli, Zoppini, et al., 2015; Piffaretti et al., 2016; Redelings et al., 2006). In the MCOD approach to gathering mortality information, all the conditions reported in the death certificate, which could be up to 20 conditions, the maximum number of conditions per death case in the dataset, and not just the UCOD alone, are treated as being relevant and important (Désesquelles et al., 2010; Fedeli, Zoppini, et al., 2015; Piffaretti et al., 2016; Redelings et al., 2006). The MCOD was treated as a continuous variable indicating the number of causes of death that coexist for each of the death cases. An explicit list of the causes of death considered are based on the list documented in the reports of the National Center for Health Statistics (U.S. Department of Health and Human Services, 2009a, 2009b, 2009c, 2009d, 2009e) and are identical for each for each of the years under study, 1959 to 2005.

The key independent variables were education level, race, place of residence, and year of death. The education level was an ordinal variable, and it reflected the number of years of formal education that the deceased person had. Race was a categorical variable measured at the nominal level of measurement. The categories for this variable were White, Black, American Indian (including Aleuts and Eskimos), Chinese, Japanese, Hawaiian (including part-Hawaiian), Filipino, Asian Indian, Korean, Samoan,

Vietnamese, Guamanian, Other Asian or Pacific Islander, and Combined Other Asian or Pacific Islander.

The place of residence was also a categorical variable measured at the nominal level of measurement. The place of residence is based on the state or territory of the United States where the deceased person was a resident. The year of death, an independent variable, was a categorical variable measured at the ordinal level of measurement such that the trends and variations in the coexisting causes of death over the years under study spanning five decades (i.e., 1959 to 2005) could be investigated.

The main covariates that I considered in the study were gender, age, and marital status. Gender was a categorical variable measured at the nominal level of measurement. The relevant categories were female and male. The age was measured at the interval level of measurement and is the number of years lived for each of the cases or deceased people.

Study Design

This research was an analytic study, and I made use of quantitative methods in both the descriptive and the inferential parts of the study (see Creswell & Creswell, 2017). This allowed me to have numerical quantities for describing the study parameters and to be able to statistically quantify the relationships between the dependent variable and the independent variables of interest. This study also contained some elements of ecological study design, wherein the average value of a variable over a small geographical unit is used to represent the value of the variable for the subset of the population under study who reside in that geographical unit (see Friis & Sellers, 2013).

This design was appropriate for advancing the knowledge in this discipline because it helps in providing new information on the MCOD in the United States as well as answer the research questions posed in this study. In the first aspect of this quantitative study, I explored the distribution of the number of coexisting MCOD across the United States. In the subsequent aspects of the study, I explored the relationships between the number of coexisting MCOD and various independent variables using correlational and inferential statistical techniques to test whether there are statistically significant relationships between the independent and the dependent variables of interest and to assess the extent and degree of the relationships if they exist.

Methodology

Population

I limited this study to the U.S. population. The data set was from the death cases recorded in the states and territories of the United States including American Samoa, Guam, Northern Marianas, Puerto Rico and the Virgin Islands. Furthermore, in this study, I also focused on death cases reported between the year 1959 and the year 2005. Since the population of the United States, which is approximately 323.1 million in the year 2016, was the targeted population, the annual mortality was estimated at to be about 2.71 million deaths and the gross mortality rate was estimated to be 844.0 deaths per 100,000 population (Xu, Murphy, Kochanek, & Arias, 2016).

Sampling and Sampling Procedures

The entire mortality dataset was used in this study. There was no need to select a sample from the entire dataset that is available. Simple random sampling would have been used if a sample was to be selected from the MCOD dataset available. In such case,

the sample size would have been calculated using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007). *F* test for evaluating the statistical significant of multiple regression model would have been selected as the desired statistical test family. The alpha would have been set to 0.05, the power to 80%, a small effect size of 0.02 since it is desirable that the study is able to find any small effect that is important and statistically meaningful, and the number of predictors to seven (which corresponds to the seven independent variables and the variables been controlled for: education level, race, place of residence, year of death, gender, age, and marital status). The sample size calculations using this would have resulted in the minimum required sample size of 725.

Collection of Multiple Causes of Death Data in the United States

The MCOD data are collected from death certificates of all deaths of the United States residents. It is believed that more than 99 % of deaths occurring in this country are registered (U.S. Department of Health and Human Services, 2009a, 2009b, 2009c, 2009d, 2009e). Data from the information on all the death certificates from all the states and territories of the United States are then pulled together by the National Center for Health Statistics, U.S. Department of Health and Human Services, to obtain the MCOD data set.

Gaining Access to the Multiple Causes of Death Data

The MCOD data set collated by the U.S. Department of Health and Human Services, National Center for Health Statistics (2008a) were used in this study. The data set for this research study is hosted on the website of ICPSR, www.icpsr.umich.edu, which is a subdomain of the website of the University of Michigan. To gain access to the data set, each user needs to create account with the ICPSR and agree to the *Terms of Use* agreement electronically through the website. This is how I have been able to gain access

to the MCOD dataset that is hosted by the ICPSR. I provide a copy of *Terms of Use* agreement that I signed electronically through ICPSR's website in the Appendix.

Instrumentation and Operationalization of Constructs

Instrumentation. The main instrument used for collecting the original data set is death certificate. The data are then collated at each state in the U.S. and forwarded to the National Center for Health Statistics (2008a).

Death certificate. A death certificate is issued by a medical practitioner certifying the deceased state of a person, the date, location and causes of the person's death (Kircher & Anderson, 1987; Kotabagi, Chaturvedi, & Banerjee, 2004; Messite & Stellman, 1996). Used over many years to report the mortality information, the death certificate has proven to have construct validity and internal consistency/reliability (Antini, Rajs, Muñoz-Quezada, Mondaca, & Heiss, 2015; Hunt et al., 1993; Poe et al., 1993). This instrument has been sufficient for gathering MCOD data which are used for answering the research questions in this study (National Center for Health Statistics, 2008a).

Operationalization. I have also provided the operational definition of each of the study variables.

MCOD. MCOD variable examines any mention of a disease in death certificates because identifying a single disease as the UCOD has been shown to be an oversimplification of the process/events leading to death (Désesquelles et al., 2010; Fedeli, Zoppini, et al., 2015; Piffaretti et al., 2016; Redelings et al., 2006). In the MCOD approach to gathering mortality information, all the conditions reported in the death certificate, which could be up to 20 conditions (and not just the UCOD) alone are treated as been relevant and important (Désesquelles et al., 2010; Fedeli, Zoppini, et al., 2015;

Piffaretti et al., 2016; Redelings et al., 2006). This was the dependent variable of interest. It was mainly treated as a continuous variable indicating the number of causes of death that coexist for each of the death cases. For example, if two diseases/conditions are reported as the causes of death (based on the MCOD approach explained in the introduction) then the value of this variable were 2, if three were reported, then the value of this variable were 3, and so on.

Education level. The education level of each of the cases/deceased person reflects the number of years of formal education that the deceased person completed. In this study, education level could be viewed as a proxy to socioeconomic status because socioeconomic status is not present in the secondary dataset being used for this study. The education level is measured at ordinal level of measurement and has classes/levels such as *8th grade or less*; *9th to 12th grade, no diploma*; *high school graduate or GED completed*; *some college credit, but no degree*; *associate degree*; *bachelor's degree*; *master's degree*; and *doctorate or professional degree*.

Race. Race is a categorical variable measured at nominal level of measurement. Its categories include White, Black, American Indian (includes Aleuts and Eskimos), Chinese, Japanese, Hawaiian (includes part-Hawaiian), Filipino, Asian Indian, Korean, Samoan, Vietnamese, Guamanian, Other Asian or Pacific Islander, and Combined other Asian or Pacific Islander.

Place of residence. The place of residence variable is based on the states and territories in the United States where the subject resided while alive as stated on the record/death certificate. It is a categorical variable measured at nominal level of measurement.

Year of death. This is the year that the subject died. It was treated as a categorical variable measured at ordinal level of measurement. This variable can have values between year 1959 and year 2005.

Gender. Gender is a categorical variable measured at nominal level of measurement. It has female and male as possible values.

Age. This is the age at which the subject died. It was measured in years, and was measured at interval level of measurement.

Marital status. The marital status would contain information regarding the marital status of the subject at the time of death. It is a categorical variable measured at nominal level of measurement. The valid categories are *never married, single*; *married*; *widowed*; *divorced*; and *marital status unknown*.

Data Analysis Plan

Software/statistical computing platform. The R Statistical Computing Platform version 3.4.3 (Team, 2013) and Python 3.6 on a Linux-based operating system were used in this study. The primary reason for choosing the R Statistical Computing Platform and Python Programming language is related to their scalability, which makes them appropriate for handling very large datasets with millions of cases that were dealt with in this study. In addition, the programmability that R and Python make possible allowed easy tracking of the computation activities and easy revision of the statistical computations as necessary. Furthermore, the open source nature of R and Python make them available for free. This allows the possibility of sharing any group of codes generated in this study with other researchers who may make use of the group of codes in their work and build new solutions/projects on them.

Data cleaning. Before the actual data analysis, I carried out data cleaning. At the data cleaning stage, I extracted (from the raw data) the columns that correspond to the variables of interest. Thereafter, I discarded entries/cases with missing values in any of the variables of interest, as well as those with outliers or inconsistent/unreasonable/impossible values.

Data transformation and generation of study parameters. At this stage, I carried out necessary variable re-coding and/or data transformations. Sometimes some of the needed study parameters/variables are not directly available in the secondary dataset or are not available in the needed format. I used variable recoding technique to recode any variable that is not available in the needed format into the needed format. Any other variable that is not directly available from the dataset and needs to be derived/computed is calculated from the variables that are directly available from the secondary dataset. Some transformations is used to achieve this. For example, *REPORTED AGE IN YEARS* variable, which is directly available in the secondary dataset will be transformed into ordinal variable, age groups. Age groups will be an ordinal (categorical) variable with six categories (namely, 0-4 years, 5-14 years, 15-24 years, 25-34 years, 35-44 years, 45-54 years, 55-64 years, and 65 years old and above).

Descriptive statistics. The nature of the data was explored and described using various descriptive statistics. For describing the continuous variables, descriptive statistics such as mean and standard deviation, are used. While I use frequency distribution, proportion, and mode for describing categorical variables (Rose & Sullivan, 1993). I considerably explored the data using graphical descriptive statistics such as bar/column charts.

Inferential statistics. I used inferential statistics approaches to test each of the null hypothesis that the study has. This allowed me to answer the research questions of interest. The research questions of interest (and the corresponding null and alternative hypothesis) are listed below.

Research Question 1: Is there any relationship between the number of coexisting multiple causes of death per death case and the state or territory of residence in the United States?

$H_0$1: There is no relationship between the number of coexisting multiple causes of death and the state or territory of residence in the United States.

$H_1$1: There is a relationship between the number of coexisting multiple causes of death and the state or territory of residence in the United States.

Research Question 2. Are there variations in the number of coexisting multiple causes of death per death case in the United States from 1 year to another?

$H_0$2: There are no variations in the number of coexisting multiple causes of death in the United States from 1 year to another.

$H_1$2: There are variations in the number of coexisting multiple causes of death in the United States from 1 year to another.

Research Question 3. Is there any relationship between the number of coexisting multiple causes of death per death case and race in the United States?

$H_0$3: There is no relationship between the number of coexisting multiple causes of death and race in the United States.

$H_1$3: There is a relationship the number of coexisting multiple causes of death and race in the United States.

Research Question 4. Is there any relationship between the number of coexisting multiple causes of death per death case and education level in the United States?

$H_0$4: There is no relationship between the number of coexisting multiple causes of death and education level in the United States.

$H_1$4: There is a relationship between the number of coexisting multiple causes of death and education level in the United States.

The potential effects of place/state of residence on the number of MCOD that coexist (in other words, the variations in the number of MCOD that coexist) that is investigated through the research question accounts for the spatial dimension of this study, while the potential variations in the variations in the number of MCOD that coexist across time (from the year 1959 to the year 2005) accounts for the temporal dimension of this study. These (i.e. the spatial dimension and the temporal dimension) explain why this study investigates spatiotemporal variations in the coexistence of MCOD. The other factors being consider include race (which is covered by Research Question 3), and education level (which is covered by Research Question 4).

Multiple linear regression modelling. To assess each of the research questions by statistically testing each of the corresponding null hypothesis, I used multiple linear regression analysis. Multiple linear regression analysis is appropriate for modelling and understanding the relationship between a dependent variable of interest (which is the number of causes of death that coexist) and two or more independent/explanatory variables (Ahlbom, 2017; Daniel & Cross, 2010), making it suitable for this study involving a continuous dependent variable and seven independent variables and

covariates. The dependent variable is the number of causes of death that coexist (such as one if only one cause of death is reported, two if two causes of death is reported, and so on), while the independent variables and the covariates are education level, race, place of residence, year of death, gender, age, and marital status. The inclusion of gender, age, and marital status in the analysis is aimed at controlling their potential confounding effects because these variables have the potentials of having relations with both the dependent variable and the independent variables of interest (thus potential confounders). I used F test to assess the statistical significance of the fitted model based on the regression sum of squares and residuals sum of squares.

If the model is statistically significant, I used *T* test to test whether each of the regression coefficients is statistically significant or not. *T* test is the appropriate test for conducting hypothesis test on any regression coefficient obtained while using linear regression modelling techniques (Ahlbom, 2017; Daniel & Cross, 2010; Sullivan, 2011). The model is carefully diagnosed. Some of the model diagnostics that used are the assessment of the regression residuals, assessment for possible autocorrelation using Durbin-Watson statistic, etc. (Ahlbom, 2017; Daniel & Cross, 2010). Any model violation was carefully investigated and reported if it could not be fixed.

Prior to fitting the multiple linear regression models for answering the research questions, I also carried out the test of normality (to see if the continuous variables follow normal distributions or not), test of equality of variance, and Pearson correlation between the continuous independent and dependent variables. Pearson correlation is appropriate for assessing linear relationship/correlation between two continuous variables (Daniel & Cross, 2010; Pearson, 1895; Sullivan, 2011) such as the number of causes of death that

coexist and the age at death in this study. These tests are important for assessing the assumptions upon which the Multiple Linear Regression Modelling (used for answering the research questions) is based (Ahlbom, 2017; Daniel & Cross, 2010; Sullivan, 2011).

Test of normality. To test whether the dependent variable and the continuous independent variables follow the normal distribution or not, I used Kolmogorov-Smirnov test of normality (Lilliefors, 1967; Massey Jr, 1951).

Test of equality of variance. I used Levene's test for equality of variances to test whether the assumption of equality of variance is met or not (Carroll & Schneider, 1985; Levene, 1961).

Pearson correlation. To assess linear relationship between the continuous dependent variable and independent variables, I used Pearson correlation (Pearson, 1895). The Pearson correlation allowed me to know the strength and the direction of the linear relationship between the continuous dependent variable and each of the continuous independent variables. The statistical significance of the Pearson correlation coefficients is assessed using *T* test (Ahlbom, 2017; Daniel & Cross, 2010).

Threats to Validity

Threats to External Validity

External validity is highly related to the generalizability of the results of the study (Ahlbom, 2017; Daniel & Cross, 2010; Sullivan, 2011). The United States is unique and considerably different from other countries in the world, including other highly developed countries. There are differences in the systems of government as well as in the healthcare system. These and other fundamental differences between the United States and other countries which could not be accounted for in this study constitute an important

threat to external validity. There is, unfortunately, no easy way to address this issue in the study as the study is limited to the U.S. population (and may indeed lack generalizability to other populations).

Threats to Internal Validity

It is generally possible that factors that cannot be easily measure or easily accounted for (such as confounders) may influence the outcome of interest and the researcher may wrongly attribute the effects, which indeed originate from the influences of confounders, to the independent variable of interest or the treatment under investigation (Daniel & Cross, 2010). This leads to threats to internal validity (Ahlbom, 2017; Daniel & Cross, 2010; Sullivan, 2011). Indeed, the less chance for confounding in a study, the higher its internal validity is. Gender, age, and marital status have the potentials of influencing the dependent variable of interest and pose threats to the internal validity of the study. To address this issue, the effects of gender, age, and marital status were controlled in the multiple linear regression modeling.

Threats to Construct Validity

Construct validity has to do with the degree to which a test or a variable measures what it claims or purports to measure (Daniel & Cross, 2010). The lack of socioeconomic status variable in the secondary data set that is used for this study and the plan to use education level (which is one of the important components of socioeconomic status) as a proxy for the socioeconomic status variable may be a source of threat to construct validity. Since the secondary data set does not specifically contain a socioeconomic status variable, there is no easy way to address this potential issue, rather than to clearly state in

the results that education level may only be viewed as a proxy to socioeconomic status and may not directly be interpreted as been socioeconomic status as a whole.

The revisions/changes to the ICD upon which the MCOD data are based may also a potential source of threats to construct validity. The ICD (which is the international standard for reporting diseases and health conditions as well as for reporting causes of death) has gone through a number of revisions since its first creation in 1893. The revision of the ICD over the years suggest that there are differences in how the causes of death were reported between the year 1959 and the year 2005 (which this study focuses on). Such possibility of construct validity issue could introduce problems in the comparison of the MCOD across the years (if the causes of death are not reported uniformly). To address the potentials issue regarding the changes in the ICDs, the previous ICDs are linked to the current ICD-10 using an interconversion table that maps the previous ICDs to the current ICD-10. (It is assumed that any non-traceable differences in the ICDs are random and not systematic and would not result in any significant loss of information across the years.)

Ethical Considerations

Agreement to Gain Access to the Data

The data set for this research study is hosted on the website of ICPSR, www.icpsr.umich.edu, which is a sub-domain of the website of the University of Michigan. To gain access to the data set, each user needs to create account with the ICPSR and agree to the *Terms of Use* agreement electronically through the website. This is how I have been able to gain access to the MCOD dataset that is hosted by the ICPSR. As required, I have ensured that the dataset does not get transferred to others through me,

as any individual who needs access to the data set has to directly obtain the data set from the ICPSR after agreeing to the *Terms of Use*. I provide a copy of *Terms of Use* in the Appendix and also attach it to the IRB application.

Compliance with Institutional Review Board (IRB) Ethical Standards

The proposal of this study (as well as the *Terms of Use* agreement for the MCOD secondary dataset been used for this study) was submitted to Walden University's IRB before proceeding with the actual analysis of the secondary dataset. Any revision to this study that were suggested by the IRB on ethical grounds were carefully addressed. The study was only conducted after securing IRB approval. The study was conducted in accordance with the proposed research/study plan that was approved by the IRB. I ensured a complete compliance with the policies and procedures related to ethical standards in research. In the event that any significant change had to be made to the study/research plan originally approved by the IRB, the updated research/study plan was sent back to the IRB for review and approval.

Anonymity

The data were anonymous and de-identified. They do not contain personal information that would allow the data to be traced back and used to identify the individual the data came from. Furthermore, the dataset (since they were extracted from death certificates) are not for human subject who are alive.

Other Ethical Issues: Research Integrity and Thoroughness

I maintain the highest level of research integrity by being objective and putting aside any form bias and subjective view towards any subset of the population of interest. Furthermore, I ensured that all the statistical procedures are executed with highest level

of thoroughness and diligence thereby ensuring that the results are correct and trustworthy.

Summary

In this chapter, I have presented information on the methodology of the study. The research design and rationale, the key study variables and their operational definitions, the targeted population, the process of gaining access to the MCOD data set have been presented in detail. The data analysis approach, including the software/statistical computing platform that were used, the data cleaning and data transformation strategies, the descriptive statistics approaches, and the inferential statistics approaches that were used have also be explained in detail. I have also discussed the potential threats to internal, external, and construct validity, and the applicable ethical considerations.

In the next chapter (Chapter 4), I will present the results of the study and their interpretations. The basic descriptive statistics will be presented first. They will be followed by the results of the inferential statistics (i.e., the statistical tests) making references to the research questions of interest and what the answer to each of the research question is (based on whether the corresponding null hypothesis is rejected or not).

Chapter 4: Results

Introduction

Mortality rates are frequently used as key health indicators (Dwyer-Lindgren et al., 2016; Mackenbach et al., 2015; Nordentoft et al., 2013; Smith et al., 2014; Weber et al., 2013), making them of interest and importance to the fields of epidemiology and public health. Researchers have demonstrated that MCOD data have the capability of providing important information that could not possibly be gathered from other mortality data (T.-H. Lu & Lin, 2010; Redelings et al., 2006). However, there has been considerable underutilization of MCOD data despite the fact that the National Center for Health Statistics uses a lot of resources to routinely collect MCOD it (U.S. Department of Health and Human Services, 2009a, 2009b, 2009c, 2009d, 2009e), thereby leaving a gap in mortality knowledge from the MCOD perspective. The results of this study help towards bridging the gap and add to the utilization of the MCOD data. I designed this study for the purpose of examining the factors, such as place of residence, race, etc., that may influence the number of MCOD that coexist.

In this study, I used quantitative research methods involving numerical and statistical techniques to analyze the coexistence of causes of death in approximately 80 million death cases and how some independent variables of interest influence the number of causes of death that coexist across the states and territories of the United States from 1959 to 2005 using MCOD data. I developed one of the four research questions to determine whether there is a relationship between the number of coexisting MCOD per death case and the state or territory of residence in the United States. Another research question was related to whether there are variations in the number of coexisting MCOD

per death case in the United States from 1 year to another within the study period. With the third research question, I explored the possibility of any relationship between the number of coexisting MCOD per death case and race in the United States, while with the last research question, I examined the possibility of relationships between the number of coexisting MCOD per death case and the number of years of formal education completed.

In this chapter, I will present data set information, such as the time frame that the data covers; descriptive statistics that appropriately characterize the dataset; descriptive statistics for the number of coexisting MCOD across the years; the descriptive statistics on the variations in the number of coexisting MCOD across states of residence, across races, across education levels, across genders, across marital statuses, and across age groups. I will also present inferential statistics including the evaluation of statistical assumptions, the test of hypothesis for each of the four research questions, the 95% confidence intervals for each of the regression coefficients, beta, the results of multiple comparison post hoc analysis carried out with Fisher's LSD, and the Cohen's *d* effect size for differences between two groups. My interpretations will also be presented.

Data Collection

The MCOD data are collected from death certificates of all deaths of the U.S. residents. It is believed that more than 99% of deaths occurring in this country are registered (U.S. Department of Health and Human Services, 2009a, 2009b, 2009c, 2009d, 2009e). Data from the information on all the death certificates from all the states and territories of the United States are then pulled together by the National Center for Health Statistics, U.S. Department of Health and Human Services to obtain the MCOD data set.

The main instrument used for collecting the original data set is a death certificate. A death certificate is issued by a medical practitioner certifying the deceased state of a person, the date, location, and causes of the person's death (Kircher & Anderson, 1987; Kotabagi et al., 2004; Messite & Stellman, 1996). Used over many years to report the mortality information, the death certificate has proven to have construct validity and internal consistency (reliability; Antini et al., 2015; Hunt et al., 1993; Poe et al., 1993). The data gathered through the death certificates are collated at each state in the United States and forwarded to the National Center for Health Statistics (2008a). Since the information of all the reported death cases are collated across all the states in the United States, it is believed that the dataset represents the true mortality information for the United States.

In addition to the number of coexisting MCOD, the state and territory of residence, the year of death, race, and education levels, in this study, I also made use of additional variables, such as marital status, gender, and age group, in the regression modelling because univariate and bivariate analyses show that these variables have the potentials of influencing the dependent variable of interest, the number of coexisting MCOD. The descriptive statistics of the distributions of the number of coexisting MCOD across marital status, gender, and age groups show that the number of coexisting MCOD varies across race, marital status, gender, and age groups. These are in addition to the variations in the number of coexisting MCOD across the years, the state/territory of residence, race, and education levels.

Results

Descriptive Statistics

Prior to attempting any inferential statistics, it is essential to first have a good understanding of the available dataset, their nature, and their distributions (Ahlbom, 2017; Daniel & Cross, 2010; Field, 2013). This is achievable through descriptive statistics. In this research, I used various graphical, descriptive, statistical approaches, such heatmaps and columnor bar charts, for exploring the dataset.

Available dataset for the variables of interest between the year 1959 and the year 2005. I explored the available dataset for the variables of interest between the years of 1959 and 2005 using a heatmap. The heatmap is shown in Figure 1. The rows represent each of the variables of interest, while the column represents each of the years from 1959 to 2005. The blue cells indicate that the data for the variable was available for that year, while the red cells with white square patches indicate that the data for the variable was not available for that year. The white square patches are added to the red cells to make the red and the blue cells differentiable even when the figure is printed in black and white.

Through the heatmap, it is noticeable that the number of coexisting MCOD is available for the years 1968 to the year 1980 and from the year 1982 to the year 2005 (see Figure 2). On the other hand, the data for the UCOD, race, gender, and age are available for all the years from the year 1959 to 2005 (see Figure 1). The place of residence data are available from the year 1959 to 2004 but not available for the year 2005, while education level are only available for the years 1989 to 2005 (see Figure 1). The marital

status data are available for the year 1959 to 1961 and from the year 1979 to 2005 (see Figure 1).

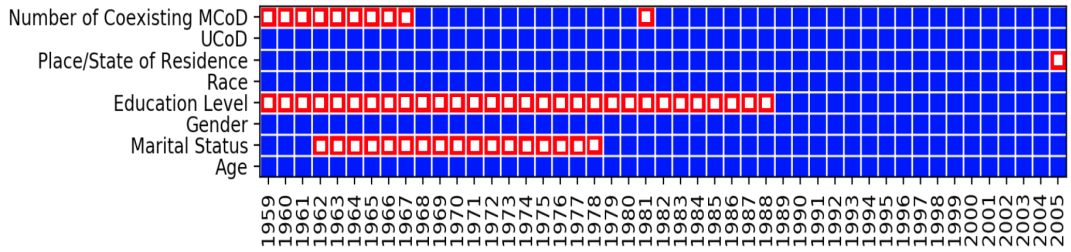

Figure 1. A heatmap showing the available dataset for the variables of interest between the year 1959 and the year 2005.

The number of coexisting MCOD across the years. The average number of coexisting MCOD for the years 1968 to 2005 (except for the year 1981, which was not available from the dataset) are shown in Figure 2. Each column in the column chart represents the average number of coexisting MCOD per deceased person for the respective year, while the error bar is based on the standard error of the number of coexisting MCOD. The error bars were scaled by a factor of 10 to make them visible. From the distribution shown in Figure 2, it was noticeable that the number of coexisting MCOD rose slowly from the year 1968 to 1985, then plateaued until the year 1988, then decreased steadily until the year 1999, after which there has been a rapid increase in the average number of coexisting MCOD. A more detailed distribution of the number of coexisting MCOD for each of the years, showing not just the average and the standard error, are shown in Figure A1 in the appendix.

At this point it should be noted that while the vertical axis represents the number of coexisting MCOD and is shared by both the average and the standard error of the mean for number of coexisting MCOD, the number written within each of the columns of the

column chart is the number of death cases for which each of the statistics is based. For example, *N*=1,930,082 written inside the column for 1968 shows that data from 1.93 million death cases were used for calculating the statistics for the year 1968 shown in Figure 2.

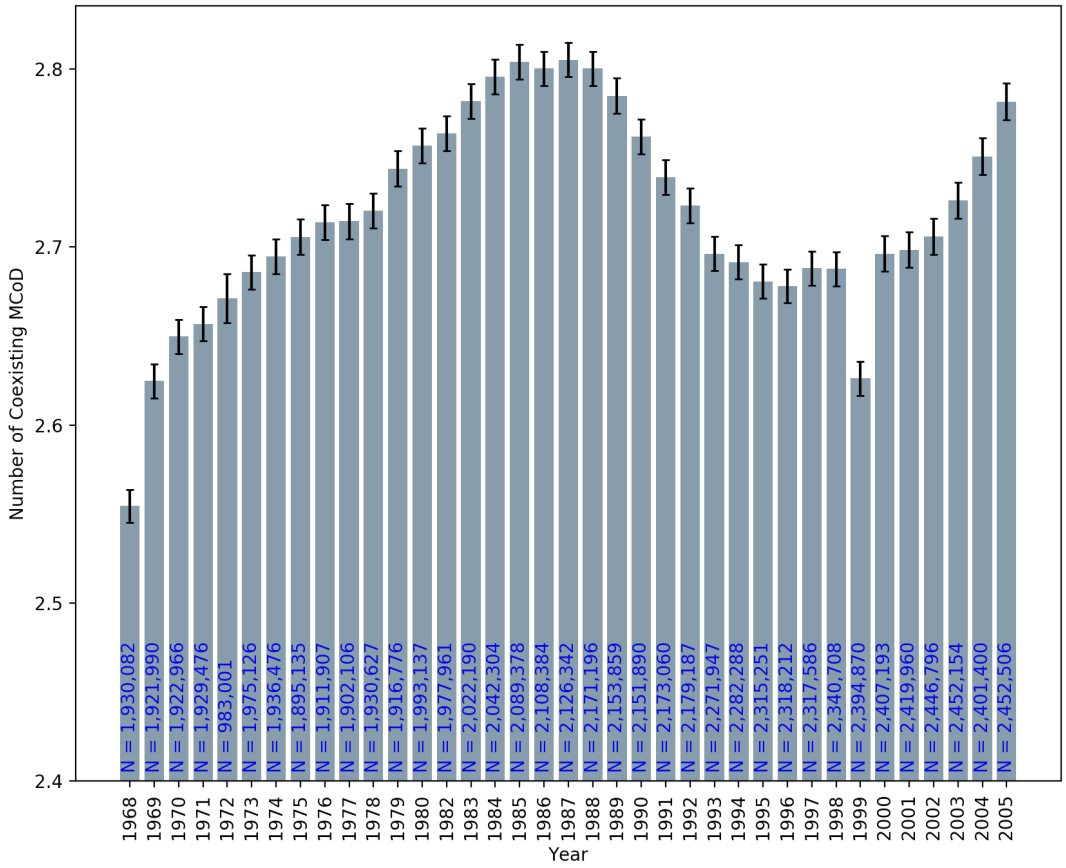

Figure 2. A column chart for the number of coexisting MCOD across the years.

Variations in the number of coexisting MCOD across the states/territories of residence. The average number of coexisting MCOD across the states of residence are shown in Figure 3. Each column in the column chart represent the average number of coexisting MCOD per deceased person for the respective state, while the error bar is based on the standard error of the number of coexisting MCOD. The error bars have been

scaled by a factor of 10, just as in the previous figure and in the subsequent figures that have error bars, so as to make them visible. From the distribution shown in Figure 3, the average number of coexisting MCOD varies across the states. More detailed distributions of the number of coexisting MCOD for each of the states of residence (showing not just the average and the standard error, but the entire distribution of the number of coexisting MCOD for each state) are shown in Figure A2.

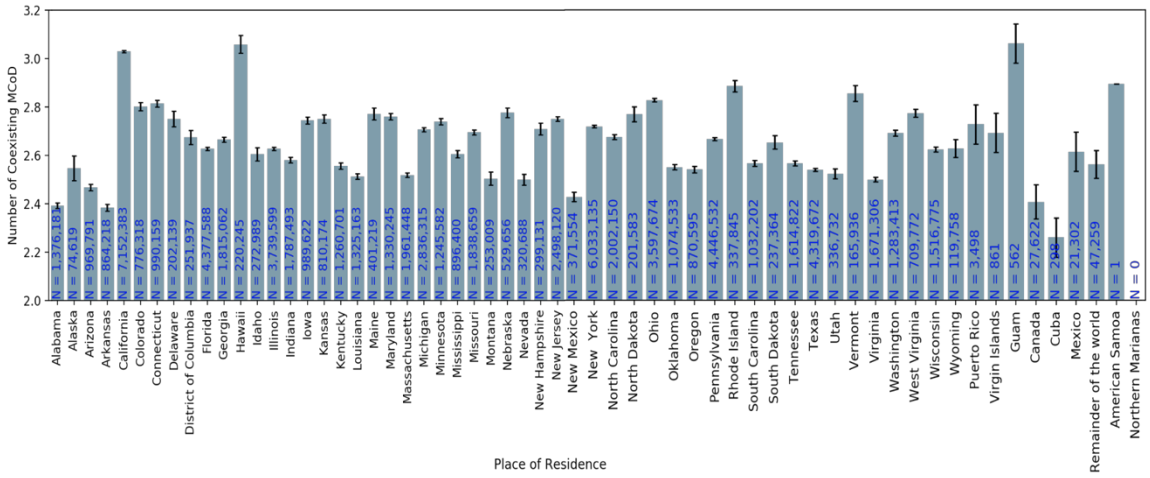

Figure 3. Variations in the number of coexisting MCOD across states/territories of residence. To further aid visualization, I provide a high-resolution version of this figure here https://drive.google.com/file/d/1_J2vl5kYcBfgPIj9olNOpI7m51tdJWrW/view and here https://goo.gl/hMBRqc.

Variations in the number of coexisting MCOD across races. The average number of coexisting MCOD across races are shown in Figure 4. Each column in the column chart represent the average number of coexisting MCOD per deceased person for the respective race, while the error bar is based on the standard error of the number of coexisting MCOD. The results show that, on the average, the number of coexisting MCOD is lowest for the Black, followed by the White, while it is highest for the other races combined (Figure 4). A more detailed distribution of the number of coexisting

MCOD for each of the races (showing not just the average and the standard error, but the full distribution of the number of coexisting MCOD for each of the races) is shown in Figure A3.

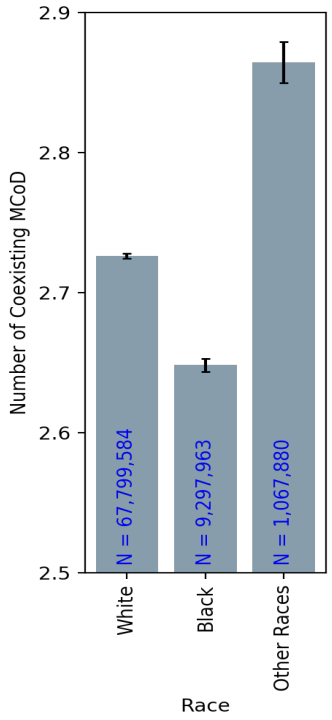

Figure 4. Variations in the number of coexisting MCOD across races.

Variations in the number of coexisting MCOD across education levels. The distribution of the average number of coexisting MCOD across the levels of education (measured by the number of years of formal education completed) shows that, on the average, the number of coexisting MCOD decreases with increasing number of years of formal education completed for those who completed one year of formal education to those who completed 17 or more years of formal education (Figure 5). A more detailed distribution of the number of coexisting MCOD for each of the education levels (showing

not just the average and the standard error, but the full distribution of the number of coexisting MCOD for each of the education levels) is shown in Figure A4.

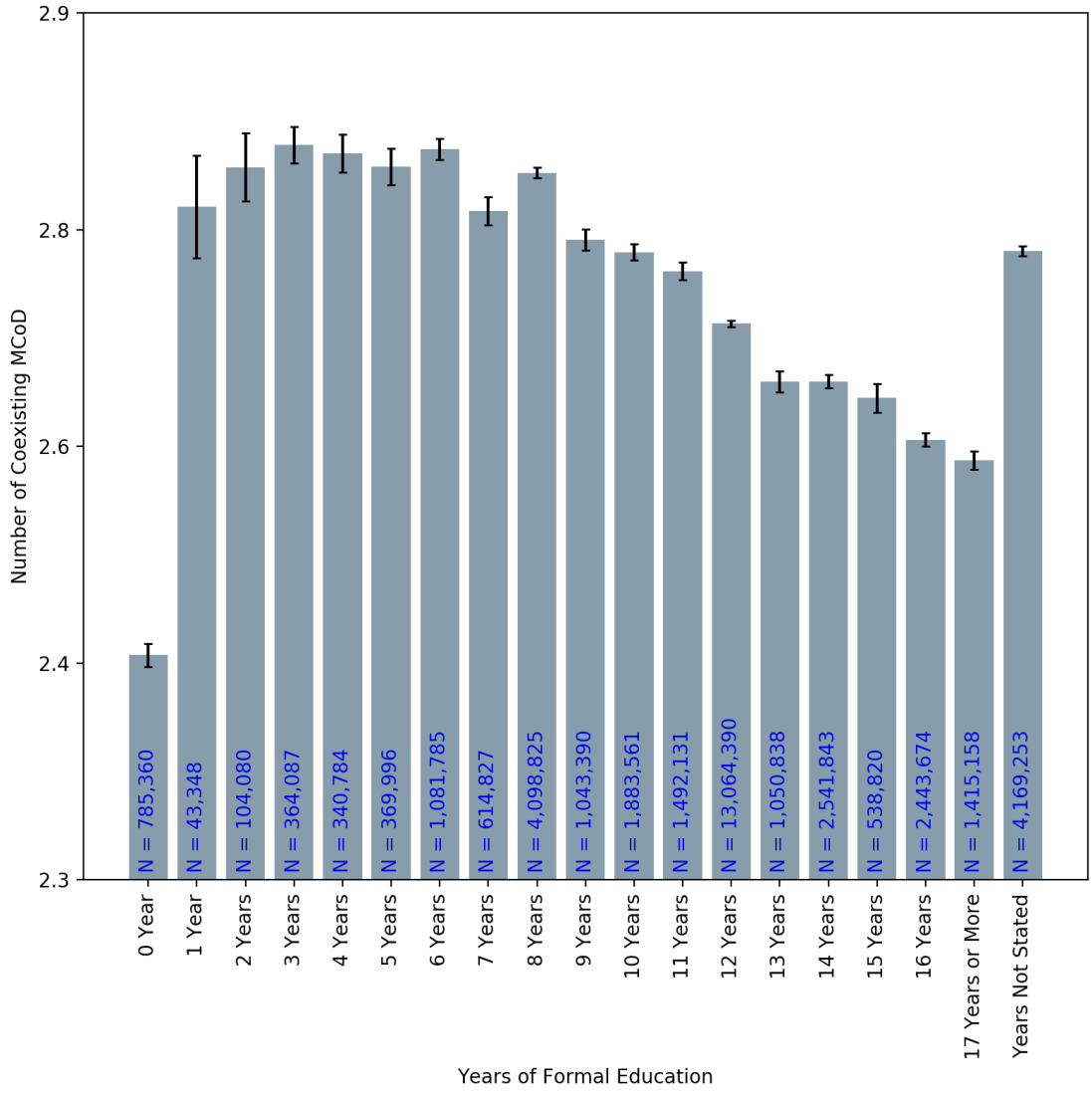

Figure 5. Variations in the number of coexisting MCOD across education levels.

Variations in the number of coexisting MCOD across genders. The variations in the number of coexisting MCOD was also explored across genders and the results are displayed in Figure 6. On the average, the number of coexisting MCOD is lower for the

males compared to the females (Figure 6). A more detailed distribution of the number of coexisting MCOD for males and females (showing not just the average and the standard error, but the full distribution of the number of coexisting MCOD for each of the genders) is shown in Figure A5.

Readers should, please, note that while the vertical axis represents the number of coexisting MCOD and is shared by both the average and the standard error of the mean for number of coexisting MCOD, the number written within each of the columns of the column chart is the number of death cases for which each of the statistics is based. For example, *N*=40,847,116 written inside the male's column shows that data from 40.85 million death cases were used for calculating the year male's statistics shown in Figure 6.

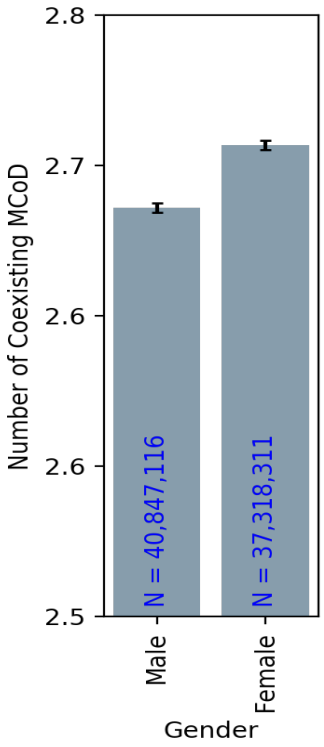

Figure 6. Variations in the number of coexisting MCOD across genders.

Variations in the number of coexisting MCOD across marital statuses. The variations in the average number of coexisting MCOD across marital statuses are presented in Figure 7, and show that, on the average, the number of coexisting MCOD is highest for the widowed followed by the married, the divorced, and the single (i.e. never married) individuals. The detailed distribution of the number of coexisting MCOD for each of the marital statuses (showing not just the average and the standard error, but the full distribution of the number of coexisting MCOD for each of the marital status) is shown in Figure A6.

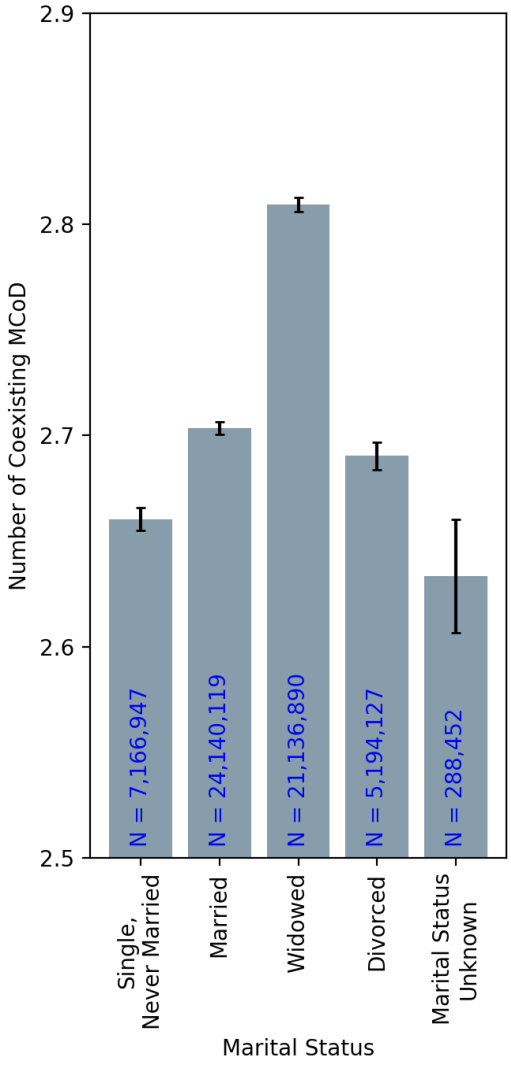

Figure 7. Variations in the number of coexisting MCOD across marital statuses.

Variations in the number of coexisting MCOD across age groups. Across the age groups, the distribution of the average number of coexisting MCOD shows that the number of coexisting MCOD increase with age until it reaches a peak in the 15 to 24 years age group, after which it decreases reaching a low point at the 45 to 54 years age group (Figure 8). It increases again to reach a second peak at the age of 65 years or older (Figure 8). Detailed distribution of the number of coexisting MCOD for each of the age

groups (showing not just the average and the standard error, but the full distribution of the number of coexisting MCOD for each of the age groups) is shown in Figure A7.

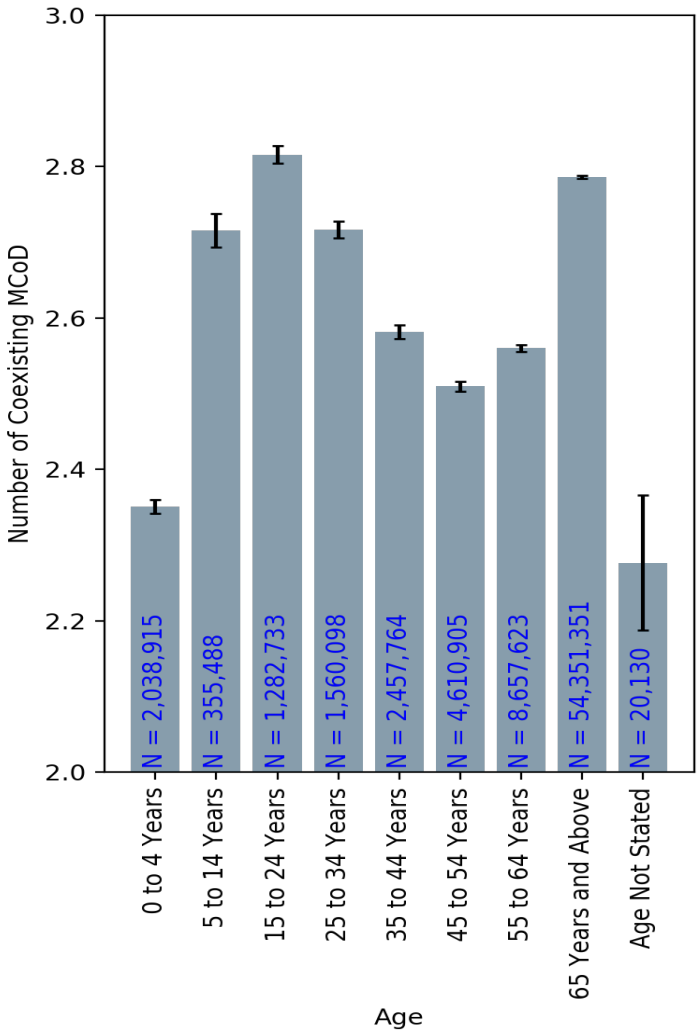

Figure 8. Variations in the number of coexisting MCOD across age groups.

Inferential Statistics

Statistical assumptions. A number of statistical assumptions are crucial in multiple linear regression modelling (Ahlbom, 2017; Daniel & Cross, 2010; Field, 2013). Some of the important assumptions tested prior to conducting multiple linear regression analysis in this study are the assumption of normality (Lilliefors, 1967), the assumption

of linear relationship, and the assumption of little or no multicollinearity (Vatcheva, Lee, McCormick, & Rahbar, 2016).

Assumption of normality. The assumption of normality was evaluated using Kolmogorov-Smirnov test of normality (Lilliefors, 1967; Massey Jr, 1951). With a $p < 0.001$ (Table 2), the distributions of the number of coexisting MCOD, the number of years of formal education completed, and age in years are statistically different from normal distribution. Therefore, the assumption of normality is not met. This is not surprising for the number of coexisting MCOD, given the highly skewed nature of the distribution of the number of coexisting MCOD. Furthermore, the distributions of intensity variables are often skewed in nature, and the number of coexisting MCOD can be likened to a measure of intensity – in this case, the intensity of coexisting MCOD.

Table 2

Kolmogorov-Smirnov Test of Normality for the Continuous Variables

Variable	Kolmogorov-Smirnov Statistics	*p*
Number of Coexisting MCOD	0.8413	<0.001
Number of Years of Formal Education Completed	0.9737	<0.001
Age in Years	0.9790	<0.001

Assumption of linear relationship. In linear regression model, it is assumed that there is a linear relationship between the dependent variable and the continuous independent variables of interest. The assumption is tested using Pearson correlation and *t* test. The results show that there is a linear relationship between the dependent variable (namely, the number of coexisting MCOD) and the continuous independent variables,

namely the number of years of formal education completed (r = -0.0118, p < 0.001, Table 3) and the age in years (r = 0.0688, p < 0.001, Table 3). This assumption is, therefore, met.

Table 3

Pearson Correlation Between Dependent Variable and the Continuous Independent Variables

Variable	*Pearson's r*	*p*
Number of Coexisting MCOD *vs* Number of Years of Formal Education Completed	-0.0118	<0.001
Number of Coexisting MCOD *vs* Age in Years	0.0688	<0.001

Assumption of little or no multicollinearity. Very high correlations between independent variables is regarded as multicollinearity. The assumption was tested using Pearson correlation analysis and t-test and the results show that the there are no strong correlations (*Pearson's r* = 0.0831, Table 4) between the independent variables. This makes the assumption of little or no multicollinearity to be met.

Table 4

Pearson Correlation Between the Continuous Independent Variables

Variable	*Pearson's r*	*p*
Number of Years of Formal Education Completed *vs* Age in Years	0.0831	<0.001

Research Question 1. Is there any relationship between the number of coexisting multiple causes of death per death case and the state or territory of residence in the United States?

$H_0$1: There is no relationship between the number of coexisting multiple causes of death and the state or territory of residence in the United States.

$H_1$1: There is a relationship between the number of coexisting multiple causes of death and the state or territory of residence in the United States.

Results for Research Question 1.

Hypothesis testing. The null hypothesis that there is no relationship between the number of coexisting multiple causes of death and the state or territory of residence in the United States has been tested using multiple linear regression modelling (which allowed for the simultaneous control of the effects of other factors on the dependent variable). The state or territory of residence (which is a categorical variable) is represented using dummy coding, and the District of Columbia is treated as the reference category such that every other state is compared to the DC. The model is statistically significant and the state or territory of residence is statistically significant in the model ($p < 0.05$) (Table 5, Table A1). Therefore, the first null hypothesis is rejected and the alternative hypothesis that there is a relationship between the number of coexisting multiple causes of death and the state or territory of residence in the United States is accepted.

Regression coefficients and confidence intervals. The regression coefficients, *B*, shown in the table indicates how each of the states or territory compares to the DC. For example, a regression coefficient of -0.2913 (with a 95% C. I. of (-0.31, -0.273)) for the state of Alabama indicates that the average number of coexisting MCOD in Alabama is

statistically ($p < 0.001$) lower than that of the DC but only by about 0.3 (Table 5). On the other hand, a regression coefficient of 0.3556 (with a 95% C. I. of (0.325, 0.387)) for the state of Arkansas indicates that the average number of coexisting MCOD in Arkansas is statistically ($p < 0.001$) higher than that of the DC but only by about 0.4 (Table 5). The $p = 0.185$ for Delaware shows that average number of coexisting MCOD in Delaware is not statistically ($p = 0.185$) different from that of the DC. A more detailed comparison of each of the states to the DC are shown in Table 5.

Effect size and post hoc analyses. Multiple comparison post hoc analysis were carried out with Fisher's LSD, and Cohen's *d* was used as a measure of effect size for the difference between each pair of states/territories of residence. The results of the multiple comparison post hoc analysis and the effect size are presented in Table 6. The average number of coexisting MCOD are statistically different ($p < 0.001$) for virtually all the pairs of states/territory of residence except for a few pairs of states/territory of residence such as Alabama vs Cuba ($p = 0.206$), Alaska vs Kentucky ($p = 0.064$), etc. (Table 6). The statistical difference ($p < 0.001$) in the average number of coexisting MCOD for virtually all the pairs of states/territory of residence observed from the Fisher's LSD post hoc analysis is consistent with the distribution of the average number of coexisting MCOD presented in Figure 3 under the descriptive statistics subsection. It is also worthy of note that statistical significance of most of the pairwise comparison in Fisher's LSD post hoc analysis can be attributed to the very high power of the statistical test resulting from the very large value of *N* (since *N* is in millions in this study). Even though, the multiple comparison results show statistically significant difference between each pair of states/territories of residence, the effect size are small (close to 0.2) in most cases and are

sometimes medium (close to 0.5, Cohen, 1988, 1992; Kelley & Preacher, 2012; Sawilowsky, 2009).

Table 5

*The Regression Coefficients for the States of Residence Extracted from the Full Regression Model**

			95% C. I. of B			
States of Residence**	*B*	*SE of B*	*LB*	*UB*	*t*	*p*
Alabama	-0.2913	0.009	-0.31	-0.273	-30.9	<0.001
Alaska	-0.1493	0.008	-0.165	-0.133	-18.4	<0.001
Arizona	0.0229	0.009	0.005	0.041	2.525	0.012
Arkansas	0.3556	0.016	0.325	0.387	22.45	<0.001
California	-0.0851	0.015	-0.115	-0.055	-5.57	<0.001
Colorado	-0.1787	0.008	-0.195	-0.162	-21.4	<0.001
Connecticut	-0.1745	0.009	-0.192	-0.157	-19.2	<0.001
Delaware	0.0136	0.01	-0.007	0.034	1.325	0.185
Florida	-0.1523	0.01	-0.171	-0.133	-15.8	<0.001
Georgia	-0.2855	0.01	-0.304	-0.267	-29.9	<0.001
Hawaii	-0.0472	0.024	-0.094	-<0.001	-1.98	0.048
Idaho	0.0302	0.013	0.005	0.056	2.313	0.021
Illinois	0.1054	0.009	0.087	0.124	11.12	<0.001
Indiana	-0.2082	0.009	-0.226	-0.191	-23.1	<0.001
Iowa	-0.1157	0.009	-0.133	-0.099	-13.4	<0.001
Kansas	-0.1282	0.01	-0.147	-0.109	-13.3	<0.001
Kentucky	-0.038	0.01	-0.058	-0.018	-3.66	<0.001

(table continues)

States of Residence**	*B*	*SE of B*	*95% C. I. of B* *LB*	*UB*	*t*	*p*
Louisiana	-0.0148	0.009	-0.033	0.003	-1.64	0.102
Maine	-0.2572	0.016	-0.289	-0.226	-16.1	<0.001
Maryland	0.1008	0.012	0.077	0.124	8.357	<0.001
Massachusetts	-0.2219	0.013	-0.247	-0.197	-17.6	<0.001
Michigan	-0.2965	0.01	-0.316	-0.278	-30.5	<0.001
Minnesota	-0.019	0.015	-0.048	0.009	-1.31	0.191
Mississippi	-0.0632	0.009	-0.08	-0.046	-7.2	<0.001
Missouri	-0.2157	0.013	-0.241	-0.191	-16.9	<0.001
Montana	0.1207	0.008	0.105	0.137	14.77	<0.001
Nebraska	0.0328	0.009	0.016	0.05	3.72	<0.001
Nevada	0.1754	0.017	0.142	0.209	10.32	<0.001
New Hampshire	0.311	0.008	0.295	0.327	37.18	<0.001
New Jersey	-0.041	0.01	-0.061	-0.021	-4.08	<0.001
New Mexico	-0.135	0.01	-0.155	-0.115	-13.2	<0.001
New York	-0.0069	0.008	-0.023	0.009	-0.84	0.398
North Carolina	-0.2981	0.01	-0.318	-0.278	-28.8	<0.001
North Dakota	0.3356	0.014	0.308	0.363	23.88	<0.001
Ohio	-0.0267	0.01	-0.046	-0.007	-2.71	0.007
Oklahoma	-0.0654	0.017	-0.098	-0.033	-3.96	<0.001

(table continues)

States of Residence**	*B*	*SE of B*	*95% C. I. of B* *LB*	*UB*	*t*	*p*
Oregon	0.0193	0.009	0.001	0.037	2.114	0.035
Pennsylvania	-0.0061	0.008	-0.022	0.01	-0.75	0.453
Rhode Island	-0.1351	0.013	-0.161	-0.109	-10.2	<0.001
South Carolina	0.3074	0.018	0.272	0.343	16.81	<0.001
South Dakota	-0.1875	0.009	-0.205	-0.17	-20.6	<0.001
Tennessee	0.0365	0.01	0.018	0.055	3.809	<0.001
Texas	0.2766	0.011	0.255	0.298	24.99	<0.001
Utah	0.3836	0.008	0.368	0.399	47.87	<0.001
Vermont	-0.1575	0.009	-0.176	-0.139	-16.9	<0.001
Virginia	-0.0442	0.021	-0.086	-0.003	-2.09	0.037
Washington	0.0803	0.103	-0.121	0.282	0.781	0.435
West Virginia	0.0692	0.195	-0.312	0.451	0.356	0.722
Wisconsin	0.4669	0.3	-0.121	1.055	1.558	0.119
Wyoming	-0.2464	0.044	-0.333	-0.16	-5.56	<0.001
Puerto Rico	-0.6476	0.379	-1.391	0.095	-1.71	0.088
Virgin Islands	0.1005	0.046	0.01	0.191	2.18	0.029
Guam	-0.0178	0.03	-0.076	0.04	-0.6	0.548
Canada	0.0236	0.01	0.003	0.044	2.25	0.024
Cuba	3E-14	1E-14	2E-15	5.1E-14	2.121	0.034

(table continues)

States of Residence**	*B*	*SE of B*	*95% C. I. of B* *LB*	*UB*	*t*	*p*
Mexico	0.1333	0.01	0.113	0.153	13.14	<0.001
Remainder of the world	0.0693	0.016	0.037	0.101	4.255	<0.001
American Samoa	0.0687	0.016	0.037	0.101	4.202	<0.001

* The dependent variable is the number of coexisting MCOD. The full regression model has independent variables that include the year of death, the place of residence, education level, race, gender, age, and marital status. The full regression model is statistically significant ($p < 0.001$, see Table A1), and has a small effect size based on the coefficient of determination of 0.022.

** The States of Residence is a categorical variable and is represented using dummy coding. The District of Columbia is treated as the reference category so it does not explicitly appear in the table as every other state is compared to it.

Table 6

The Multiple Comparison Post hoc Analysis with Fisher's LSD and Cohen's d Effect Size for State or Territory of Residence *

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
Alabama	Alaska	0.154	0.113	0.133	0.176	30.055	1450798	<0.001
Alabama	Arizona	0.076	0.058	0.068	0.083	43.244	2345970	<0.001
Alabama	Arkansas	-0.008	-0.006	-0.016	0	-4.103	2240397	<0.001
Alabama	California	0.638	0.449	0.632	0.643	482.437	8528562	<0.001
Alabama	Colorado	0.411	0.292	0.402	0.419	205.654	2152497	<0.001
Alabama	Connecticut	0.423	0.306	0.415	0.43	231.905	2366338	<0.001
Alabama	Delaware	0.358	0.26	0.345	0.372	109.445	1578318	<0.001
Alabama	District of Columbia	0.283	0.206	0.27	0.295	94.853	1628116	<0.001
Alabama	Florida	0.236	0.174	0.23	0.241	177.593	5753767	<0.001
Alabama	Georgia	0.273	0.199	0.267	0.28	175.886	3191241	<0.001
Alabama	Hawaii	0.668	0.471	0.654	0.681	205.14	1596424	<0.001
Alabama	Idaho	0.213	0.155	0.201	0.225	74.06	1649168	<0.001
Alabama	Illinois	0.236	0.172	0.23	0.241	172.068	5115778	<0.001
Alabama	Indiana	0.189	0.136	0.183	0.196	119.803	3163672	<0.001

(table continues)

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
Alabama	Iowa	0.353	0.252	0.345	0.36	190.731	2365801	<0.001
Alabama	Kansas	0.359	0.256	0.351	0.367	182.992	2186353	<0.001
Alabama	Kentucky	0.164	0.117	0.157	0.171	95.44	2636880	<0.001
Alabama	Louisiana	0.121	0.089	0.114	0.128	72.788	2701342	<0.001
Alabama	Maine	0.38	0.271	0.37	0.39	151.173	1777398	<0.001
Alabama	Maryland	0.368	0.258	0.361	0.375	212.536	2706424	<0.001
Alabama	Massachusetts	0.127	0.095	0.121	0.134	85.913	3337627	<0.001
Alabama	Michigan	0.315	0.226	0.309	0.321	217.322	4212494	<0.001
Alabama	Minnesota	0.348	0.243	0.341	0.355	196.194	2621761	<0.001
Alabama	Mississippi	0.213	0.152	0.205	0.221	112.403	2272579	<0.001
Alabama	Missouri	0.304	0.218	0.297	0.31	192.875	3214838	<0.001
Alabama	Montana	0.112	0.082	0.1	0.125	37.949	1629188	<0.001
Alabama	Nebraska	0.385	0.28	0.375	0.394	172.952	1905835	<0.001
Alabama	Nevada	0.108	0.08	0.096	0.119	40.643	1696867	<0.001
Alabama	New Hampshire	0.318	0.233	0.306	0.329	115.203	1675310	<0.001
Alabama	New Jersey	0.359	0.253	0.353	0.365	238.235	3874299	<0.001

(table continues)

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
Alabama	New Mexico	0.087	0.064	0.076	0.097	34.494	1747733	<0.001
Alabama	New York	0.412	0.305	0.407	0.418	323.355	7409314	<0.001
Alabama	North Carolina	0.364	0.253	0.357	0.37	227.893	3378329	<0.001
Alabama	North Dakota	0.469	0.339	0.455	0.482	141.902	1577762	<0.001
Alabama	Ohio	0.534	0.354	0.528	0.54	353.071	4973853	<0.001
Alabama	Oklahoma	0.224	0.164	0.217	0.232	127.423	2450712	<0.001
Alabama	Oregon	0.214	0.157	0.206	0.221	114.301	2246774	<0.001
Alabama	Pennsylvania	0.355	0.247	0.349	0.36	253.24	5822711	<0.001
Alabama	Rhode Island	0.599	0.429	0.588	0.61	223.186	1714024	<0.001
Alabama	South Carolina	0.242	0.175	0.235	0.25	134.327	2408381	<0.001
Alabama	South Dakota	0.339	0.245	0.326	0.352	110.256	1613543	<0.001
Alabama	Tennessee	0.242	0.167	0.235	0.249	144.188	2991001	<0.001
Alabama	Texas	0.212	0.149	0.206	0.217	152.311	5695851	<0.001
Alabama	Utah	0.194	0.142	0.183	0.205	73.904	1712911	<0.001
Alabama	Vermont	0.565	0.409	0.55	0.58	157.474	1542115	<0.001
Alabama	Virginia	0.167	0.123	0.161	0.174	106.592	3047485	<0.001
Alabama	Washington	0.382	0.271	0.375	0.389	220.967	2659592	<0.001

(table continues)

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
Alabama	West Virginia	0.474	0.333	0.465	0.482	227.86	2085951	<0.001
Alabama	Wisconsin	0.306	0.22	0.299	0.313	187.046	2892954	<0.001
Alabama	Wyoming	0.31	0.226	0.293	0.328	75.175	1495937	<0.001
Alabama	Puerto Rico	0.423	0.31	0.325	0.52	18.288	1379677	<0.001
Alabama	Virgin Islands	0.383	0.281	0.186	0.58	8.228	1377040	<0.001
Alabama	Guam	0.797	0.584	0.553	1.04	13.835	1376741	<0.001
Alabama	Canada	0.064	0.047	0.029	0.099	7.727	1403801	<0.001
Alabama	Cuba	-0.1	-0.073	-0.435	0.235	-1.264	1376477	0.206
Alabama	Mexico	0.296	0.217	0.256	0.336	31.387	1397481	<0.001
Alabama	Remainder of the world	0.238	0.174	0.211	0.265	37.21	1423438	<0.001
Alaska	Arizona	-0.079	-0.062	-0.101	-0.057	-16.344	1044408	<0.001
Alaska	Arkansas	-0.162	-0.121	-0.184	-0.14	-31.764	938835	<0.001
Alaska	California	0.483	0.338	0.462	0.505	91.857	7227000	<0.001
Alaska	Colorado	0.256	0.174	0.234	0.278	45.476	850935	<0.001
Alaska	Connecticut	0.269	0.191	0.247	0.29	50.229	1064776	<0.001
Alaska	Delaware	0.204	0.143	0.179	0.229	33.39	276756	<0.001

(table continues)

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
Alaska	District of Columbia	0.128	0.09	0.104	0.152	21.68	326554	<0.001
Alaska	Florida	0.082	0.06	0.06	0.103	16.263	4452205	<0.001
Alaska	Georgia	0.119	0.086	0.097	0.141	23.039	1889679	<0.001
Alaska	Hawaii	0.513	0.313	0.489	0.538	73.994	294862	<0.001
Alaska	Idaho	0.059	0.042	0.035	0.083	10.077	347606	<0.001
Alaska	Illinois	0.081	0.059	0.06	0.103	15.967	3814216	<0.001
Alaska	Indiana	0.035	0.025	0.013	0.056	6.587	1862110	<0.001
Alaska	Iowa	0.198	0.136	0.177	0.22	36.031	1064239	<0.001
Alaska	Kansas	0.205	0.141	0.183	0.227	36.782	884791	<0.001
Alaska	Kentucky	0.01	0.007	-0.012	0.032	1.849	1335318	0.064
Alaska	Louisiana	-0.034	-0.025	-0.055	-0.012	-6.572	1399780	<0.001
Alaska	Maine	0.226	0.151	0.203	0.249	37.743	475836	<0.001
Alaska	Maryland	0.214	0.145	0.192	0.236	38.424	1404862	<0.001
Alaska	Massachusetts	-0.027	-0.021	-0.049	-0.005	-5.511	2036065	<0.001
Alaska	Michigan	0.161	0.114	0.14	0.182	30.755	2910932	<0.001
Alaska	Minnesota	0.193	0.129	0.172	0.215	34.238	1320199	<0.001

(table continues)

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
Alaska	Mississippi	0.059	0.041	0.037	0.081	10.713	971017	<0.001
Alaska	Missouri	0.149	0.105	0.128	0.171	28.181	1913276	<0.001
Alaska	Montana	-0.042	-0.03	-0.066	-0.018	-7.266	327626	<0.001
Alaska	Nebraska	0.23	0.164	0.208	0.253	42.014	604273	<0.001
Alaska	Nevada	-0.047	-0.036	-0.07	-0.023	-8.74	395305	<0.001
Alaska	New Hampshire	0.163	0.118	0.14	0.187	28.928	373748	<0.001
Alaska	New Jersey	0.205	0.141	0.184	0.226	38.081	2572737	<0.001
Alaska	New Mexico	-0.068	-0.051	-0.091	-0.045	-12.59	446171	<0.001
Alaska	New York	0.258	0.192	0.237	0.279	51.992	6107752	<0.001
Alaska	North Carolina	0.209	0.14	0.188	0.231	37.736	2076767	<0.001
Alaska	North Dakota	0.314	0.212	0.29	0.339	49.469	276200	<0.001
Alaska	Ohio	0.38	0.244	0.359	0.401	65.919	3672291	<0.001
Alaska	Oklahoma	0.07	0.051	0.048	0.092	13.469	1149150	<0.001
Alaska	Oregon	0.059	0.043	0.037	0.081	11.368	945212	<0.001
Alaska	Pennsylvania	0.2	0.137	0.179	0.222	37.285	4521149	<0.001
Alaska	Rhode Island	0.444	0.296	0.421	0.468	73.307	412462	<0.001

(table continues)

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
Alaska	South Carolina	0.088	0.062	0.066	0.11	16.455	1106819	<0.001
Alaska	South Dakota	0.185	0.127	0.16	0.209	30.083	311981	<0.001
Alaska	Tennessee	0.088	0.058	0.066	0.109	15.523	1689439	<0.001
Alaska	Texas	0.057	0.04	0.036	0.079	10.811	4394289	<0.001
Alaska	Utah	0.04	0.029	0.016	0.063	7.147	411349	<0.001
Alaska	Vermont	0.41	0.279	0.385	0.436	63.425	240553	<0.001
Alaska	Virginia	0.013	0.01	-0.009	0.035	2.532	1745923	0.011
Alaska	Washington	0.228	0.157	0.206	0.249	41.666	1358030	<0.001
Alaska	West Virginia	0.319	0.211	0.297	0.342	54.751	784389	<0.001
Alaska	Wisconsin	0.152	0.108	0.13	0.173	28.671	1591392	<0.001
Alaska	Wyoming	0.156	0.11	0.129	0.183	23.671	194375	<0.001
Alaska	Puerto Rico	0.268	0.193	0.168	0.368	11.141	78115	<0.001
Alaska	Virgin Islands	0.228	0.164	0.03	0.426	4.793	75478	<0.001
Alaska	Guam	0.642	0.461	0.398	0.887	10.894	75179	<0.001
Alaska	Canada	-0.09	-0.066	-0.131	-0.05	-9.366	102239	<0.001
Alaska	Cuba	-0.254	-0.183	-0.59	0.081	-3.152	74915	0.002
Alaska	Mexico	0.141	0.102	0.096	0.186	13.222	95919	<0.001

(table continues)

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
Alaska	Remainder of the world	0.083	0.06	0.049	0.117	10.22	121876	<0.001

* This table on multiple comparison post hoc analysis with Fisher's LSD and Cohen's d effect size for state or territory of residence is to large and may span about 70 pages. It has therefore been truncated. The full table is made available here https://goo.gl/mjMG1C.

Research Question 2. Are there variations in the number of coexisting multiple causes of death per death case in the United States from 1 year to another?

$H_0$2: There are no variations in the number of coexisting multiple causes of death in the United States from 1 year to another.

$H_1$2: There are variations in the number of coexisting multiple causes of death in the United States from 1 year to another.

Results for Research Question 2.

Hypothesis testing. The null hypothesis that there are no variations in the number of coexisting multiple causes of death in the United States from 1 year to another has been tested using multiple linear regression modelling (which allowed for the simultaneous control of the effects of the other factors on the dependent variable). The year of death (which is an ordinal variable) is represented using dummy coding, and the year 2004 is treated as the reference category such that every other year is compared to the year 2004. The regression model is statistically significant and the year of death is

statistically significant in the model ($p < 0.05$, Table 7, Table A1). Therefore, the second null hypothesis is rejected and the alternative hypothesis that there are variations in the number of coexisting multiple causes of death in the United States from year to year within the study period is accepted.

Regression coefficients and confidence intervals. The regression coefficients, *B*, shown in the table indicates how each of the year of death compares to the year 2004. For example, a regression coefficient of 0.0901 (with a 95% C. I. of (0.081, 0.099)) for the year 1989 indicates that the average number of coexisting MCOD in the year 1989 is statistically higher ($p < 0.001$) than that of the year 2004 but only by about 0.1 (Table 7). On the other hand, a regression coefficient of -0.0861 with a 95% C. I. of (-0.095, -0.077)) for the year 1999 indicates that the average number of coexisting MCOD in the year 1999 is statistically lower ($p < 0.001$) than that of the year 2004 but only by about 0.1 (Table 7). The $p = 0.140$ for the year 1993 shows that that average number of coexisting MCOD in the year 1993 is not statistically ($p = 0.140$) different from that of the year 2004. A more detailed comparison of each of the years 1989 through 2003 against the year 2004 are shown in Table 7.

Effect size and post hoc analyses. Multiple comparison post hoc analysis were carried out with Fisher's LSD, and Cohen's *d* was used as a measure of effect size for the difference between each pair of years. The results of the multiple comparison post hoc analysis and the effect size are presented in Table 8. The average number of coexisting MCOD are statistically different ($p < 0.001$) for virtually all the pairs of years of death except for a few pairs of years of death such as the year 1992 vs the year 2003 ($p = 0.039$), the year 1993 vs the year 2000 ($p = 0.991$), etc. (Table 8, Table A2). The

statistical difference ($p < 0.001$) in the average number of coexisting MCOD for virtually all the pairs of years of death observed from the Fisher's LSD post hoc analysis is consistent with the distribution of the average number of coexisting MCOD presented in Figure 2 under the descriptive statistics subsection.

It is also worthy of note that statistical significance of most of the pairwise comparison in Fisher's LSD post hoc analysis can be attributed to the very high power of the statistical test resulting from the very large value of N (since N is in millions in this study). Therefore, even though, the multiple comparison results show statistically significant difference between each pair of the years of death, the effect size are small (about 0.1 or less) in most of the cases (Table 8, Table A2, Cohen, 1988, 1992; Kelley & Preacher, 2012; Sawilowsky, 2009).

Table 7

*The Regression Coefficients for the Year of Death Extracted from the Full Regression Model**

			95% C. I. of B			
Year of Death**	*B*	*SE of B*	*LB*	*UB*	*t*	*p*
Year 1989	0.0901	0.005	0.081	0.099	18.92	<0.001
Year 1990	0.064	0.005	0.055	0.073	13.43	<0.001
Year 1991	0.0375	0.005	0.028	0.047	7.906	<0.001
Year 1992	0.0217	0.005	0.012	0.031	4.581	<0.001
Year 1993	-0.0069	0.005	-0.016	0.002	-1.48	0.140
Year 1994	-0.0138	0.005	-0.023	-0.005	-2.95	0.003
Year 1995	-0.0259	0.005	-0.035	-0.017	-5.54	<0.001
Year 1996	-0.0232	0.005	-0.032	-0.014	-4.96	<0.001
Year 1997	-0.0239	0.005	-0.033	-0.015	-5.11	<0.001
Year 1998	-0.0203	0.005	-0.029	-0.011	-4.34	<0.001
Year 1999	-0.0861	0.005	-0.095	-0.077	-18.5	<0.001
Year 2000	-0.0145	0.005	-0.024	-0.005	-3.13	0.002
Year 2001	-0.0128	0.005	-0.022	-0.004	-2.75	0.006
Year 2002	-0.0053	0.005	-0.014	0.004	-1.14	0.255
Year 2003	-0.008	0.005	-0.017	0.001	-1.66	0.097

* The dependent variable is the number of coexisting MCOD. The full regression model has independent variables that include the year of death, the place of residence, education level, race, gender, age, and marital status. The full regression model is statistically significant ($p < 0.001$, see Table A1), and has a small effect size based on the coefficient of determination of 0.022.

** The Year of Death is a categorical variable and is represented using dummy coding. The year 2004 is the reference category so it does not explicitly appear in the table as every other year is compared to it.

Table 8

The Multiple Comparison Post hoc Analysis with Fisher's LSD and Cohen's d Effect Size for Year of Death

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
Yr 1989	Yr 1990	-0.023	-0.016	-0.028	-0.018	-16.57	4305747	<0.001
Yr 1989	Yr 1991	-0.046	-0.032	-0.051	-0.04	-33.103	4326917	<0.001
Yr 1989	Yr 1992	-0.062	-0.043	-0.067	-0.056	-44.772	4333044	<0.001
Yr 1989	Yr 1993	-0.089	-0.062	-0.094	-0.083	-64.999	4425804	<0.001
Yr 1989	Yr 1994	-0.093	-0.064	-0.099	-0.088	-68.245	4436145	<0.001
Yr 1989	Yr 1995	-0.104	-0.072	-0.109	-0.099	-76.309	4469108	<0.001
Yr 1989	Yr 1996	-0.107	-0.074	-0.112	-0.102	-78.088	4472069	<0.001
Yr 1989	Yr 1997	-0.097	-0.067	-0.102	-0.092	-70.497	4471443	<0.001
Yr 1989	Yr 1998	-0.097	-0.067	-0.102	-0.092	-70.754	4494565	<0.001
Yr 1989	Yr 1999	-0.159	-0.109	-0.164	-0.154	-116.028	4548727	<0.001
Yr 1989	Yr 2000	-0.089	-0.06	-0.094	-0.083	-63.471	4561050	<0.001
Yr 1989	Yr 2001	-0.087	-0.058	-0.092	-0.081	-61.842	4573817	<0.001
Yr 1989	Yr 2002	-0.079	-0.052	-0.084	-0.074	-56.23	4600653	<0.001

(table continues)

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
Yr 1989	Yr 2003	-0.059	-0.039	-0.064	-0.054	-41.677	4606011	<0.001
Yr 1989	Yr 2004	-0.034	-0.022	-0.039	-0.029	-23.874	4555257	<0.001
Yr 1990	Yr 1991	-0.023	-0.016	-0.028	-0.017	-16.48	4324948	<0.001
Yr 1990	Yr 1992	-0.039	-0.027	-0.044	-0.034	-28.165	4331075	<0.001
Yr 1990	Yr 1993	-0.066	-0.046	-0.071	-0.061	-48.199	4423835	<0.001
Yr 1990	Yr 1994	-0.071	-0.049	-0.076	-0.065	-51.514	4434176	<0.001
Yr 1990	Yr 1995	-0.081	-0.056	-0.087	-0.076	-59.536	4467139	<0.001
Yr 1990	Yr 1996	-0.084	-0.058	-0.089	-0.079	-61.348	4470100	<0.001
Yr 1990	Yr 1997	-0.074	-0.051	-0.079	-0.069	-53.831	4469474	<0.001
Yr 1990	Yr 1998	-0.074	-0.051	-0.08	-0.069	-54.079	4492596	<0.001
Yr 1990	Yr 1999	-0.136	-0.093	-0.141	-0.131	-99.273	4546758	<0.001
Yr 1990	Yr 2000	-0.066	-0.044	-0.071	-0.061	-47.061	4559081	<0.001
Yr 1990	Yr 2001	-0.064	-0.043	-0.069	-0.059	-45.472	4571848	<0.001
Yr 1990	Yr 2002	-0.056	-0.037	-0.061	-0.051	-39.932	4598684	<0.001
Yr 1990	Yr 2003	-0.036	-0.024	-0.041	-0.031	-25.451	4604042	<0.001
Yr 1990	Yr 2004	-0.011	-0.007	-0.016	-0.006	-7.818	4553288	<0.001

(table continues)

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
Yr 1991	Yr 1992	-0.016	-0.011	-0.021	-0.011	-11.737	4352245	<0.001
Yr 1991	Yr 1993	-0.043	-0.03	-0.048	-0.038	-31.645	4445005	<0.001
Yr 1991	Yr 1994	-0.048	-0.033	-0.053	-0.043	-35.041	4455346	<0.001
Yr 1991	Yr 1995	-0.059	-0.041	-0.064	-0.053	-43.047	4488309	<0.001
Yr 1991	Yr 1996	-0.061	-0.042	-0.066	-0.056	-44.898	4491270	<0.001
Yr 1991	Yr 1997	-0.051	-0.035	-0.057	-0.046	-37.431	4490644	<0.001
Yr 1991	Yr 1998	-0.052	-0.036	-0.057	-0.046	-37.671	4513766	<0.001
Yr 1991	Yr 1999	-0.113	-0.078	-0.118	-0.108	-82.939	4567928	<0.001
Yr 1991	Yr 2000	-0.043	-0.029	-0.048	-0.038	-30.899	4580251	<0.001
Yr 1991	Yr 2001	-0.041	-0.027	-0.046	-0.036	-29.344	4593018	<0.001
Yr 1991	Yr 2002	-0.033	-0.022	-0.039	-0.028	-23.859	4619854	<0.001
Yr 1991	Yr 2003	-0.013	-0.009	-0.018	-0.008	-9.4	4625212	<0.001
Yr 1991	Yr 2004	0.012	0.008	0.006	0.017	8.127	4574458	<0.001
Yr 1992	Yr 1993	-0.027	-0.019	-0.032	-0.022	-19.756	4451132	<0.001
Yr 1992	Yr 1994	-0.032	-0.022	-0.037	-0.026	-23.198	4461473	<0.001
Yr 1992	Yr 1995	-0.042	-0.029	-0.048	-0.037	-31.168	4494436	<0.001

(table continues)

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
Yr 1992	Yr 1996	-0.045	-0.031	-0.05	-0.04	-33.042	4497397	<0.001
Yr 1992	Yr 1997	-0.035	-0.024	-0.04	-0.03	-25.633	4496771	<0.001
Yr 1992	Yr 1998	-0.035	-0.024	-0.041	-0.03	-25.868	4519893	<0.001
Yr 1992	Yr 1999	-0.097	-0.067	-0.102	-0.092	-71.048	4574055	<0.001
Yr 1992	Yr 2000	-0.027	-0.018	-0.032	-0.022	-19.29	4586378	<0.001
Yr 1992	Yr 2001	-0.025	-0.017	-0.03	-0.02	-17.765	4599145	<0.001
Yr 1992	Yr 2002	-0.017	-0.011	-0.022	-0.012	-12.334	4625981	<0.001
Yr 1992	Yr 2003	0.003	0.002	-0.002	0.008	2.066	4631339	0.039
Yr 1992	Yr 2004	0.028	0.018	0.023	0.033	19.465	4580585	<0.001
Yr 1993	Yr 1994	-0.005	-0.003	-0.01	0	-3.565	4554233	<0.001
Yr 1993	Yr 1995	-0.016	-0.011	-0.021	-0.01	-11.58	4587196	<0.001
Yr 1993	Yr 1996	-0.018	-0.012	-0.023	-0.013	-13.517	4590157	<0.001
Yr 1993	Yr 1997	-0.008	-0.006	-0.013	-0.003	-6.107	4589531	<0.001
Yr 1993	Yr 1998	-0.009	-0.006	-0.014	-0.003	-6.334	4612653	<0.001
Yr 1993	Yr 1999	-0.07	-0.048	-0.075	-0.065	-51.978	4666815	<0.001
Yr 1993	Yr 2000	0	0	-0.005	0.005	0.011	4679138	0.991

(table continues)

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
Yr 1993	Yr 2001	0.002	0.001	-0.003	0.007	1.509	4691905	0.131
Yr 1993	Yr 2002	0.01	0.007	0.005	0.015	6.925	4718741	<0.001
Yr 1993	Yr 2003	0.03	0.02	0.025	0.035	21.429	4724099	<0.001
Yr 1993	Yr 2004	0.055	0.036	0.049	0.06	38.855	4673345	<0.001
Yr 1994	Yr 1995	-0.011	-0.008	-0.016	-0.006	-7.975	4597537	<0.001
Yr 1994	Yr 1996	-0.013	-0.009	-0.019	-0.008	-9.911	4600498	<0.001
Yr 1994	Yr 1997	-0.003	-0.002	-0.009	0.002	-2.545	4599872	0.011
Yr 1994	Yr 1998	-0.004	-0.003	-0.009	0.001	-2.769	4622994	0.006
Yr 1994	Yr 1999	-0.065	-0.044	-0.07	-0.06	-48.231	4677156	<0.001
Yr 1994	Yr 2000	0.005	0.003	0	0.01	3.499	4689479	<0.001
Yr 1994	Yr 2001	0.007	0.005	0.002	0.012	4.984	4702246	<0.001
Yr 1994	Yr 2002	0.014	0.009	0.009	0.019	10.369	4729082	<0.001
Yr 1994	Yr 2003	0.035	0.023	0.03	0.04	24.812	4734440	<0.001
Yr 1994	Yr 2004	0.059	0.039	0.054	0.065	42.148	4683686	<0.001
Yr 1995	Yr 1996	-0.003	-0.002	-0.008	0.002	-1.957	4633461	0.05
Yr 1995	Yr 1997	0.007	0.005	0.002	0.012	5.396	4632835	<0.001

(table continues)

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
Yr 1995	Yr 1998	0.007	0.005	0.002	0.012	5.177	4655957	<0.001
Yr 1995	Yr 1999	-0.054	-0.037	-0.06	-0.049	-40.377	4710119	<0.001
Yr 1995	Yr 2000	0.016	0.011	0.011	0.021	11.347	4722442	<0.001
Yr 1995	Yr 2001	0.018	0.012	0.013	0.023	12.819	4735209	<0.001
Yr 1995	Yr 2002	0.025	0.017	0.02	0.03	18.19	4762045	<0.001
Yr 1995	Yr 2003	0.045	0.03	0.04	0.05	32.648	4767403	<0.001
Yr 1995	Yr 2004	0.07	0.046	0.065	0.075	49.959	4716649	<0.001
Yr 1996	Yr 1997	0.01	0.007	0.005	0.015	7.33	4635796	<0.001
Yr 1996	Yr 1998	0.01	0.007	0.005	0.015	7.114	4658918	<0.001
Yr 1996	Yr 1999	-0.052	-0.035	-0.057	-0.047	-38.349	4713080	<0.001
Yr 1996	Yr 2000	0.018	0.012	0.013	0.023	13.246	4725403	<0.001
Yr 1996	Yr 2001	0.02	0.013	0.015	0.025	14.711	4738170	<0.001
Yr 1996	Yr 2002	0.028	0.019	0.023	0.033	20.067	4765006	<0.001
Yr 1996	Yr 2003	0.048	0.032	0.043	0.053	34.494	4770364	<0.001
Yr 1996	Yr 2004	0.073	0.048	0.068	0.078	51.758	4719610	<0.001
Yr 1997	Yr 1998	0	0	-0.005	0.005	-0.221	4658292	0.825

(table continues)

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
Yr 1997	Yr 1999	-0.062	-0.042	-0.067	-0.057	-45.534	4712454	<0.001
Yr 1997	Yr 2000	0.008	0.005	0.003	0.013	5.993	4724777	<0.001
Yr 1997	Yr 2001	0.01	0.007	0.005	0.015	7.469	4737544	<0.001
Yr 1997	Yr 2002	0.018	0.012	0.013	0.023	12.833	4764380	<0.001
Yr 1997	Yr 2003	0.038	0.025	0.033	0.043	27.236	4769738	<0.001
Yr 1997	Yr 2004	0.063	0.041	0.058	0.068	44.508	4718984	<0.001
Yr 1998	Yr 1999	-0.061	-0.041	-0.067	-0.056	-45.35	4735576	<0.001
Yr 1998	Yr 2000	0.009	0.006	0.004	0.014	6.218	4747899	<0.001
Yr 1998	Yr 2001	0.011	0.007	0.006	0.016	7.695	4760666	<0.001
Yr 1998	Yr 2002	0.018	0.012	0.013	0.023	13.065	4787502	<0.001
Yr 1998	Yr 2003	0.038	0.025	0.033	0.043	27.485	4792860	<0.001
Yr 1998	Yr 2004	0.063	0.041	0.058	0.068	44.775	4742106	<0.001
Yr 1999	Yr 2000	0.07	0.046	0.065	0.075	50.976	4802061	<0.001
Yr 1999	Yr 2001	0.072	0.048	0.067	0.077	52.369	4814828	<0.001
Yr 1999	Yr 2002	0.08	0.053	0.075	0.085	57.604	4841664	<0.001
Yr 1999	Yr 2003	0.1	0.065	0.095	0.105	71.927	4847022	<0.001

(table continues)

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
Yr 1999	Yr 2004	0.125	0.081	0.12	0.13	88.857	4796268	<0.001
Yr 2000	Yr 2001	0.002	0.001	-0.003	0.007	1.472	4827151	0.141
Yr 2000	Yr 2002	0.01	0.006	0.005	0.015	6.802	4853987	<0.001
Yr 2000	Yr 2003	0.03	0.019	0.025	0.035	21.08	4859345	<0.001
Yr 2000	Yr 2004	0.055	0.035	0.05	0.06	38.232	4808591	<0.001
Yr 2001	Yr 2002	0.008	0.005	0.003	0.013	5.325	4866754	<0.001
Yr 2001	Yr 2003	0.028	0.018	0.023	0.033	19.585	4872112	<0.001
Yr 2001	Yr 2004	0.053	0.034	0.047	0.058	36.723	4821358	<0.001
Yr 2002	Yr 2003	0.02	0.013	0.015	0.025	14.237	4898948	<0.001
Yr 2002	Yr 2004	0.045	0.028	0.04	0.05	31.377	4848194	<0.001
Yr 2003	Yr 2004	0.025	0.016	0.02	0.03	17.224	4853552	<0.001

Research Question 3. Is there any relationship between the number of coexisting multiple causes of death per death case and race in the United States?

$H_0$3: There is no relationship between the number of coexisting multiple causes of death and race in the United States.

$H_1$3: There is a relationship the number of coexisting multiple causes of death and race in the United States.

Results for Research Question 3.

Hypothesis testing. The third null hypothesis that there is no relationship between the number of coexisting multiple causes of death and race in the United States has also been tested using multiple linear regression modelling (which allowed for the simultaneous control of the effects of other factors on the dependent variable). Race (which is a categorical variable) is represented using dummy coding, and the White race is treated as the reference category such that every other race is compared to the White. The multiple linear regression model is statistically significant and race is statistically significant in the model ($p < 0.05$, Table 9, Table A1). Therefore, the third null hypothesis is also rejected and the alternative hypothesis that there is a relationship between the number of coexisting multiple causes of death and race in the United States is accepted.

Regression coefficients and confidence intervals. The regression coefficients, *B*, shown in the table indicates how each of the races compares to the White. A regression coefficient of 0.0403 (with a 95% C. I. of (0.035, 0.045)) for the Black race indicates that the average number of coexisting MCOD for the African Americans is statistically ($p < 0.001$) higher than that of the White but only by about 0.04 units (Table 5). In a similar

way, a regression coefficient of 0.0628 (with a 95% C. I. of (0.05, 0.075)) for the other races indicates that the average number of coexisting MCOD for the races other than White and Black is statistically ($p < 0.001$) higher than that of the White but only by about 0.06 units (Table 9).

Effect size and post hoc analyses. Multiple comparison post hoc analysis were carried out with Fisher's LSD, and Cohen's *d* was used as a measure of effect size for the difference between each pair of groups. The results of the multiple comparison post hoc analysis and the effect size are presented in Table 10. The average number of coexisting MCOD are statistically different ($p < 0.001$) for all the pairs of races (Table 10). The statistical difference ($p < 0.001$) in the average number of coexisting MCOD for all the pairs of races observed from the Fisher's LSD post hoc analysis is consistent with the distribution of the average number of coexisting MCOD presented in Figure 4 under the descriptive statistics subsection. Furthermore, it is worthy of note that (even though all the pairwise comparison in Fisher's LSD post hoc analysis are statistical significance, $p < 0.001$) the effect size is small (Table 10, Cohen, 1988, 1992; Kelley & Preacher, 2012; Sawilowsky, 2009).

Table 9

*The Regression Coefficients for Race Extracted from the Full Regression Model**

			95% C. I. of B			
Race**	*B*	*SE of B*	*LB*	*UB*	*t*	*p*
Black	0.0403	0.002	0.035	0.045	16.16	<0.001
Other Races	0.0628	0.006	0.05	0.075	9.774	<0.001

* The dependent variable is the number of coexisting MCOD. The full regression model has independent variables that include the year of death, the place of residence, education level, race, gender, age, and marital status. The full regression model is statistically significant ($p < 0.001$, see Table A1), and has a small effect size based on the coefficient of determination of 0.022.

** Race is a categorical variable and is represented using dummy coding. White is the reference category so it does not explicitly appear in the table as the other races are compared to it.

Table 10

The Multiple Comparison Post hoc Analysis with Fisher's LSD and Cohen's d Effect Size for Races

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	95% C. I. of *MD* *LB*	*UB*	*t*	*df*	*p*
White	Black	-0.078	-0.054	-0.079	-0.077	-155.846	77097545	<0.001
White	Other Races	0.138	0.096	0.135	0.141	98.907	68867462	<0.001
Black	Other Races	0.216	0.149	0.213	0.22	145.891	10365841	<0.001

Research Question 4. Is there any relationship between the number of coexisting multiple causes of death per death case and education level in the United States?

$H_0$4: There is no relationship between the number of coexisting multiple causes of death and education level in the United States.

$H_1$4: There is a relationship between the number of coexisting multiple causes of death and education level in the United States.

Results for Research Question 4.

Hypothesis testing. The fourth null hypothesis that there is no relationship between the number of coexisting multiple causes of death and education level in the United States has also been tested using multiple linear regression modelling. The education level (which is the number of years of formal education completed) is treated

as a continuous variable for the regression modelling. The model is statistically significant and the education level is statistically significant in the model ($p < 0.05$, Table 11, Table A1). Therefore, the null hypothesis is rejected and the alternative hypothesis that there is a relationship between the number of coexisting multiple causes of death and education level in the United States is accepted.

Regression coefficients and confidence intervals. The regression coefficients, *B*, shown in the table indicates how every unit increase in the number of years of formal education completed influences the average number of coexisting MCOD (Table 11). More specifically, a regression coefficient of -0.0089 (with a 95% C. I. of (-0.009, -0.008)) for the number of years of formal education completed indicates that for every unit increase in the number of years of formal education completed, the average number of coexisting MCOD reduces by approximately 0.01 unit (Table 11). Although, the number of years of formal education completed is statistically significant ($p < 0.001$) in the model and has an effect on the number of coexisting MCOD, the effect size (approximately 0.01) is small.

Table 11

*The Regression Coefficients for the States of Residence Extracted from the Full Regression Model**

			95% C. I. of B			
Variable	*B*	*SE of B*	*LB*	*UB*	*t*	*p*
Number of Years of Formal Education	-0.0089	~=0.000	-0.009	-0.008	-41.7	<0.001

* The dependent variable is the number of coexisting MCOD. The full regression model has independent variables that include the year of death, the place of residence, education level, race, gender, age, and marital status. The full regression model is statistically significant ($p < 0.001$, see Table A1), and has a small effect size based on the coefficient of determination of 0.022.

The Potential confounders controlled for in the regression model. While testing the hypotheses and assessing the effects of the four main independent variables of interest (namely, year of death, place of residence, race, number of years of formal education completed) on the dependent variable of interest (namely, the number of coexisting MCOD), it was necessary to control for the potential effects of other variables (which may be potential confounders). For this purpose, age (measured in years), gender (limited to male and female) and marital status were included in the model and their effects on the dependent variables were assessed.

Age. The age (which is the number of years the person lived) is treated as a continuous variable for the regression modelling. The age is statistically significant in the model ($p < 0.001$, Table 12, Table A1). A regression coefficient of 0.0056 for age indicates that for every unit increase in age, the average number of coexisting MCOD increases by approximately 0.01 unit (Table 12). Although, age is statistically significant

($p < 0.001$) in the model and has an effect on the number of coexisting MCOD, the effect size (approximately 0.01) is small.

Gender. Gender (which is treated as a categorical variable) is represented using dummy coding, and male serves as the reference category such that female is compared to male. The gender variable is statistically significant in the model ($p < 0.001$, Table 12, Table A1). A regression coefficient of 0.0037 (with a *95% C. I.* of (0.04, 0.034)) for female indicates that the average number of coexisting MCOD for the females is statistically ($p < 0.001$) higher than that of the males but only by about 0.04 (Table 12) representing a small effect size.

Marital status. The marital status (which is a categorical variable) is represented using dummy coding, and *Single, Never Married* is treated as the reference category such that every other marital status is compared to the *Single, Never Married* group. The marital status variable is statistically significant in the model ($p < 0.05$, Table 12, Table A1). The regression coefficients, *B*, shown in the table indicates how each of the marital statuses compares to the *Single, Never Married* group. For example, a regression coefficient of 0.0482 (with a 95% C. I. of (0.043, 0.054)) for married indicates that the average number of coexisting MCOD for the married people is statistically ($p < 0.001$) higher than that of the *Single, Never Married* people but only by about 0.05 (Table 12). In a similar way, a regression coefficient of 0.0526 (with a 95% C. I. of (0.049, 0.057)) for the state of widowed indicates that the average number of coexisting MCOD for the widowed is statistically ($p < 0.001$) higher than that for the *Single, Never Married* individuals but only by about 0.05 (Table 12).

The results of the multiple comparison post hoc analysis and the effect size for marital status (Table 13) show that the average number of coexisting MCOD are statistically different ($p < 0.001$) for all the pairs of marital status. It is also worthy of note that statistical significance of most of the pairwise comparison in Fisher's LSD post hoc analysis can be attributed to the very high power of the statistical test resulting from the very large value of N (since N is in millions in this study). Even though, the multiple comparison results show statistically significant difference between each pair of marital status, the effect size are small (i.e. just approximately 0.1) in most cases and are sometimes even smaller (Table 13, Cohen, 1988, 1992; Kelley & Preacher, 2012; Sawilowsky, 2009).

Table 12

*The Regression Coefficients for the Potential Confounders Extracted from the Full Regression Model**

Variables	*B*	*SE of B*	*95% C. I. of B* *LB*	*UB*	*t*	*p*
Intercept	2.3971	0.009	2.379	2.415	257.2	<0.001
Age in Years	0.0056	5E-05	0.006	0.006	119.7	<0.001
Gender**						
Female	0.037	0.002	0.04	0.034	21.8	<0.001
Marital Status***						
Married	0.0482	0.003	0.043	0.054	17.39	<0.001
Widowed	0.0526	0.002	0.049	0.057	26.36	<0.001
Divorced	0.0225	0.003	0.017	0.028	8.06	<0.001
Marital Status Unknown	-0.053	0.012	-0.076	-0.03	-4.55	<0.001

* The dependent variable is the number of coexisting MCOD. The full regression model has independent variables that include the year of death, the place of residence, education level, race, gender, age, and marital status. The full regression model is statistically significant ($p < 0.001$, see Table A1), and has a small effect size based on the coefficient of determination of 0.022.
** Gender is a categorical variable and is represented using dummy coding. Male is the reference category so it does not explicitly appear in the table as female is compared to it.
*** Marital Status is a categorical variable and is represented using dummy coding. "Single, Never Married" is the reference category so it does not explicitly appear in the table as other marital status are compared to it.

Table 13

The Multiple Comparison Post hoc Analysis with Fisher's LSD and Cohen's d Effect Size for Marital Status

Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), M*D*	Cohen's *d*	*95% C. I. of MD* *LB*	*UB*	*t*	*df*	*p*
SNM*	Married	0.043	0.03	0.041	0.045	69.591	31307064	<0.001
SNM*	Widowed	0.149	0.102	0.147	0.151	235.839	28303835	<0.001
SNM*	Divorced	0.03	0.021	0.028	0.032	35.906	12361072	<0.001
SNM*	MSU**	-0.027	-0.019	-0.034	-0.019	-9.971	7455397	<0.001
Married	Widowed	0.106	0.072	0.105	0.107	242.708	45277007	<0.001
Married	Divorced	-0.013	-0.009	-0.015	-0.011	-18.384	29334244	<0.001
Married	MSU**	-0.07	-0.048	-0.077	-0.062	-25.546	24428569	<0.001
Widowed	Divorced	-0.119	-0.081	-0.121	-0.117	-164.621	26331015	<0.001
Widowed	MSU**	-0.176	-0.119	-0.183	-0.168	-63.598	21425340	<0.001
Divorced	MSU**	-0.057	-0.039	-0.064	-0.049	-20.061	5482577	<0.001

*SNM = Single, Never Married; **MSU = Marital Status Unknown

Summary

The natures and the distributions of the approximately 80 million death cases analysed have been presented using the appropriate numerical and graphical descriptive statistics techniques. The inferential statistics for testing the hypotheses have also been presented, and the research questions posed have been answered. The results for the first research question shows that there is a statistically significant relationship between the number of coexisting multiple causes of death and the state or territory of residence in the

United States. In a similar way, the results from the test of hypothesis for the second research question shows that there are statistically significant variations in the number of coexisting multiple causes of death in the United States from year to year within the study period. The test of the null hypothesis for the third research question reveals that there is a statistically significant relationship between the number of coexisting multiple causes of death and race in the United States. And the results for the fourth research question shows a statistically significant relationship between the number of coexisting multiple causes of death and the number of year of formal education completed. Overall, the state or territory of residence, the race, the year of death, the number of year of formal education completed, as well as age, gender, and marital status influence the average number of coexisting MCOD in the United States.

In the next chapter, Chapter 5, I will present some additional interpretation of the findings of this study, the limitations of the study, some recommendations, and some implications for positive social change. I will also present methodological and theoretical implications of the study. Some recommendations for practice will also be presented.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The study and practice of epidemiology and public health benefit from mortality statistics, such as mortality rates, which are frequently used as key health indicators (Dwyer-Lindgren et al., 2016; Mackenbach et al., 2015; Nordentoft et al., 2013; Smith et al., 2014; Weber et al., 2013). Furthermore, MCOD data offer important information that could not possibly be gathered from other mortality data (T.-H. Lu & Lin, 2010; Redelings et al., 2006). The considerable underutilization of MCOD, despite the fact that the National Center for Health Statistics uses a lot of resources to routinely collect MCOD data (U.S. Department of Health and Human Services, 2009a, 2009b, 2009c, 2009d, 2009e) has been shown to be an issue and has created a knowledge gap in this area of epidemiology. Designed for the purpose of quantitatively examining the factors, such as place of residence, race, etc., that influence the number of MCOD that coexist, the results of this study have helped in slightly reducing the knowledge gap and adding to the utilization of the MCOD data.

In this quantitative study, I used numerical and statistical techniques to analyze the coexistence of causes of death in approximately 80 million death cases across the states and territories of the United States from the year 1959 to 2005. I explored the nature of the coexistence of MCOD. This made it possible to answer four research questions in addition to providing graphical descriptive statistics for the mortality dataset.

The findings of this study have shown that there is a statistically significant relationship between the number of coexisting MCOD and the state or territory of residence in the United States. In a similar way, there are statistically significant

variations in the number of coexisting MCOD in the United States from year to year, at least within the study period. Furthermore, there is a statistically significant relationship between the number of coexisting MCOD and race in the United States. In addition, a statistically significant relationship exists between the number of coexisting MCOD and the number of years of formal education completed. Moreover, age, gender, and marital status have statistically significant influences on the average number of coexisting MCOD in the United States. In this chapter, I will present some additional interpretations of the findings of the study in comparison to the findings of previous studies, the limitations of the study, recommendations for further research, the implications for positive social change, and methodological and empirical implications of the study as well as implications for research.

Interpretation of the Findings

State or Territory of Residence Affects the Number of Coexisting MCOD

The results of this study showed that the state or territory of residence influences the number of coexisting MCOD to a statistically significant degree (see Table 5). This findings is in line with the findings of previous studies, which consistently showed that the place of residence has effects on individuals' wellbeing, morbidity, and mortality (Foreman et al., 2017; Martins-Melo et al., 2015, 2016; Meyers et al., 2014; Zhao et al., 2017). In their study of the trends and spatial clusters of HIV and HCV from the year 2002 to 2011 in Massachusetts using multiple cause of death data, Meyers et al. (2014) showed that HIV and HCV disease burdens and mortalities are not uniform across all places of residence, suggesting that there is a relationship between place of residences

and morbidity and mortality. Martins-Melo et al. (2015) also showed that mortality from schistosomiasis varies across places of residence and across time.

The effect of place of residence on mortality statistics that I observed in this study is not specific to the United States alone. In fact, previous research studies conducted in other countries have also shown the ability of place of residence to influence the health and mortality. A study conducted in Shanghai, China and Hong Kong showed that the place of residence does affect the risk of death from various possible causes (Zhao et al., 2017). In a similar way, Gordon et al. (2017) showed that mortality and causes of death varied in Israel across regions and places of residence. Furthermore, in a separate and independent study conducted in Brazil, the researchers found that spatial patterns exist in the mortality from the neglected tropical diseases in Brazil, meaning that mortality from the neglected tropical diseases varied across various places of residence (Martins-Melo et al., 2016).

Variations in the Number of Coexisting MCOD from Year to Year

The findings of this study showed that there are variations in the number of coexisting MCOD in the United States from year to year within the study period (see Table 7). This is not an isolated observation in regards to temporal variations in mortality-related statistics because other previous studies have also indicated the possibility of temporal variations in mortality statistics. In their work, Martins-Melo et al. (2015) showed that schistosomiasis-related deaths were not constant over time. The findings of this study that the number of coexisting MCOD varies over the years is also in line with findings from other researchers who have shown the rising trend of cause-specific mortality in the United States (Ly et al., 2016); the trend of visceral leishmaniasis

in Brazil (Martins-Melo et al., 2014); non-AIDS cancer mortality in San Francisco, California (Hessol, Ma, et al., 2018); maternal mortality in the United States (Joseph et al., 2017); and excess mortality in Northern Italy (Fedeli et al., 2017).

Relationship Between Race and the Number of Coexisting MCOD

The findings of this study showed that there is a relationship between the number of coexisting MCOD and race in the United States (see Table 9). This is consistent with the findings of previous studies on the effects of race on health and longevity and sickness and mortality (Beydoun et al., 2016; Curtin & Hoyert, 2017; Garcia-Alexander & Woo, 2015; Yu et al., 2017). Previous research studies have also established racial disparities in various mortality measures including the crude mortality rate and the cause-specific mortality rates (Beydoun et al., 2016; Curtin & Hoyert, 2017; Garcia-Alexander & Woo, 2015; Yu et al., 2017), such as maternal mortality as well as maternal morbidity (Curtin & Hoyert, 2017) and infant mortality (Garcia-Alexander & Woo, 2015). Furthermore, a nationwide study of cause-specific mortality among the patients who required maintenance dialysis in the United States showed that there is racial disparity in the risk of mortality from infection that is not related to their dialysis (Yu et al., 2017). In addition, Beydounet al. (2016) found that race does directly and indirectly, through mediating and moderating factors, influence all-cause and cause-specific mortality among adults in the United States. The findings of this study and the evidence from previous studies consistently suggests that race affects health outcomes and mortality.

Higher Education Attainment Reduces the Average Number of MCOD That Coexist

The findings of this study showed that there is a relationship between the number of coexisting MCOD and education level in the United States. A regression coefficient of

-0.0089 (with a 95% CI of [-0.009, -0.008]) for the number of years of formal education completed indicates that for every unit increase in the number of years of formal education completed, the average number of coexisting MCOD reduces by approximately 0.01 unit (see Table 11). This is in agreement with the findings of previous studies on the protective nature of having higher educational attainment, wherein the researchers suggested the importance of education level in individuals' wellbeing, health, sickness, other aspects of life, longevity, and death (Benito-León et al., 2016; Fedeli, Avossa, et al., 2015; Kulhánová et al., 2014; Mackenbach et al., 2015). Kulhánová et al. (2014) also showed how educational inequalities affect mortality by cause of death in the Netherlands. Sasson (2016) reported that differences in educational attainment introduced diverging trends in cause-specific mortality and the number of life years lost. In similar ways, Schiltz et al. (2018) found that cognitive impairment, which is related to influence educational attainment, has a statistically significant effect on the leading causes of death, and Calvin et al. (2017), through their 68-year, prospective, population study, indicated that childhood intelligence, which influences educational attainment, affects the major causes of death.

While assessing the effects of year of death, place of residence, race, number of years of formal education completed (which are the four main independent variables of interest) on the number of coexisting MCOD (which is the dependent variable), it was necessary to control for the potential effects of potential confounders. For this purpose, age (measured in years), gender (limited to male and female) and marital status were included in the model. This made it possible to assess their effects on the dependent variable.

Relationship Between Age and the Number of Coexisting MCOD

The results of this study show that age has a statistically significant ($p < 0.001$) effect on the number of MCOD that coexist (Table 12) and has a regression coefficient of 0.0056 such that for age indicates that for every unit increase in age, the average number of coexisting MCOD increases by approximately 0.01 unit (Table 12). Various previous research have also shown that health outcomes, morbidity, and mortality are affected by age (Gabet et al., 2016; MacDorman et al., 2017a; Orosco et al., 2015; Taneja et al., 2016; Tate et al., 2016). MacDorman, Declercq, and Thoma (2017b) showed that maternal mortality is significantly affected by maternal age, while Taneja et al. (2016) showed that dynamic relationships exist between age and health defects and between age and mortality , and Orosco et al. (2015) have shown that thyroid cancer-specific mortality is influenced by age.

Relationship Between Gender and the Number of Coexisting MCOD

A statistically significant ($p < 0.001$) relationship exists between gender and the number of MCOD that coexist (Table 12) such that females, on the average, have a statistically ($p < 0.001$) higher number of coexisting MCOD than their male counterparts. This is consistent with the findings of other previous research studies on mortality. While studying HIV/AIDS in San Francisco and the death that result from HIV/AIDS, researchers found the existence of gender differences in causes of death among the people with HIV/AIDS (Hessol, Schwarcz, et al., 2018). I also been previously shown that gender influences COPD-related mortality (Ni & Xu, 2016), life expectancy in the United States (Acciai & Firebaugh, 2017), mortalities from sepsis (Ogundipe et al.,

2018), premature mortality resulting from systemic lupus erythematosus-related causes (Falasinnu et al., 2017), and so on.

Relationship Between Marital Status and the Number of Coexisting MCOD

The findings of this study reveals that marital status has a statistically significant ($p < 0.05$, Table 12) effect on the number of coexisting MCOD. This is in agreement with previous studies such as the work by Kravdal (2017) which showed that marital status (as well as the spouse's educational attainment have considerable effects on the mortality and on inequality in mortality in Norway. These also hold true for renal cell carcinoma (Marchioni et al., 2017), for head and neck cancer outcomes (Inverso et al., 2015), for the survival of patients with colorectal cancer (Li et al., 2015), and for mortality from heart failure (Lu et al., 2016).

Limitations of the Study

Generalizability Limitations

This study is limited to the population the US citizens alone. The dataset is from the death cases of U.S. citizens from the states and territories of the United States including American Samoa, Guam, Northern Marianas, Puerto Rico and the Virgin Islands alone. Furthermore, the study focuses on the death cases reported between the year 1959 and the year 2005 alone. The results of this study may, therefore, not be generalizable to other populations but should generalize well to the population of the United States because the entire data set comes from the United States. Nonetheless, the results of the study might offer some (although, very little/minimal) insights about the MCOD in other developed nations that are similar to the United States in a number of

ways. The results may not be generalizable to many years before the study period and/or to many years after the study period.

Potential Validity Limitations

Lack of socioeconomic status variable. In health science and in social science research studies, it is often of interest to know the effects of socioeconomic status on the dependent variable. The same is true for the current study: namely, it is generally of interest to know the potential effects of socioeconomic status on the coexistence of MCOD. However, the secondary data set that used for this study does not specifically contain any socioeconomic status variable. This is, indeed, a limitation as there is no way to go back in time and collect the socioeconomic status variable for each of the death cases reported in the dataset. So, socioeconomic status cannot be directly accounted for in this study.

Changes in the ICD. The ICD serves as the foundation for the identification of health trends and statistics around the world. It is the international standard for reporting diseases and health conditions as well as for reporting causes of death (U.S. Department of Health and Human Services, 2009a, 2009b, 2009c, 2009d, 2009e). The ICD has gone through a number of revisions since its first creation in 1893. It was titled *International List of Causes of Death* at that time, and was later (in 1948) entrusted to the WHO which published its sixth edition, ICD-6. ICD-10 is the current version at the time of writing this work. The changes to the ICD over the years suggest that there are differences in how the causes of death were reported between the year 1959 and the year 2005 (which this study focuses on). This is a limitation as such variations could introduce problems in the

comparison of the MCOD across the years (if the causes of death are not reported uniformly).

However, this limitation is very subtle for the current study and cannot be shown to have any serious effect on the findings of this study because only the number of coexisting MCOD is used as the dependent variable in this study. Since the number of coexisting MCOD is essentially just a count, it is expected that the changes in the ICD over the years would not have any considerable effect on this variable.

Potential misreporting of the causes of death. It is possible that, in some cases, the reported causes of death are not the exact diseases or events that caused the death. Such misreporting of the causes of death is another potential limitation of this study and the dataset used. There is no way of going back in time and ensuring that the causes of death information reported the death certificate for each of the death cases is indeed accurate and correct.

Recommendations for Further Research

The limited nature or lack of adequate information on the coexistence of MCOD as suggested by previous works (Fedeli et al., 2016; Haneuse, 2017; Piffaretti et al., 2016) in addition to the lack of information and knowledge on the disparities in the coexistence of MCOD across the U.S. amounts to a gap in the literature. The use of MCOD data in this study constitute a positive step in the right direction, it does not by itself bring an end to this gap in the literature. There continues to be an abundance of unanalysed and un-interpreted raw MCOD data. Indeed, some important questions regarding our understanding of what influences our health and sickness and ultimately

our wellbeing and longevity (which are all of fundamental interests in epidemiology and in public health) remain unanswered even after this study.

For example, subsequent studies may investigate the possibility of developing a generalized approach of describing join odds (or the join probability distribution) for pairs or groups of coexisting multiple causes of death, such that answers to critical and more specific mortality-related questions could be made readily available. Such attempt would make it possible to have answers to important questions and be able to obtain facts that are currently not available. Through such future research studies, it would be possible to know whether the odds of dying from a combination of *Alzheimer's disease, heart failure and renal failure* is higher than or lower than the odds of dying from a combination of *diabetes, stroke, and hypertension*. It would be possible to know how the odds of dying from *Alzheimer's disease, heart failure, renal failure, and colorectal cancer* that coexist compare to or differ from the odds of dying from *lung cancer, diabetes, stroke, and hypertension* that coexist; and so on. Since all these questions are relevance to epidemiology and public health but cannot be answered from or found in the existing literature, future studies that provide a generalizable way of answering these and similar kinds of questions would constitute a great contribution to the fields of epidemiology and public health.

Implications

Positive Social Change

This study offers insights into how the number of coexisting MCOD vary across the United States, and across races and education levels, and lays a foundation for further investigation of what people are dying from. This study reveals in the simplest possible

forms (to the general people with diverse backgrounds and various education level) the spatiotemporal variations, the racial variations, and the educational variations in the MCOD. Furthermore, the results of how gender, age, and marital status influences the number of coexisting MCOD provided by this work may be enlightening for many members of the general public. All these pieces of information could help people to be more aware of how the various variables that apply to them and to their loved ones may influence their risk of death from a combination of conditions. Been better informed of how those risks apply to them as individuals, may aid risk avoidance, longevity, and positive social change. In a similar way, the information may also have the potentials of helping public health practitioners in identifying individuals or communities that are at higher risks of death from a number of coexisting MCOD such that actions can be taken to lower the risks. All these have the potentials of improving people's wellbeing, enhancing longevity, and contributing to positive social change.

Methodological and Empirical Implications

This study provides numerical descriptive statistics on the number of MCOD that coexists and offers insights for understanding the factors that influence the coexistence of MCOD. The spatial and temporal disparities in the number of coexisting MCOD that this study identifies add to the existing body of knowledge and constitute a significant contribution towards this field of epidemiology.

Implications for Research

The results of this study and the data presentation approach used in this study can serve as the basis for future studies. For example, future researchers can now know beforehand that the number of coexisting MCOD is skewed. This may help them in

planning accordingly regarding the best statistical analysis method for handling data involving the number of coexisting MCOD. The data analysis approaches used in the study can serve as an example for future research. The computer programs I have written for handling the huge dataset (made up by approximately 80 million death cases) used in the study and for carrying out the statistical analyses reported in these study can serve as a tool for other researchers who may reuse the computer program as it is or build new statistical analysis tasks on top of it.

Conclusion

Mortality rates are routinely used as important health indicators. However, the mortality metrics derived from UCOD alone have limited powers in revealing all the possible and important information about the health of the population and what the people are dying from and is unable to capture the complexity of the conditions that may surround some death cases. Furthermore, MCOD information are able to provide important information that cannot possibly be extracted from other mortality data, making MCOD information very important.

This study has made use of MCOD data exploring the distribution of the number of coexisting MCOD across various factors such as place of residence, year, race, educational attainment, age, gender, marital status, and so on. The hypothesis tested in this study has shown that the state or territory of residence, the race, the year of death, the number of year of formal education completed, as well as age, gender, and marital status influence the average number of coexisting MCOD in the United States. While each of this is shown to have statistically significant effects on the number of coexisting MCOD, the associated effect sizes are small at the individual level. These suggest that the

complexity of coexistence of MCOD is indeed high and that there are many important factors that may contribute to the number of MCOD that coexist. However, it is important to recognize that despite the smallness of the effect sizes observed, the variables are important at the population level and any measures that could improve the tunable independent variables (such as educational attainment, marital status, etc.) would be of public health importance. It is also important to know that the complexity of coexisting MCOD makes it impossible to bring a complete understanding to its nature (most especially at a national level) through one study. Therefore, despite that this study has contributed to the body of knowledge in this field, this area of epidemiology and public health has the potentials of benefiting tremendously from further mortality statistics studies like the current study.

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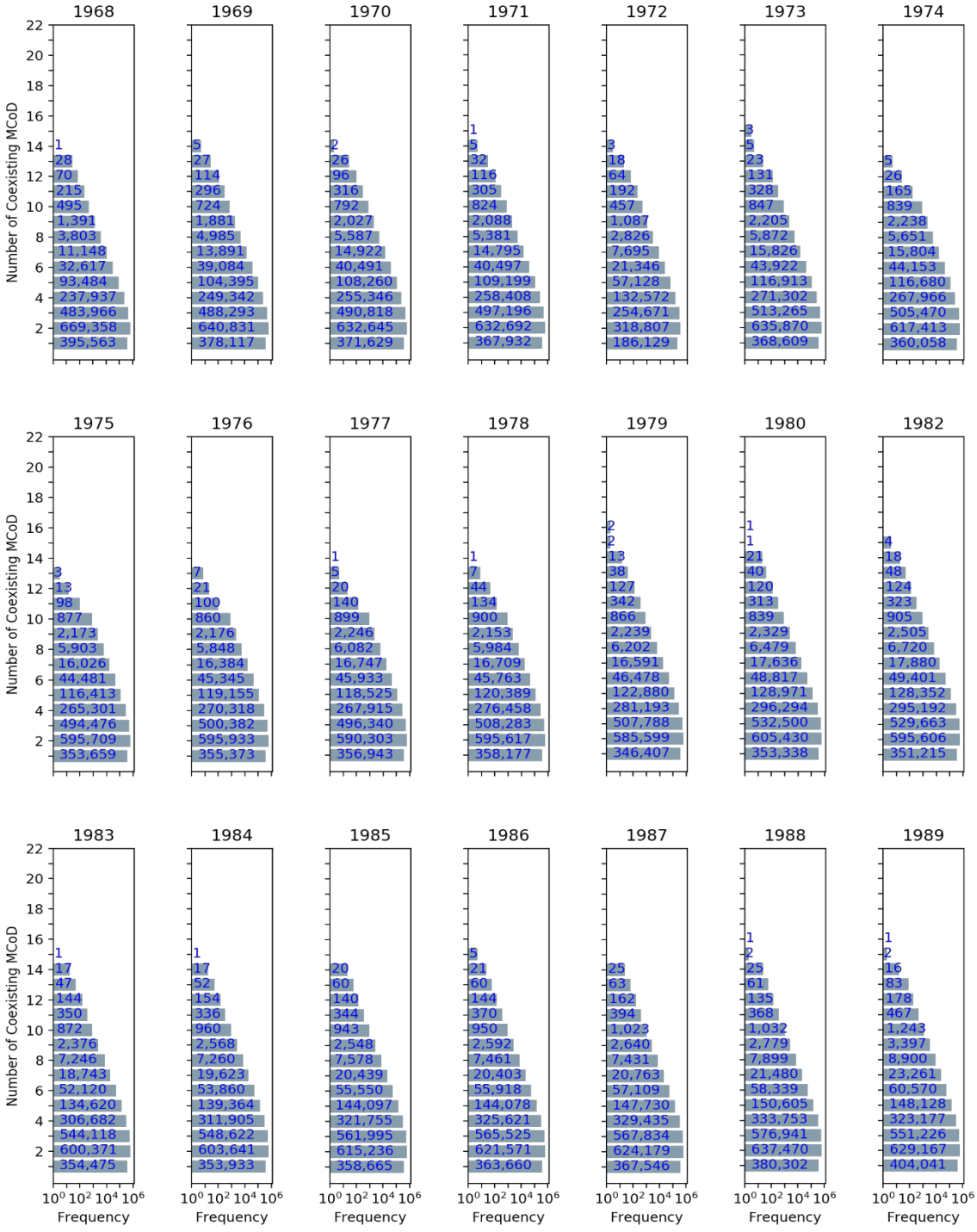
Appendix


1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1982
1983
1984
1985
1986
1987
1988
1989
Number of Coexisting MCoD
Frequency

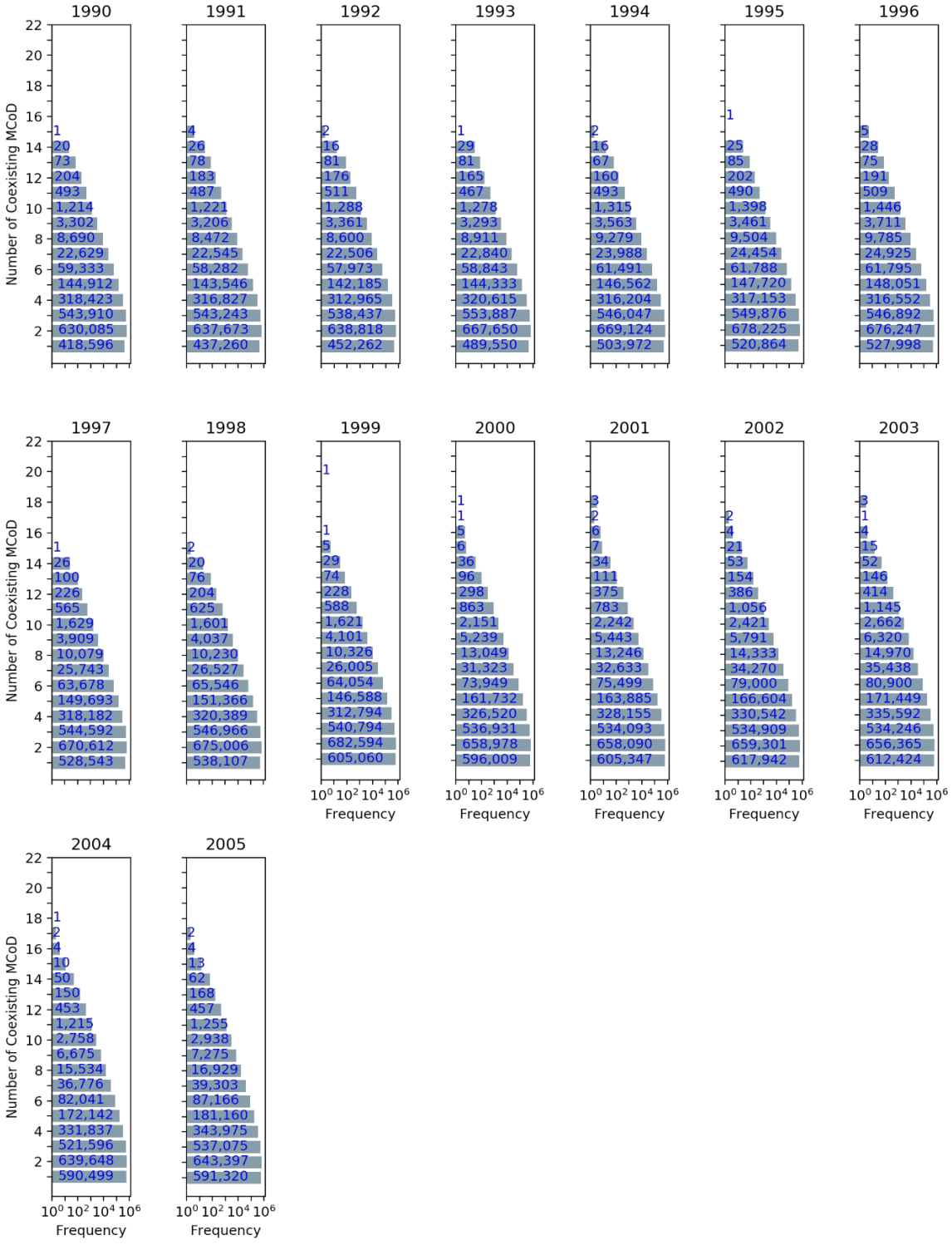
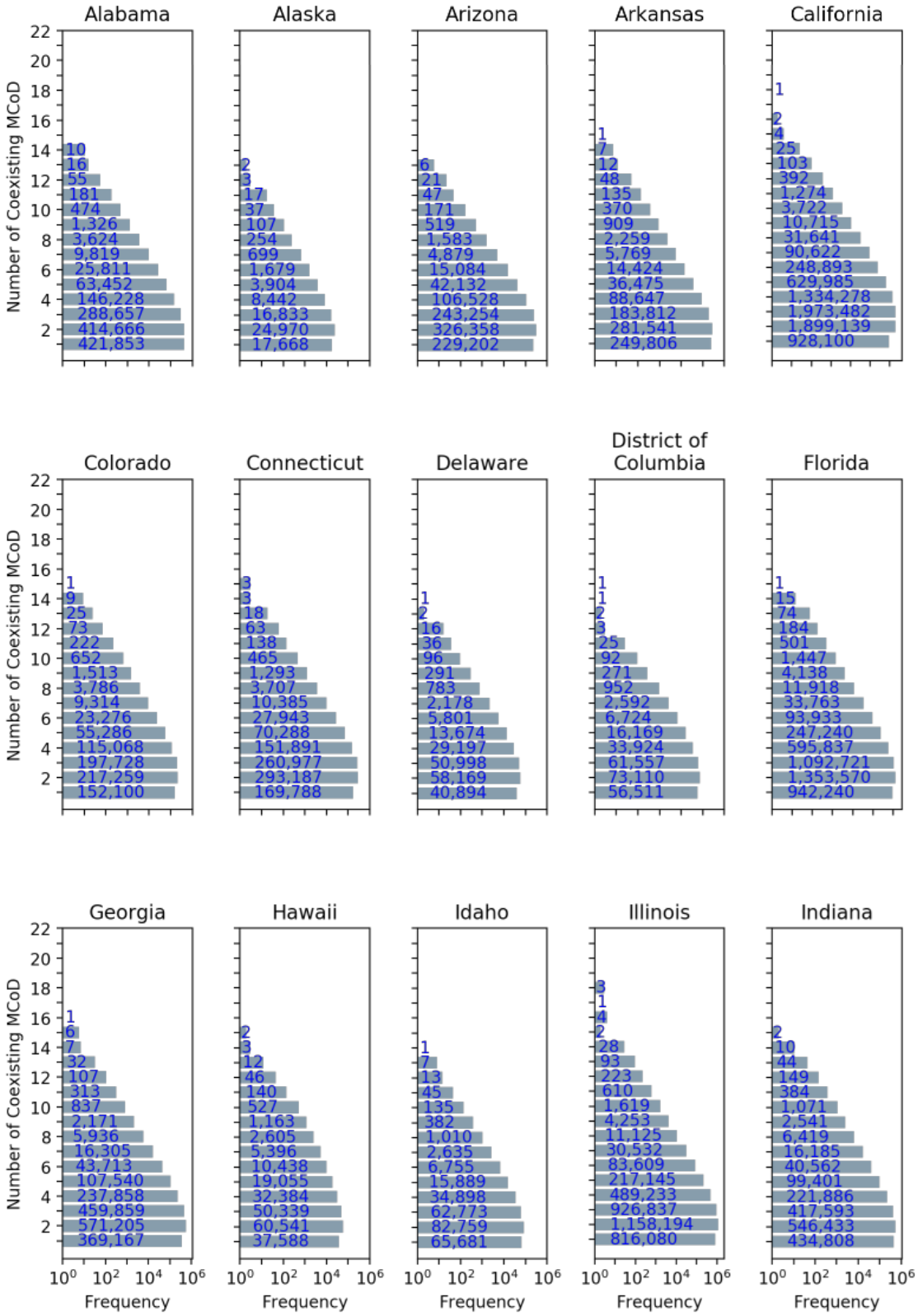
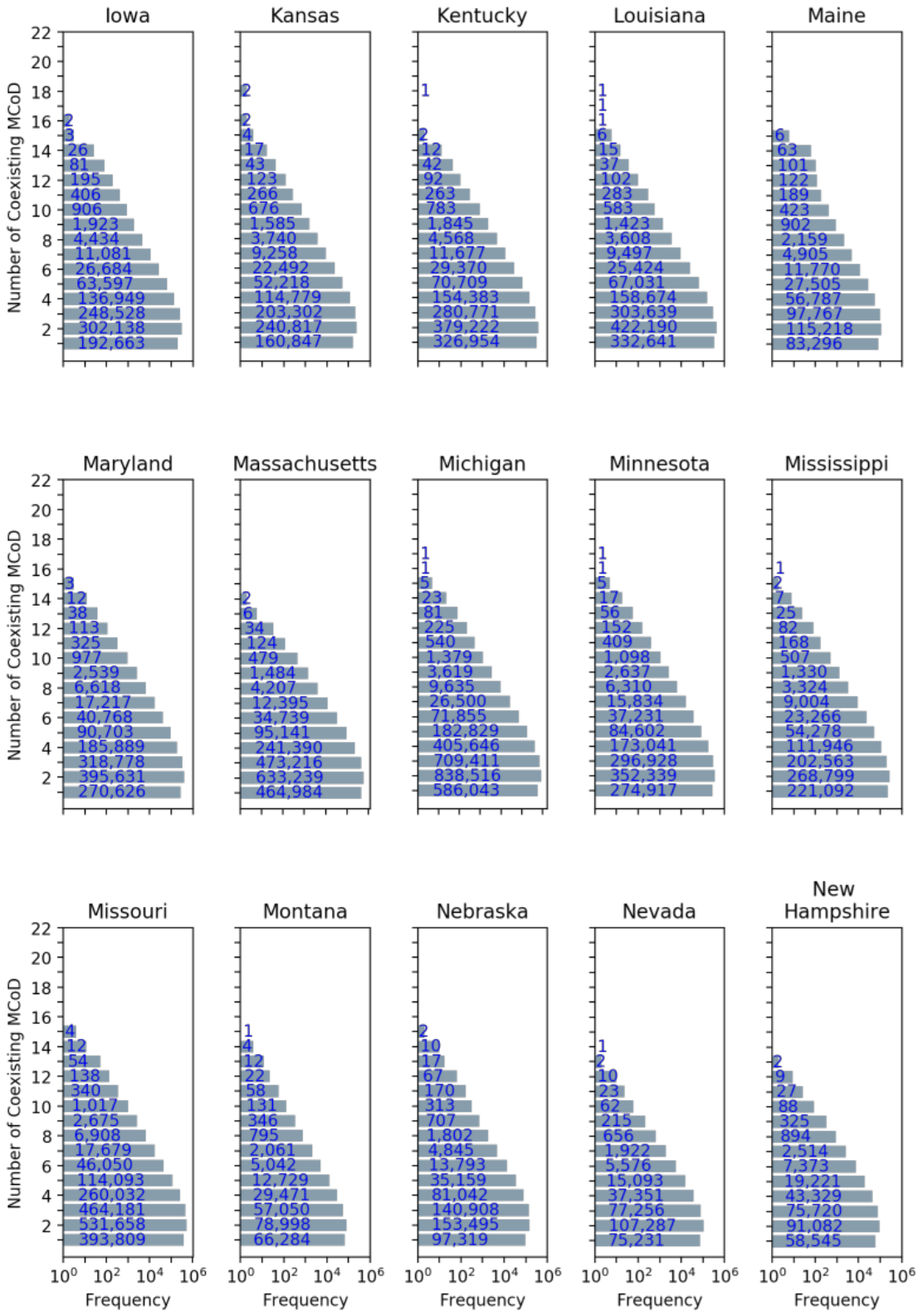
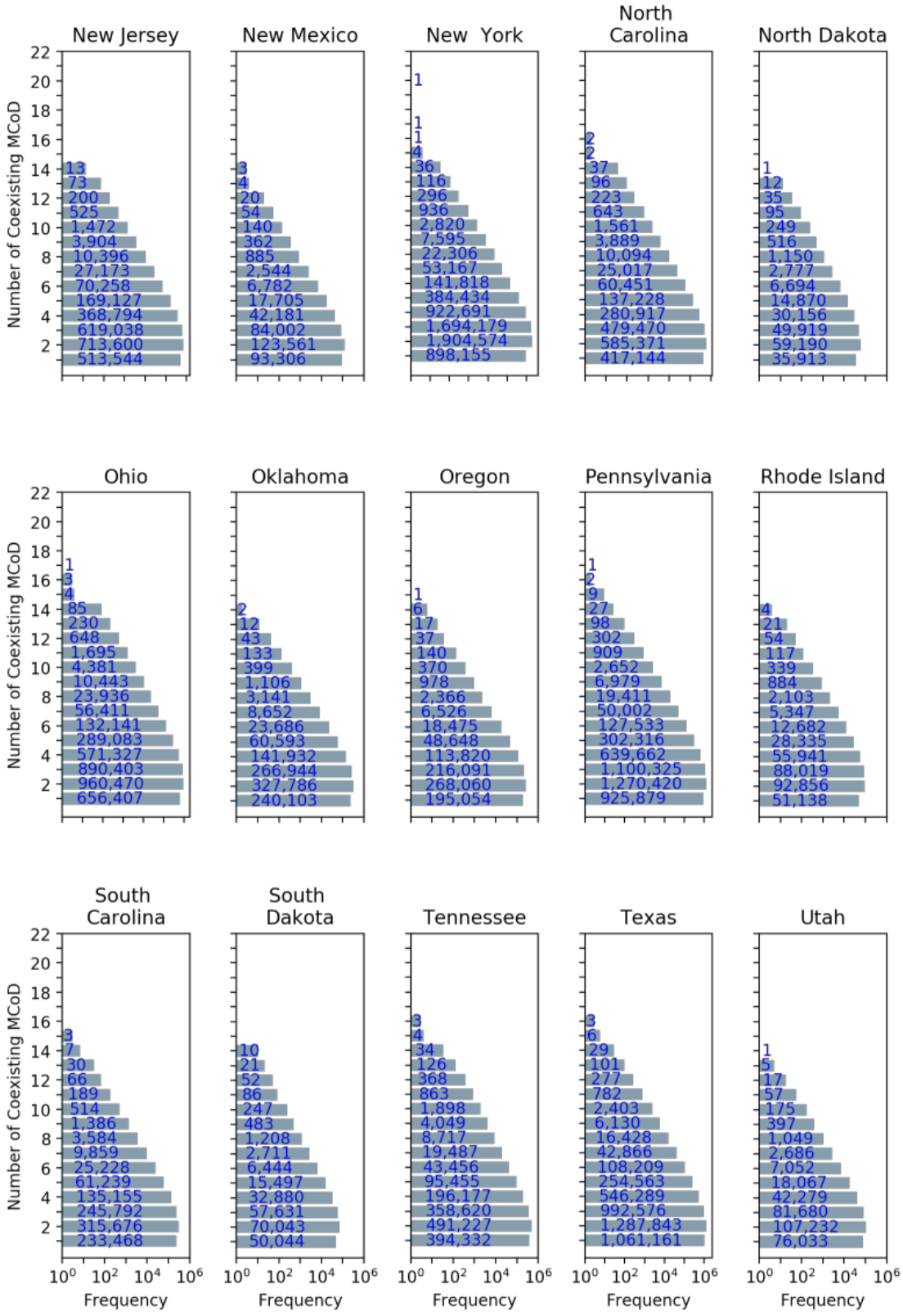


Figure A1. A column chart for the number of coexisting MCOD across the years.


Alabama
Alaska
Arizona
Arkansas
California
Colorado
Connecticut
Delaware
District of Columbia
Florida
Georgia
Hawaii
Idaho
Illinois
Indiana
Number of Coexisting MCoD
Frequency


Iowa
Kansas
Kentucky
Louisiana
Maine
Maryland
Massachusetts
Michigan
Minnesota
Mississippi
Missouri
Montana
Nebraska
Nevada
New Hampshire
Number of Coexisting MCoD
Frequency


New Jersey
New Mexico
New York
North Carolina
North Dakota
Ohio
Oklahoma
Oregon
Pennsylvania
Rhode Island
South Carolina
South Dakota
Tennessee
Texas
Utah
Number of Coexisting MCoD
Frequency

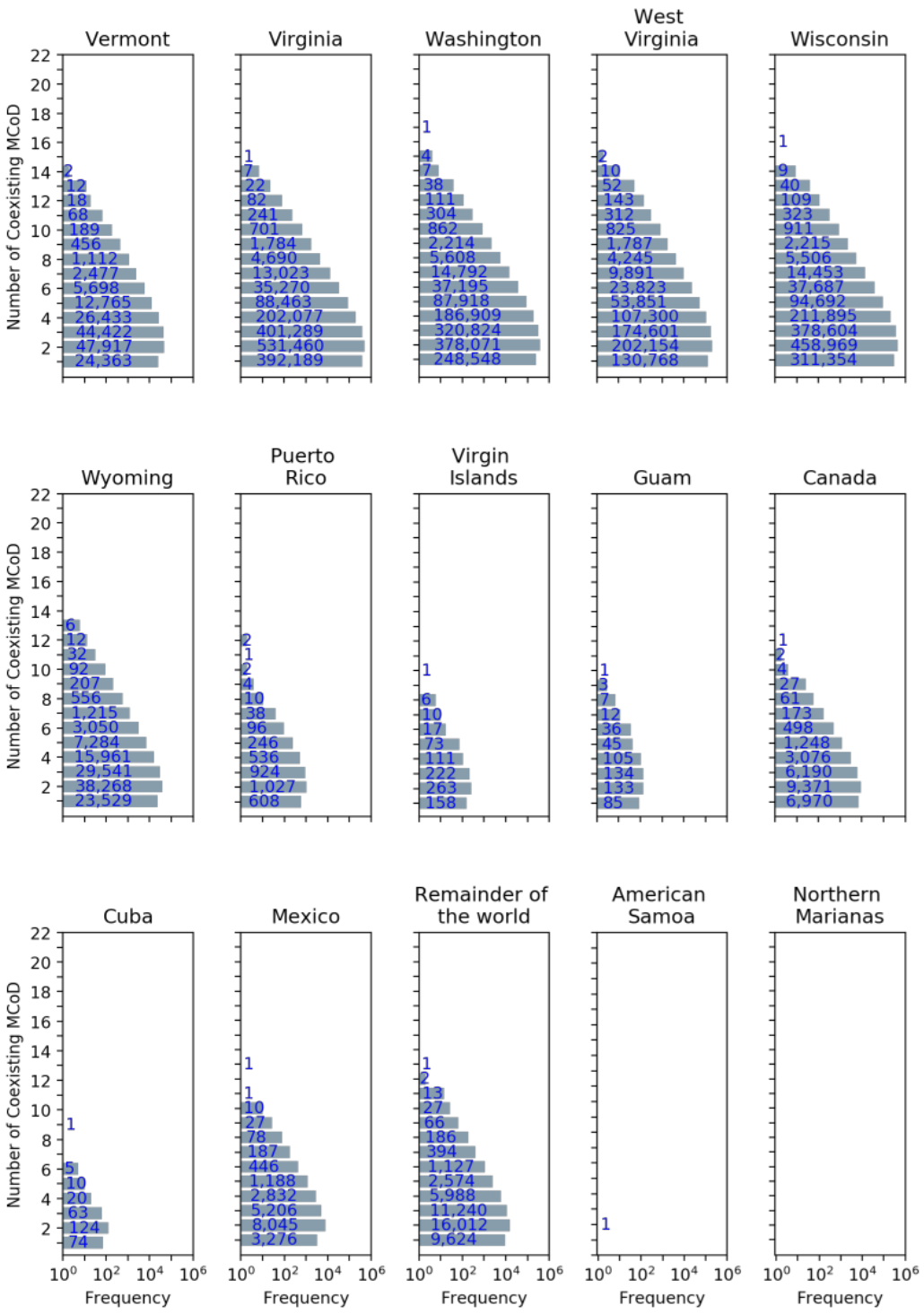


Figure A2. Variations in the number of coexisting MCOD across states/territories of residence.

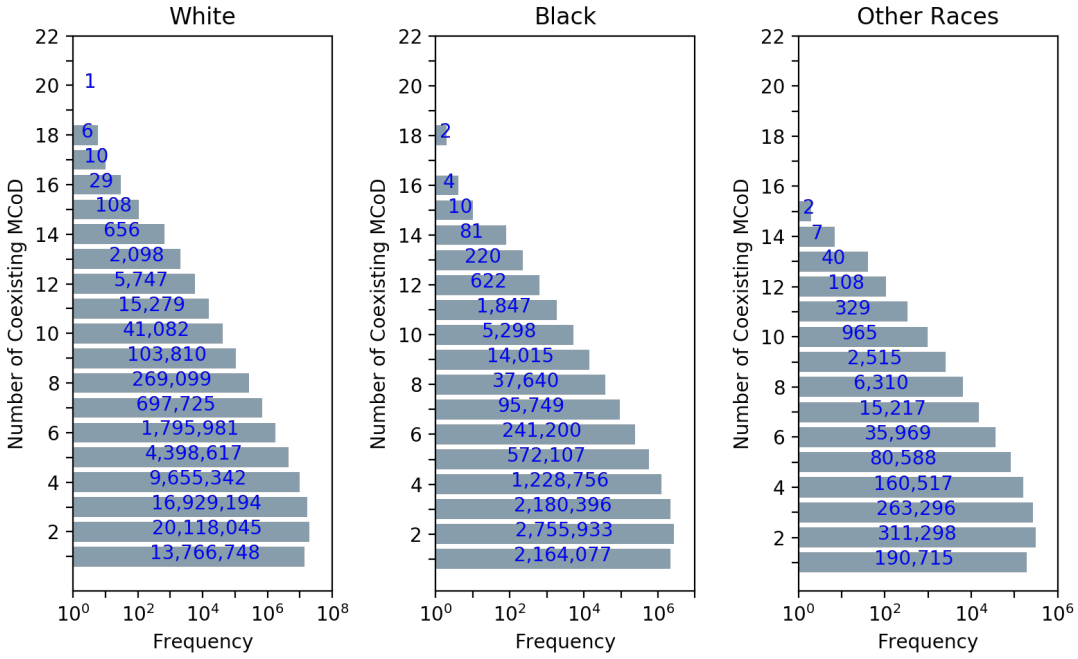


Figure A3. Variations in the number of coexisting MCOD across races.

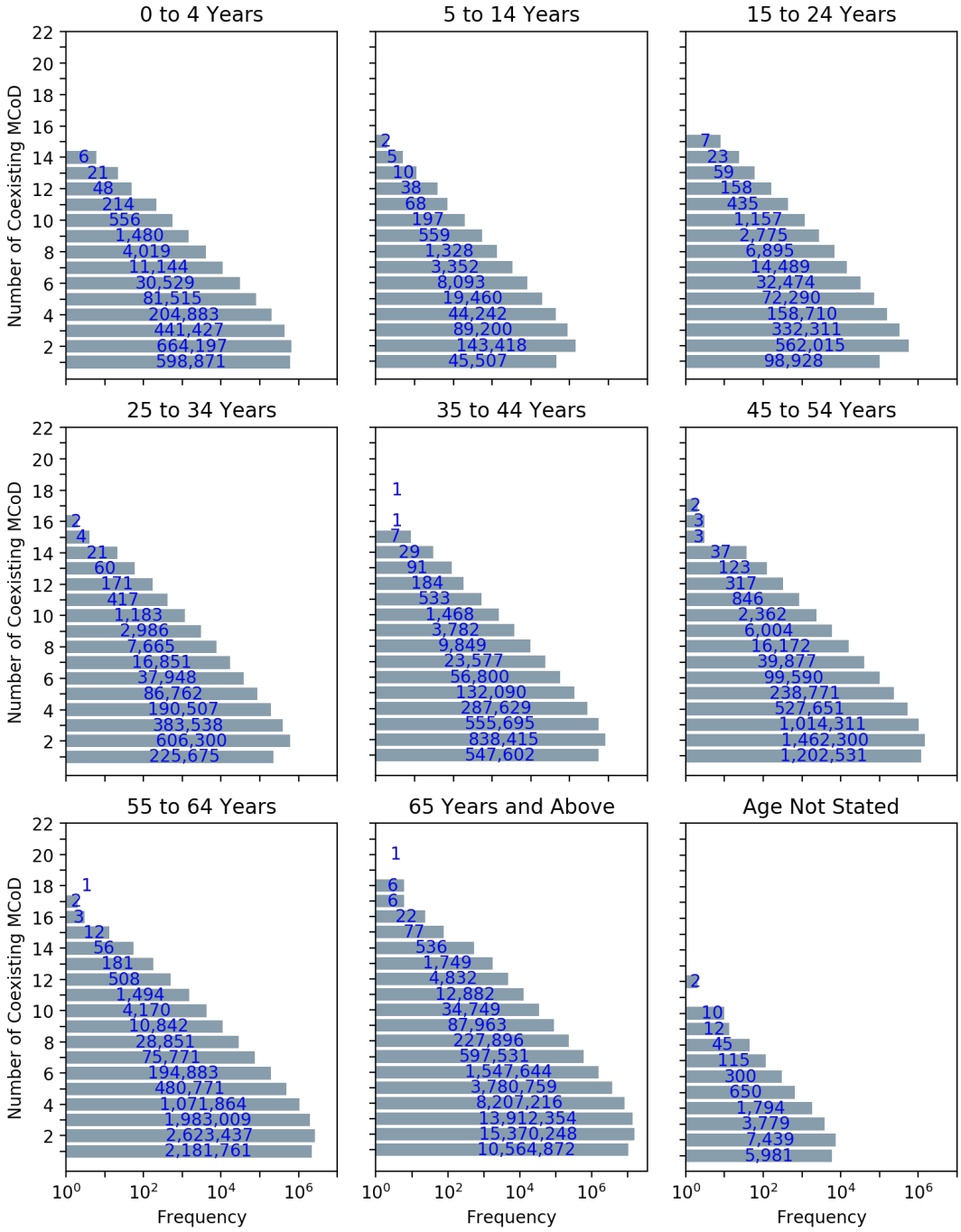


Figure A4. Variations in the number of coexisting MCOD across education levels.

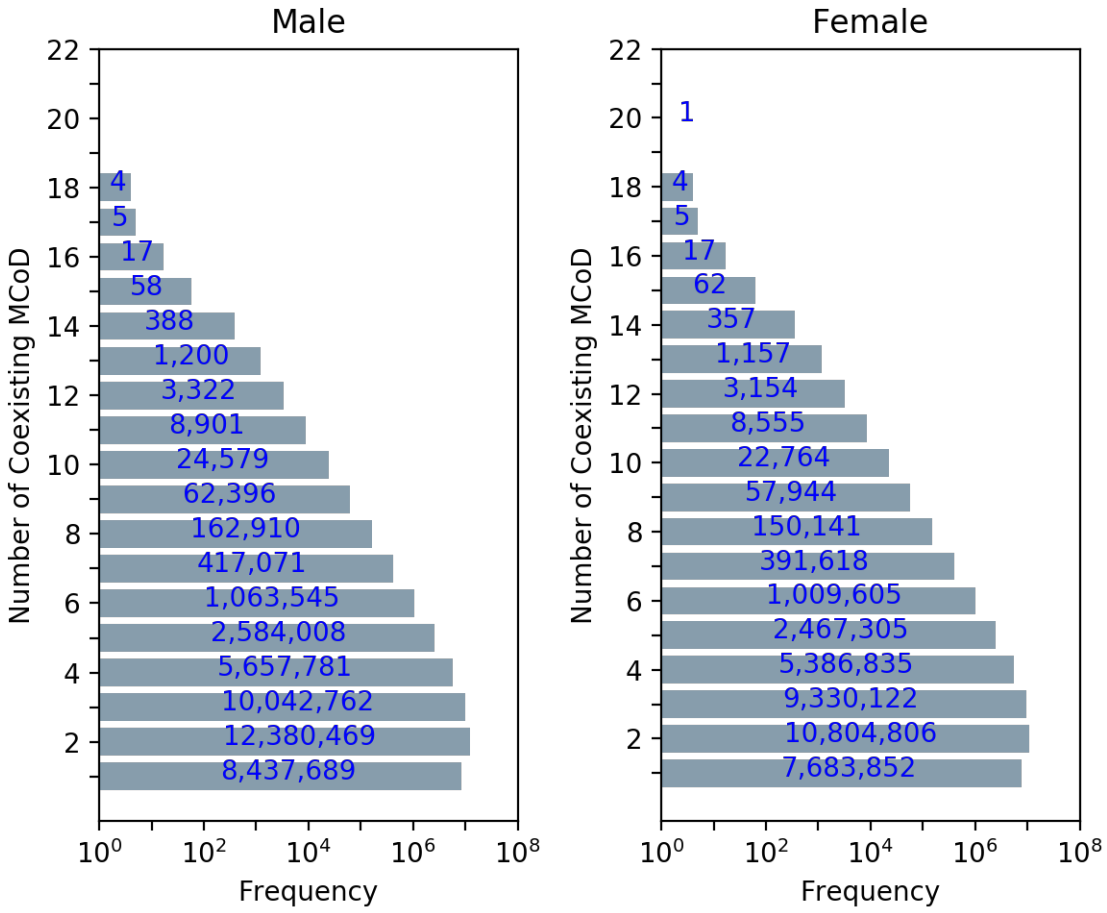


Figure A5. Variations in the number of coexisting MCOD across genders.

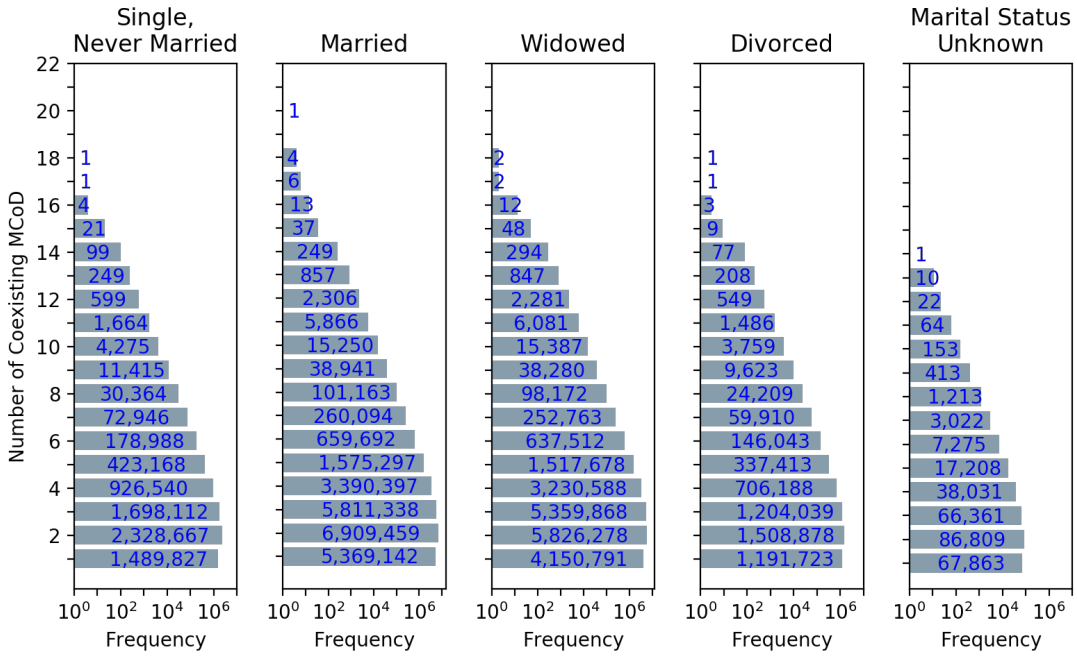


Figure A6. Variations in the number of coexisting MCOD across marital statuses.

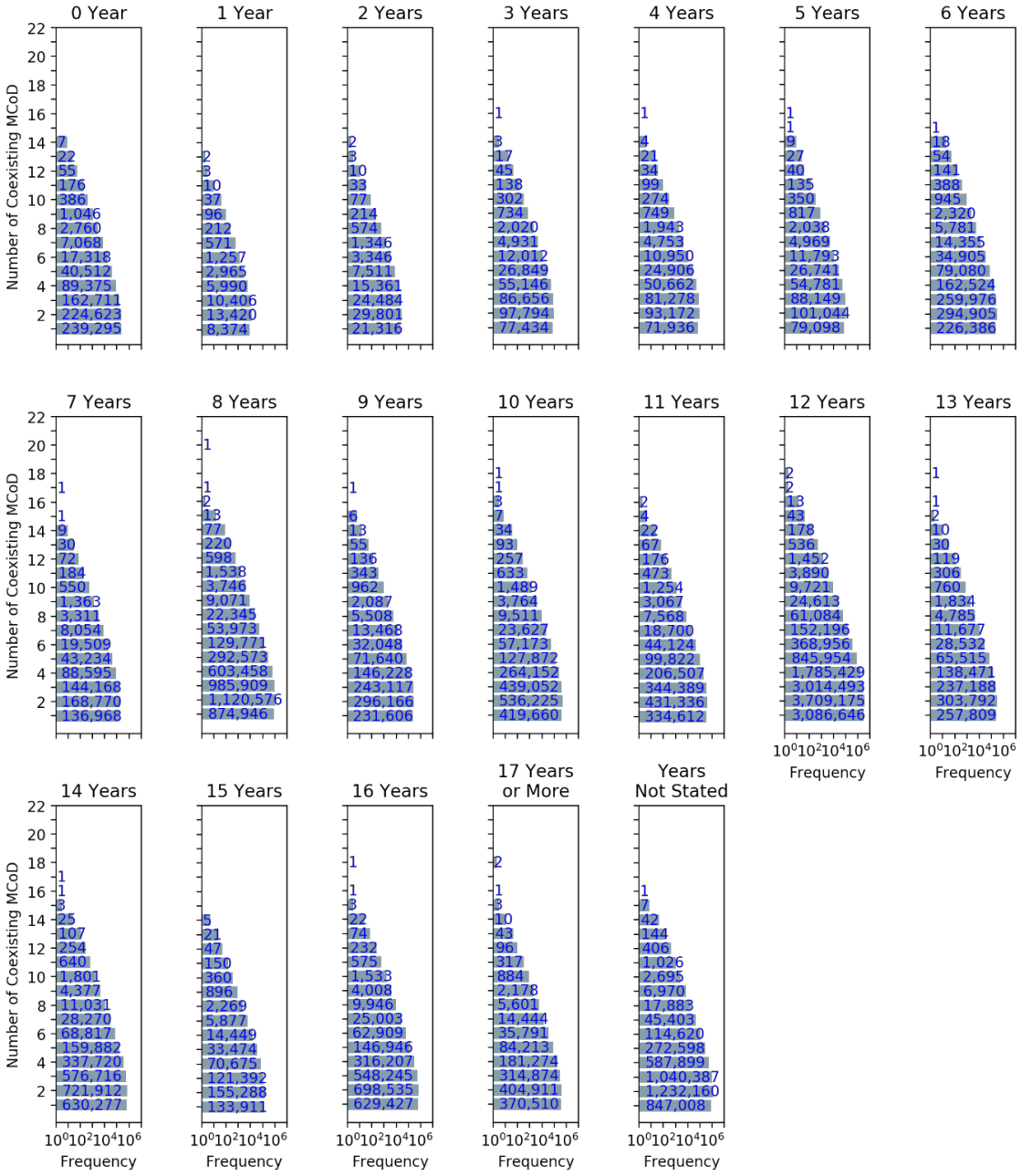


Figure A7. Variations in the number of coexisting MCOD across age groups.

Table A1

*The Regression Coefficients for the Full Regression Model**

			95% C. I. of B			
	B	*SE of B*	*LB*	*UB*	*t*	*p*
States of Residence**						
Alabama	-0.2913	0.009	-0.31	-0.273	-30.9	<0.001
Alaska	-0.1493	0.008	-0.165	-0.133	-18.4	<0.001
Arizona	0.0229	0.009	0.005	0.041	2.525	0.012
Arkansas	0.3556	0.016	0.325	0.387	22.45	<0.001
California	-0.0851	0.015	-0.115	-0.055	-5.57	<0.001
Colorado	-0.1787	0.008	-0.195	-0.162	-21.4	<0.001
Connecticut	-0.1745	0.009	-0.192	-0.157	-19.2	<0.001
Delaware	0.0136	0.01	-0.007	0.034	1.325	0.185
Florida	-0.1523	0.01	-0.171	-0.133	-15.8	<0.001
Georgia	-0.2855	0.01	-0.304	-0.267	-29.9	<0.001
Hawaii	-0.0472	0.024	-0.094	-<0.001	-1.98	0.048
Idaho	0.0302	0.013	0.005	0.056	2.313	0.021
Illinois	0.1054	0.009	0.087	0.124	11.12	<0.001
Indiana	-0.2082	0.009	-0.226	-0.191	-23.1	<0.001
Iowa	-0.1157	0.009	-0.133	-0.099	-13.4	<0.001
Kansas	-0.1282	0.01	-0.147	-0.109	-13.3	<0.001
Kentucky	-0.038	0.01	-0.058	-0.018	-3.66	<0.001
Louisiana	-0.0148	0.009	-0.033	0.003	-1.64	0.102

Maine	-0.2572	0.016	-0.289	-0.226	-16.1	<0.001
Maryland	0.1008	0.012	0.077	0.124	8.357	<0.001
Massachusetts	-0.2219	0.013	-0.247	-0.197	-17.6	<0.001
Michigan	-0.2965	0.01	-0.316	-0.278	-30.5	<0.001
Minnesota	-0.019	0.015	-0.048	0.009	-1.31	0.191
Mississippi	-0.0632	0.009	-0.08	-0.046	-7.2	<0.001
Missouri	-0.2157	0.013	-0.241	-0.191	-16.9	<0.001
Montana	0.1207	0.008	0.105	0.137	14.77	<0.001
Nebraska	0.0328	0.009	0.016	0.05	3.72	<0.001
Nevada	0.1754	0.017	0.142	0.209	10.32	<0.001
New Hampshire	0.311	0.008	0.295	0.327	37.18	<0.001
New Jersey	-0.041	0.01	-0.061	-0.021	-4.08	<0.001
New Mexico	-0.135	0.01	-0.155	-0.115	-13.2	<0.001
New York	-0.0069	0.008	-0.023	0.009	-0.84	0.398
North Carolina	-0.2981	0.01	-0.318	-0.278	-28.8	<0.001
North Dakota	0.3356	0.014	0.308	0.363	23.88	<0.001
Ohio	-0.0267	0.01	-0.046	-0.007	-2.71	0.007
Oklahoma	-0.0654	0.017	-0.098	-0.033	-3.96	<0.001
Oregon	0.0193	0.009	0.001	0.037	2.114	0.035
Pennsylvania	-0.0061	0.008	-0.022	0.01	-0.75	0.453
Rhode Island	-0.1351	0.013	-0.161	-0.109	-10.2	<0.001
South Carolina	0.3074	0.018	0.272	0.343	16.81	<0.001
South Dakota	-0.1875	0.009	-0.205	-0.17	-20.6	<0.001

Tennessee	0.0365	0.01	0.018	0.055	3.809	<0.001
Texas	0.2766	0.011	0.255	0.298	24.99	<0.001
Utah	0.3836	0.008	0.368	0.399	47.87	<0.001
Vermont	-0.1575	0.009	-0.176	-0.139	-16.9	<0.001
Virginia	-0.0442	0.021	-0.086	-0.003	-2.09	0.037
Washington	0.0803	0.103	-0.121	0.282	0.781	0.435
West Virginia	0.0692	0.195	-0.312	0.451	0.356	0.722
Wisconsin	0.4669	0.3	-0.121	1.055	1.558	0.119
Wyoming	-0.2464	0.044	-0.333	-0.16	-5.56	<0.001
Puerto Rico	-0.6476	0.379	-1.391	0.095	-1.71	0.088
Virgin Islands	0.1005	0.046	0.01	0.191	2.18	0.029
Guam	-0.0178	0.03	-0.076	0.04	-0.6	0.548
Canada	0.0236	0.01	0.003	0.044	2.25	0.024
Cuba	3E-14	1E-14	2E-15	5.1E-14	2.121	0.034
Mexico	0.1333	0.01	0.113	0.153	13.14	<0.001
Remainder of the world	0.0693	0.016	0.037	0.101	4.255	<0.001
American Samoa	0.0687	0.016	0.037	0.101	4.202	<0.001
Year of Death***						
Year 1989	0.0901	0.005	0.081	0.099	18.92	<0.001
Year 1990	0.064	0.005	0.055	0.073	13.43	<0.001
Year 1991	0.0375	0.005	0.028	0.047	7.906	<0.001
Year 1992	0.0217	0.005	0.012	0.031	4.581	<0.001
Year 1993	-0.0069	0.005	-0.016	0.002	-1.48	0.140

Year 1994	-0.0138	0.005	-0.023	-0.005	-2.95	0.003
Year 1995	-0.0259	0.005	-0.035	-0.017	-5.54	<0.001
Year 1996	-0.0232	0.005	-0.032	-0.014	-4.96	<0.001
Year 1997	-0.0239	0.005	-0.033	-0.015	-5.11	<0.001
Year 1998	-0.0203	0.005	-0.029	-0.011	-4.34	<0.001
Year 1999	-0.0861	0.005	-0.095	-0.077	-18.5	<0.001
Year 2000	-0.0145	0.005	-0.024	-0.005	-3.13	0.002
Year 2001	-0.0128	0.005	-0.022	-0.004	-2.75	0.006
Year 2002	-0.0053	0.005	-0.014	0.004	-1.14	0.255
Year 2003	-0.008	0.005	-0.017	0.001	-1.66	0.097
Race****						
Black	0.0403	0.002	0.035	0.045	16.16	<0.001
Other Races	0.0628	0.006	0.05	0.075	9.774	<0.001
Number of Years of Formal Education	-0.0089	~=0.000	-0.009	-0.008	-41.7	<0.001
Age in Years	0.0056	5E-05	0.006	0.006	119.7	<0.001
Gender*****						
Female	0.037	0.002	0.04	0.034	21.8	<0.001
Marital Status******						
Married	0.0482	0.003	0.043	0.054	17.39	<0.001
Widowed	0.0526	0.002	0.049	0.057	26.36	<0.001
Divorced	0.0225	0.003	0.017	0.028	8.06	<0.001
Marital Status Unknown	-0.053	0.012	-0.076	-0.03	-4.55	<0.001

Intercept	2.3971	0.009	2.379	2.415	257.2	<0.001

* The dependent variable is the number of coexisting MCOD. The model is statistically significant ($p < 0.001$). The coefficient of determination is 0.022.
** The States of Residence is a categorical variable and is represented using dummy coding. The District of Columbia is treated as the reference category so it does not explicitly appear in the table as every other state is compared to it.
*** The Year of Death is a categorical variable and is represented using dummy coding. The year 2004 is the reference category so it does not explicitly appear in the table as every other year is compared to it.
**** Race is a categorical variable and is represented using dummy coding. White is the reference category so it does not explicitly appear in the table as the other races are compared to it.
***** Gender is a categorical variable and is represented using dummy coding. Male is the reference category so it does not explicitly appear in the table as female is compared to it.
****** Marital Status is a categorical variable and is represented using dummy coding. "Single, Never Married" is the reference category so it does not explicitly appear in the table as other marital status are compared to it.

Table A2

Multiple Comparison Results for all the Year of Death Pairs

				95% C. I. of MD				
Group 1 (I)	Group 2 (J)	Mean Dif. (J – I), *MD*	Cohen's *d*	*LB*	*UB*	*t*	*df*	*p*
Yr 1968	Yr 1969	0.07	0.054	0.065	0.076	52.925	3852070	<0.001
Yr 1968	Yr 1970	0.095	0.073	0.09	0.101	71.328	3853046	<0.001
Yr 1968	Yr 1971	0.102	0.078	0.097	0.108	76.83	3859556	<0.001
Yr 1968	Yr 1972	0.117	0.09	0.11	0.123	72.322	2913081	<0.001
Yr 1968	Yr 1973	0.131	0.1	0.126	0.137	98.724	3905206	<0.001
Yr 1968	Yr 1974	0.14	0.106	0.134	0.146	104.712	3866556	<0.001
Yr 1968	Yr 1975	0.151	0.114	0.145	0.157	112.024	3825215	<0.001
Yr 1968	Yr 1976	0.159	0.12	0.154	0.165	118.192	3841987	<0.001
Yr 1968	Yr 1977	0.16	0.121	0.154	0.166	118.255	3832186	<0.001
Yr 1968	Yr 1978	0.166	0.126	0.16	0.171	123.207	3860707	<0.001
Yr 1968	Yr 1979	0.189	0.143	0.184	0.195	140.087	3846856	<0.001
Yr 1968	Yr 1980	0.202	0.152	0.197	0.208	151.079	3923217	<0.001
Yr 1968	Yr 1982	0.209	0.157	0.204	0.215	155.505	3908041	<0.001
Yr 1968	Yr 1983	0.227	0.17	0.222	0.233	169.475	3952270	<0.001
Yr 1968	Yr 1984	0.241	0.18	0.235	0.246	179.411	3972384	<0.001
Yr 1968	Yr 1985	0.249	0.186	0.244	0.255	186.513	4019458	<0.001
Yr 1968	Yr 1986	0.246	0.184	0.24	0.251	184.195	4038464	<0.001
Yr 1968	Yr 1987	0.251	0.187	0.245	0.256	187.814	4056422	<0.001
Yr 1968	Yr 1988	0.246	0.183	0.24	0.251	184.682	4101276	<0.001

Yr 1968	Yr 1989	0.23	0.169	0.225	0.236	170.568	4083939	<0.001
Yr 1968	Yr 1990	0.207	0.152	0.202	0.213	153.619	4081970	<0.001
Yr 1968	Yr 1991	0.185	0.136	0.179	0.19	137.194	4103140	<0.001
Yr 1968	Yr 1992	0.169	0.124	0.163	0.174	125.046	4109267	<0.001
Yr 1968	Yr 1993	0.142	0.104	0.136	0.147	106.163	4202027	<0.001
Yr 1968	Yr 1994	0.137	0.1	0.131	0.142	102.027	4212368	<0.001
Yr 1968	Yr 1995	0.126	0.092	0.121	0.131	94.16	4245331	<0.001
Yr 1968	Yr 1996	0.123	0.089	0.118	0.129	91.965	4248292	<0.001
Yr 1968	Yr 1997	0.133	0.096	0.128	0.139	98.874	4247666	<0.001
Yr 1968	Yr 1998	0.133	0.096	0.128	0.138	98.633	4270788	<0.001
Yr 1968	Yr 1999	0.072	0.052	0.066	0.077	53.288	4324950	<0.001
Yr 1968	Yr 2000	0.142	0.1	0.136	0.147	102.85	4337273	<0.001
Yr 1968	Yr 2001	0.144	0.101	0.138	0.149	104.017	4350040	<0.001
Yr 1968	Yr 2002	0.151	0.105	0.146	0.157	108.808	4376876	<0.001
Yr 1968	Yr 2003	0.172	0.118	0.166	0.177	122.695	4382234	<0.001
Yr 1968	Yr 2004	0.196	0.134	0.191	0.202	138.977	4331480	<0.001
Yr 1968	Yr 2005	0.227	0.154	0.222	0.232	160.363	4382586	<0.001
Yr 1969	Yr 1970	0.025	0.019	0.019	0.031	18.321	3844954	<0.001
Yr 1969	Yr 1971	0.032	0.024	0.026	0.038	23.625	3851464	<0.001
Yr 1969	Yr 1972	0.046	0.034	0.04	0.053	28.038	2904989	<0.001
Yr 1969	Yr 1973	0.061	0.046	0.056	0.067	45.078	3897114	<0.001
Yr 1969	Yr 1974	0.07	0.052	0.064	0.075	51.193	3858464	<0.001
Yr 1969	Yr 1975	0.081	0.06	0.075	0.087	58.804	3817123	<0.001
Yr 1969	Yr 1976	0.089	0.066	0.083	0.095	64.799	3833895	<0.001
Yr 1969	Yr 1977	0.09	0.067	0.084	0.095	65.077	3824094	<0.001
Yr 1969	Yr 1978	0.096	0.071	0.09	0.101	69.648	3852615	<0.001
Yr 1969	Yr 1979	0.119	0.088	0.114	0.125	86.466	3838764	<0.001
Yr 1969	Yr 1980	0.132	0.098	0.127	0.138	96.804	3915125	<0.001
Yr 1969	Yr 1982	0.139	0.103	0.133	0.145	101.39	3899949	<0.001
Yr 1969	Yr 1983	0.157	0.116	0.152	0.163	114.99	3944178	<0.001
Yr 1969	Yr 1984	0.171	0.126	0.165	0.176	124.79	3964292	<0.001
Yr 1969	Yr 1985	0.179	0.131	0.174	0.185	131.562	4011366	<0.001
Yr 1969	Yr 1986	0.175	0.128	0.17	0.181	129.172	4030372	<0.001
Yr 1969	Yr 1987	0.18	0.132	0.175	0.186	132.751	4048330	<0.001
Yr 1969	Yr 1988	0.175	0.128	0.17	0.181	129.554	4093184	<0.001
Yr 1969	Yr 1989	0.16	0.116	0.155	0.166	116.522	4075847	<0.001
Yr 1969	Yr 1990	0.137	0.099	0.132	0.143	99.859	4073878	<0.001
Yr 1969	Yr 1991	0.115	0.083	0.109	0.12	83.576	4095048	<0.001
Yr 1969	Yr 1992	0.098	0.071	0.093	0.104	71.71	4101175	<0.001
Yr 1969	Yr 1993	0.072	0.052	0.066	0.077	52.656	4193935	<0.001
Yr 1969	Yr 1994	0.067	0.048	0.061	0.072	48.868	4204276	<0.001
Yr 1969	Yr 1995	0.056	0.04	0.051	0.061	41.047	4237239	<0.001
Yr 1969	Yr 1996	0.053	0.038	0.048	0.059	39.016	4240200	<0.001
Yr 1969	Yr 1997	0.063	0.045	0.058	0.069	46.082	4239574	<0.001
Yr 1969	Yr 1998	0.063	0.045	0.058	0.068	45.86	4262696	<0.001
Yr 1969	Yr 1999	0.001	0.001	-0.004	0.007	1.062	4316858	0.288
Yr 1969	Yr 2000	0.072	0.05	0.066	0.077	51.105	4329181	<0.001
Yr 1969	Yr 2001	0.074	0.051	0.068	0.079	52.421	4341948	<0.001

Yr 1969	Yr 2002	0.081	0.055	0.076	0.086	57.449	4368784	<0.001
Yr 1969	Yr 2003	0.101	0.069	0.096	0.107	71.401	4374142	<0.001
Yr 1969	Yr 2004	0.126	0.085	0.121	0.131	87.957	4323388	<0.001
Yr 1969	Yr 2005	0.157	0.105	0.152	0.162	109.19	4374494	<0.001
Yr 1970	Yr 1971	0.007	0.005	0.002	0.013	5.245	3852440	<0.001
Yr 1970	Yr 1972	0.021	0.016	0.015	0.028	12.88	2905965	<0.001
Yr 1970	Yr 1973	0.036	0.027	0.031	0.042	26.576	3898090	<0.001
Yr 1970	Yr 1974	0.045	0.033	0.039	0.051	32.75	3859440	<0.001
Yr 1970	Yr 1975	0.056	0.041	0.05	0.062	40.48	3818099	<0.001
Yr 1970	Yr 1976	0.064	0.047	0.058	0.07	46.423	3834871	<0.001
Yr 1970	Yr 1977	0.065	0.048	0.059	0.07	46.774	3825070	<0.001
Yr 1970	Yr 1978	0.071	0.052	0.065	0.076	51.221	3853591	<0.001
Yr 1970	Yr 1979	0.094	0.069	0.089	0.1	68.045	3839740	<0.001
Yr 1970	Yr 1980	0.107	0.079	0.102	0.113	78.165	3916101	<0.001
Yr 1970	Yr 1982	0.114	0.084	0.109	0.12	82.813	3900925	<0.001
Yr 1970	Yr 1983	0.132	0.097	0.127	0.138	96.301	3945154	<0.001
Yr 1970	Yr 1984	0.146	0.107	0.14	0.151	106.067	3965268	<0.001
Yr 1970	Yr 1985	0.154	0.112	0.149	0.16	112.729	4012342	<0.001
Yr 1970	Yr 1986	0.151	0.11	0.145	0.156	110.307	4031348	<0.001
Yr 1970	Yr 1987	0.155	0.113	0.15	0.161	113.875	4049306	<0.001
Yr 1970	Yr 1988	0.151	0.11	0.145	0.156	110.642	4094160	<0.001
Yr 1970	Yr 1989	0.135	0.097	0.13	0.141	97.953	4076823	<0.001
Yr 1970	Yr 1990	0.112	0.081	0.107	0.118	81.362	4074854	<0.001
Yr 1970	Yr 1991	0.09	0.065	0.084	0.095	65.098	4096024	<0.001
Yr 1970	Yr 1992	0.073	0.052	0.068	0.079	53.307	4102151	<0.001
Yr 1970	Yr 1993	0.047	0.034	0.041	0.052	34.153	4194911	<0.001
Yr 1970	Yr 1994	0.042	0.03	0.036	0.047	30.474	4205252	<0.001
Yr 1970	Yr 1995	0.031	0.022	0.026	0.036	22.652	4238215	<0.001
Yr 1970	Yr 1996	0.028	0.02	0.023	0.034	20.672	4241176	<0.001
Yr 1970	Yr 1997	0.038	0.027	0.033	0.044	27.8	4240550	<0.001
Yr 1970	Yr 1998	0.038	0.027	0.033	0.043	27.581	4263672	<0.001
Yr 1970	Yr 1999	-0.023	-0.016	-0.029	-0.018	-17.107	4317834	<0.001
Yr 1970	Yr 2000	0.047	0.032	0.041	0.052	33.168	4330157	<0.001
Yr 1970	Yr 2001	0.049	0.034	0.043	0.054	34.534	4342924	<0.001
Yr 1970	Yr 2002	0.056	0.038	0.051	0.061	39.644	4369760	<0.001
Yr 1970	Yr 2003	0.076	0.051	0.071	0.082	53.637	4375118	<0.001
Yr 1970	Yr 2004	0.101	0.068	0.096	0.107	70.315	4324364	<0.001
Yr 1970	Yr 2005	0.132	0.088	0.127	0.137	91.518	4375470	<0.001
Yr 1971	Yr 1972	0.014	0.01	0.007	0.021	8.595	2912475	<0.001
Yr 1971	Yr 1973	0.029	0.022	0.023	0.035	21.362	3904600	<0.001
Yr 1971	Yr 1974	0.038	0.028	0.032	0.043	27.573	3865950	<0.001
Yr 1971	Yr 1975	0.049	0.036	0.043	0.054	35.363	3824609	<0.001
Yr 1971	Yr 1976	0.057	0.042	0.051	0.063	41.309	3841381	<0.001
Yr 1971	Yr 1977	0.058	0.043	0.052	0.063	41.682	3831580	<0.001
Yr 1971	Yr 1978	0.063	0.047	0.058	0.069	46.107	3860101	<0.001
Yr 1971	Yr 1979	0.087	0.064	0.081	0.093	62.987	3846250	<0.001
Yr 1971	Yr 1980	0.1	0.074	0.095	0.106	73.074	3922611	<0.001
Yr 1971	Yr 1982	0.107	0.079	0.101	0.113	77.754	3907435	<0.001

Yr 1971	Yr 1983	0.125	0.092	0.12	0.131	91.249	3951664	<0.001
Yr 1971	Yr 1984	0.139	0.102	0.133	0.144	101.033	3971778	<0.001
Yr 1971	Yr 1985	0.147	0.107	0.142	0.153	107.682	4018852	<0.001
Yr 1971	Yr 1986	0.143	0.105	0.138	0.149	105.243	4037858	<0.001
Yr 1971	Yr 1987	0.148	0.108	0.143	0.154	108.817	4055816	<0.001
Yr 1971	Yr 1988	0.143	0.104	0.138	0.149	105.561	4100670	<0.001
Yr 1971	Yr 1989	0.128	0.092	0.123	0.134	92.928	4083333	<0.001
Yr 1971	Yr 1990	0.105	0.076	0.1	0.111	76.307	4081364	<0.001
Yr 1971	Yr 1991	0.082	0.059	0.077	0.088	60	4102534	<0.001
Yr 1971	Yr 1992	0.066	0.047	0.061	0.072	48.195	4108661	<0.001
Yr 1971	Yr 1993	0.039	0.028	0.034	0.045	28.952	4201421	<0.001
Yr 1971	Yr 1994	0.035	0.025	0.029	0.04	25.293	4211762	<0.001
Yr 1971	Yr 1995	0.024	0.017	0.018	0.029	17.447	4244725	<0.001
Yr 1971	Yr 1996	0.021	0.015	0.016	0.027	15.476	4247686	<0.001
Yr 1971	Yr 1997	0.031	0.022	0.026	0.037	22.642	4247060	<0.001
Yr 1971	Yr 1998	0.031	0.022	0.025	0.036	22.423	4270182	<0.001
Yr 1971	Yr 1999	-0.031	-0.022	-0.036	-0.025	-22.363	4324344	<0.001
Yr 1971	Yr 2000	0.039	0.027	0.034	0.045	28.119	4336667	<0.001
Yr 1971	Yr 2001	0.041	0.028	0.036	0.047	29.503	4349434	<0.001
Yr 1971	Yr 2002	0.049	0.033	0.044	0.054	34.65	4376270	<0.001
Yr 1971	Yr 2003	0.069	0.047	0.064	0.075	48.693	4381628	<0.001
Yr 1971	Yr 2004	0.094	0.063	0.089	0.099	65.451	4330874	<0.001
Yr 1971	Yr 2005	0.125	0.084	0.119	0.13	86.701	4381980	<0.001
Yr 1972	Yr 1973	0.015	0.011	0.008	0.022	8.876	2958125	<0.001
Yr 1972	Yr 1974	0.023	0.017	0.017	0.03	14.015	2919475	<0.001
Yr 1972	Yr 1975	0.035	0.026	0.028	0.041	20.476	2878134	<0.001
Yr 1972	Yr 1976	0.043	0.032	0.036	0.05	25.308	2894906	<0.001
Yr 1972	Yr 1977	0.043	0.032	0.037	0.05	25.635	2885105	<0.001
Yr 1972	Yr 1978	0.049	0.036	0.042	0.056	29.189	2913626	<0.001
Yr 1972	Yr 1979	0.073	0.053	0.066	0.08	43.004	2899775	<0.001
Yr 1972	Yr 1980	0.086	0.063	0.079	0.093	51.007	2976136	<0.001
Yr 1972	Yr 1982	0.093	0.068	0.086	0.1	54.844	2960960	<0.001
Yr 1972	Yr 1983	0.111	0.081	0.104	0.118	65.648	3005189	<0.001
Yr 1972	Yr 1984	0.124	0.09	0.118	0.131	73.483	3025303	<0.001
Yr 1972	Yr 1985	0.133	0.096	0.126	0.14	78.684	3072377	<0.001
Yr 1972	Yr 1986	0.129	0.094	0.122	0.136	76.644	3091383	<0.001
Yr 1972	Yr 1987	0.134	0.097	0.127	0.141	79.44	3109341	<0.001
Yr 1972	Yr 1988	0.129	0.093	0.122	0.136	76.628	3154195	<0.001
Yr 1972	Yr 1989	0.114	0.081	0.107	0.121	66.37	3136858	<0.001
Yr 1972	Yr 1990	0.091	0.065	0.084	0.098	53.017	3134889	<0.001
Yr 1972	Yr 1991	0.068	0.048	0.061	0.075	39.86	3156059	<0.001
Yr 1972	Yr 1992	0.052	0.037	0.045	0.059	30.362	3162186	<0.001
Yr 1972	Yr 1993	0.025	0.018	0.018	0.032	14.781	3254946	<0.001
Yr 1972	Yr 1994	0.02	0.014	0.014	0.027	11.869	3265287	<0.001
Yr 1972	Yr 1995	0.01	0.007	0.003	0.016	5.573	3298250	<0.001
Yr 1972	Yr 1996	0.007	0.005	0	0.014	4.016	3301211	<0.001
Yr 1972	Yr 1997	0.017	0.012	0.01	0.023	9.763	3300585	<0.001
Yr 1972	Yr 1998	0.017	0.012	0.01	0.023	9.576	3323707	<0.001

Yr 1972	Yr 1999	-0.045	-0.031	-0.052	-0.038	-26.053	3377869	<0.001
Yr 1972	Yr 2000	0.025	0.017	0.019	0.032	14.158	3390192	<0.001
Yr 1972	Yr 2001	0.027	0.018	0.021	0.034	15.256	3402959	<0.001
Yr 1972	Yr 2002	0.035	0.023	0.028	0.041	19.312	3429795	<0.001
Yr 1972	Yr 2003	0.055	0.036	0.048	0.062	30.361	3435153	<0.001
Yr 1972	Yr 2004	0.08	0.052	0.073	0.086	43.611	3384399	<0.001
Yr 1972	Yr 2005	0.111	0.072	0.104	0.117	60.166	3435505	<0.001
Yr 1973	Yr 1974	0.009	0.007	0.003	0.014	6.327	3911600	<0.001
Yr 1973	Yr 1975	0.02	0.015	0.014	0.025	14.311	3870259	<0.001
Yr 1973	Yr 1976	0.028	0.021	0.022	0.033	20.238	3887031	<0.001
Yr 1973	Yr 1977	0.029	0.021	0.023	0.034	20.697	3877230	<0.001
Yr 1973	Yr 1978	0.034	0.025	0.029	0.04	25.007	3905751	<0.001
Yr 1973	Yr 1979	0.058	0.043	0.052	0.064	42.015	3891900	<0.001
Yr 1973	Yr 1980	0.071	0.052	0.065	0.077	51.919	3968261	<0.001
Yr 1973	Yr 1982	0.078	0.057	0.072	0.083	56.705	3953085	<0.001
Yr 1973	Yr 1983	0.096	0.07	0.091	0.102	70.167	3997314	<0.001
Yr 1973	Yr 1984	0.11	0.08	0.104	0.115	79.982	4017428	<0.001
Yr 1973	Yr 1985	0.118	0.086	0.113	0.123	86.553	4064502	<0.001
Yr 1973	Yr 1986	0.114	0.083	0.109	0.12	84.06	4083508	<0.001
Yr 1973	Yr 1987	0.119	0.086	0.114	0.125	87.647	4101466	<0.001
Yr 1973	Yr 1988	0.114	0.083	0.109	0.12	84.327	4146320	<0.001
Yr 1973	Yr 1989	0.099	0.071	0.094	0.104	71.998	4128983	<0.001
Yr 1973	Yr 1990	0.076	0.054	0.071	0.082	55.336	4127014	<0.001
Yr 1973	Yr 1991	0.053	0.038	0.048	0.059	38.929	4148184	<0.001
Yr 1973	Yr 1992	0.037	0.026	0.032	0.043	27.121	4154311	<0.001
Yr 1973	Yr 1993	0.01	0.007	0.005	0.016	7.612	4247071	<0.001
Yr 1973	Yr 1994	0.006	0.004	0	0.011	4.048	4257412	<0.001
Yr 1973	Yr 1995	-0.005	-0.004	-0.011	0	-3.863	4290375	<0.001
Yr 1973	Yr 1996	-0.008	-0.006	-0.013	-0.003	-5.791	4293336	<0.001
Yr 1973	Yr 1997	0.002	0.001	-0.003	0.007	1.502	4292710	0.133
Yr 1973	Yr 1998	0.002	0.001	-0.004	0.007	1.282	4315832	0.2
Yr 1973	Yr 1999	-0.06	-0.042	-0.065	-0.054	-43.731	4369994	<0.001
Yr 1973	Yr 2000	0.01	0.007	0.005	0.016	7.408	4382317	<0.001
Yr 1973	Yr 2001	0.012	0.008	0.007	0.018	8.86	4395084	<0.001
Yr 1973	Yr 2002	0.02	0.014	0.015	0.025	14.142	4421920	<0.001
Yr 1973	Yr 2003	0.04	0.027	0.035	0.045	28.345	4427278	<0.001
Yr 1973	Yr 2004	0.065	0.044	0.06	0.07	45.383	4376524	<0.001
Yr 1973	Yr 2005	0.096	0.064	0.09	0.101	66.774	4427630	<0.001
Yr 1974	Yr 1975	0.011	0.008	0.005	0.017	7.999	3831609	<0.001
Yr 1974	Yr 1976	0.019	0.014	0.014	0.025	13.886	3848381	<0.001
Yr 1974	Yr 1977	0.02	0.015	0.014	0.026	14.368	3838580	<0.001
Yr 1974	Yr 1978	0.026	0.019	0.02	0.031	18.62	3867101	<0.001
Yr 1974	Yr 1979	0.049	0.036	0.044	0.055	35.571	3853250	<0.001
Yr 1974	Yr 1980	0.062	0.045	0.057	0.068	45.357	3929611	<0.001
Yr 1974	Yr 1982	0.069	0.051	0.064	0.075	50.147	3914435	<0.001
Yr 1974	Yr 1983	0.087	0.064	0.082	0.093	63.513	3958664	<0.001
Yr 1974	Yr 1984	0.101	0.074	0.095	0.106	73.274	3978778	<0.001
Yr 1974	Yr 1985	0.109	0.079	0.104	0.115	79.774	4025852	<0.001

Yr 1974	Yr 1986	0.106	0.077	0.1	0.111	77.277	4044858	<0.001
Yr 1974	Yr 1987	0.111	0.081	0.105	0.116	80.841	4062816	<0.001
Yr 1974	Yr 1988	0.106	0.077	0.1	0.111	77.513	4107670	<0.001
Yr 1974	Yr 1989	0.09	0.064	0.085	0.096	65.34	4090333	<0.001
Yr 1974	Yr 1990	0.067	0.048	0.062	0.073	48.771	4088364	<0.001
Yr 1974	Yr 1991	0.045	0.032	0.039	0.05	32.436	4109534	<0.001
Yr 1974	Yr 1992	0.029	0.021	0.023	0.034	20.702	4115661	<0.001
Yr 1974	Yr 1993	0.002	0.001	-0.004	0.007	1.237	4208421	0.216
Yr 1974	Yr 1994	-0.003	-0.002	-0.009	0.002	-2.277	4218762	0.023
Yr 1974	Yr 1995	-0.014	-0.01	-0.019	-0.009	-10.153	4251725	<0.001
Yr 1974	Yr 1996	-0.017	-0.012	-0.022	-0.011	-12.056	4254686	<0.001
Yr 1974	Yr 1997	-0.007	-0.005	-0.012	-0.001	-4.775	4254060	<0.001
Yr 1974	Yr 1998	-0.007	-0.005	-0.012	-0.002	-4.994	4277182	<0.001
Yr 1974	Yr 1999	-0.068	-0.048	-0.074	-0.063	-49.762	4331344	<0.001
Yr 1974	Yr 2000	0.002	0.001	-0.004	0.007	1.213	4343667	0.225
Yr 1974	Yr 2001	0.004	0.003	-0.002	0.009	2.673	4356434	0.008
Yr 1974	Yr 2002	0.011	0.007	0.006	0.017	7.954	4383270	<0.001
Yr 1974	Yr 2003	0.031	0.021	0.026	0.037	22.096	4388628	<0.001
Yr 1974	Yr 2004	0.056	0.038	0.051	0.062	39.089	4337874	<0.001
Yr 1974	Yr 2005	0.087	0.058	0.082	0.092	60.35	4388980	<0.001
Yr 1975	Yr 1976	0.008	0.006	0.002	0.014	5.824	3807040	<0.001
Yr 1975	Yr 1977	0.009	0.007	0.003	0.015	6.335	3797239	<0.001
Yr 1975	Yr 1978	0.015	0.011	0.009	0.02	10.503	3825760	<0.001
Yr 1975	Yr 1979	0.038	0.028	0.033	0.044	27.344	3811909	<0.001
Yr 1975	Yr 1980	0.051	0.037	0.046	0.057	36.965	3888270	<0.001
Yr 1975	Yr 1982	0.058	0.042	0.053	0.064	41.749	3873094	<0.001
Yr 1975	Yr 1983	0.076	0.055	0.071	0.082	54.971	3917323	<0.001
Yr 1975	Yr 1984	0.09	0.065	0.084	0.095	64.645	3937437	<0.001
Yr 1975	Yr 1985	0.098	0.071	0.093	0.104	71.047	3984511	<0.001
Yr 1975	Yr 1986	0.095	0.069	0.089	0.1	68.552	4003517	<0.001
Yr 1975	Yr 1987	0.099	0.072	0.094	0.105	72.082	4021475	<0.001
Yr 1975	Yr 1988	0.095	0.069	0.089	0.1	68.756	4066329	<0.001
Yr 1975	Yr 1989	0.079	0.056	0.074	0.085	56.808	4048992	<0.001
Yr 1975	Yr 1990	0.056	0.04	0.051	0.062	40.387	4047023	<0.001
Yr 1975	Yr 1991	0.034	0.024	0.028	0.039	24.176	4068193	<0.001
Yr 1975	Yr 1992	0.017	0.012	0.012	0.023	12.556	4074320	<0.001
Yr 1975	Yr 1993	-0.009	-0.006	-0.015	-0.004	-6.818	4167080	<0.001
Yr 1975	Yr 1994	-0.014	-0.01	-0.02	-0.009	-10.261	4177421	<0.001
Yr 1975	Yr 1995	-0.025	-0.018	-0.03	-0.02	-18.082	4210384	<0.001
Yr 1975	Yr 1996	-0.028	-0.02	-0.033	-0.022	-19.949	4213345	<0.001
Yr 1975	Yr 1997	-0.018	-0.013	-0.023	-0.012	-12.695	4212719	<0.001
Yr 1975	Yr 1998	-0.018	-0.013	-0.023	-0.013	-12.912	4235841	<0.001
Yr 1975	Yr 1999	-0.079	-0.055	-0.085	-0.074	-57.303	4290003	<0.001
Yr 1975	Yr 2000	-0.009	-0.006	-0.015	-0.004	-6.61	4302326	<0.001
Yr 1975	Yr 2001	-0.007	-0.005	-0.013	-0.002	-5.14	4315093	<0.001
Yr 1975	Yr 2002	0	0	-0.005	0.006	0.133	4341929	0.894
Yr 1975	Yr 2003	0.02	0.013	0.015	0.026	14.183	4347287	<0.001
Yr 1975	Yr 2004	0.045	0.03	0.04	0.051	31.097	4296533	<0.001

Yr 1975	Yr 2005	0.076	0.05	0.071	0.081	52.175	4347639	<0.001
Yr 1976	Yr 1977	0.001	0.001	-0.005	0.006	0.535	3814011	0.593
Yr 1976	Yr 1978	0.007	0.005	0.001	0.012	4.676	3842532	<0.001
Yr 1976	Yr 1979	0.03	0.022	0.025	0.036	21.569	3828681	<0.001
Yr 1976	Yr 1980	0.043	0.031	0.038	0.049	31.147	3905042	<0.001
Yr 1976	Yr 1982	0.05	0.036	0.044	0.056	35.966	3889866	<0.001
Yr 1976	Yr 1983	0.068	0.049	0.063	0.074	49.191	3934095	<0.001
Yr 1976	Yr 1984	0.082	0.059	0.076	0.087	58.883	3954209	<0.001
Yr 1976	Yr 1985	0.09	0.065	0.085	0.096	65.269	4001283	<0.001
Yr 1976	Yr 1986	0.086	0.062	0.081	0.092	62.756	4020289	<0.001
Yr 1976	Yr 1987	0.091	0.066	0.086	0.097	66.293	4038247	<0.001
Yr 1976	Yr 1988	0.086	0.062	0.081	0.092	62.944	4083101	<0.001
Yr 1976	Yr 1989	0.071	0.051	0.066	0.077	51.067	4065764	<0.001
Yr 1976	Yr 1990	0.048	0.034	0.043	0.054	34.618	4063795	<0.001
Yr 1976	Yr 1991	0.026	0.019	0.02	0.031	18.361	4084965	<0.001
Yr 1976	Yr 1992	0.009	0.006	0.004	0.015	6.729	4091092	<0.001
Yr 1976	Yr 1993	-0.018	-0.013	-0.023	-0.012	-12.741	4183852	<0.001
Yr 1976	Yr 1994	-0.022	-0.016	-0.028	-0.017	-16.162	4194193	<0.001
Yr 1976	Yr 1995	-0.033	-0.023	-0.039	-0.028	-24.01	4227156	<0.001
Yr 1976	Yr 1996	-0.036	-0.025	-0.041	-0.03	-25.867	4230117	<0.001
Yr 1976	Yr 1997	-0.026	-0.018	-0.031	-0.02	-18.571	4229491	<0.001
Yr 1976	Yr 1998	-0.026	-0.018	-0.031	-0.021	-18.79	4252613	<0.001
Yr 1976	Yr 1999	-0.088	-0.062	-0.093	-0.082	-63.291	4306775	<0.001
Yr 1976	Yr 2000	-0.018	-0.012	-0.023	-0.012	-12.367	4319098	<0.001
Yr 1976	Yr 2001	-0.015	-0.01	-0.021	-0.01	-10.877	4331865	<0.001
Yr 1976	Yr 2002	-0.008	-0.005	-0.013	-0.003	-5.562	4358701	<0.001
Yr 1976	Yr 2003	0.012	0.008	0.007	0.018	8.547	4364059	<0.001
Yr 1976	Yr 2004	0.037	0.025	0.032	0.042	25.557	4313305	<0.001
Yr 1976	Yr 2005	0.068	0.045	0.063	0.073	46.694	4364411	<0.001
Yr 1977	Yr 1978	0.006	0.004	0	0.011	4.121	3832731	<0.001
Yr 1977	Yr 1979	0.029	0.021	0.024	0.035	20.949	3818880	<0.001
Yr 1977	Yr 1980	0.042	0.031	0.037	0.048	30.484	3895241	<0.001
Yr 1977	Yr 1982	0.049	0.036	0.044	0.055	35.286	3880065	<0.001
Yr 1977	Yr 1983	0.067	0.049	0.062	0.073	48.457	3924294	<0.001
Yr 1977	Yr 1984	0.081	0.059	0.075	0.087	58.112	3944408	<0.001
Yr 1977	Yr 1985	0.089	0.064	0.084	0.095	64.471	3991482	<0.001
Yr 1977	Yr 1986	0.086	0.062	0.08	0.091	61.967	4010488	<0.001
Yr 1977	Yr 1987	0.091	0.066	0.085	0.096	65.491	4028446	<0.001
Yr 1977	Yr 1988	0.086	0.062	0.08	0.091	62.155	4073300	<0.001
Yr 1977	Yr 1989	0.07	0.05	0.065	0.076	50.333	4055963	<0.001
Yr 1977	Yr 1990	0.047	0.033	0.042	0.053	33.948	4053994	<0.001
Yr 1977	Yr 1991	0.025	0.018	0.019	0.03	17.753	4075164	<0.001
Yr 1977	Yr 1992	0.009	0.006	0.003	0.014	6.166	4081291	<0.001
Yr 1977	Yr 1993	-0.018	-0.013	-0.024	-0.013	-13.234	4174051	<0.001
Yr 1977	Yr 1994	-0.023	-0.016	-0.029	-0.018	-16.639	4184392	<0.001
Yr 1977	Yr 1995	-0.034	-0.024	-0.039	-0.028	-24.459	4217355	<0.001
Yr 1977	Yr 1996	-0.037	-0.026	-0.042	-0.031	-26.308	4220316	<0.001
Yr 1977	Yr 1997	-0.027	-0.019	-0.032	-0.021	-19.037	4219690	<0.001

Yr 1977	Yr 1998	-0.027	-0.019	-0.032	-0.021	-19.255	4242812	<0.001
Yr 1977	Yr 1999	-0.088	-0.062	-0.094	-0.083	-63.591	4296974	<0.001
Yr 1977	Yr 2000	-0.018	-0.012	-0.024	-0.013	-12.847	4309297	<0.001
Yr 1977	Yr 2001	-0.016	-0.011	-0.022	-0.011	-11.362	4322064	<0.001
Yr 1977	Yr 2002	-0.009	-0.006	-0.014	-0.003	-6.063	4348900	<0.001
Yr 1977	Yr 2003	0.012	0.008	0.006	0.017	7.996	4354258	<0.001
Yr 1977	Yr 2004	0.036	0.024	0.031	0.042	24.949	4303504	<0.001
Yr 1977	Yr 2005	0.067	0.044	0.062	0.072	46.011	4354610	<0.001
Yr 1978	Yr 1979	0.024	0.018	0.018	0.029	16.945	3847401	<0.001
Yr 1978	Yr 1980	0.037	0.027	0.031	0.042	26.496	3923762	<0.001
Yr 1978	Yr 1982	0.044	0.032	0.038	0.049	31.345	3908586	<0.001
Yr 1978	Yr 1983	0.062	0.045	0.056	0.067	44.581	3952815	<0.001
Yr 1978	Yr 1984	0.075	0.054	0.07	0.081	54.293	3972929	<0.001
Yr 1978	Yr 1985	0.084	0.061	0.078	0.089	60.671	4020003	<0.001
Yr 1978	Yr 1986	0.08	0.058	0.074	0.085	58.142	4039009	<0.001
Yr 1978	Yr 1987	0.085	0.061	0.079	0.09	61.687	4056967	<0.001
Yr 1978	Yr 1988	0.08	0.058	0.074	0.085	58.318	4101821	<0.001
Yr 1978	Yr 1989	0.065	0.046	0.059	0.07	46.49	4084484	<0.001
Yr 1978	Yr 1990	0.042	0.03	0.036	0.047	30.007	4082515	<0.001
Yr 1978	Yr 1991	0.019	0.014	0.014	0.024	13.703	4103685	<0.001
Yr 1978	Yr 1992	0.003	0.002	-0.003	0.008	2.052	4109812	0.04
Yr 1978	Yr 1993	-0.024	-0.017	-0.029	-0.019	-17.509	4202572	<0.001
Yr 1978	Yr 1994	-0.029	-0.021	-0.034	-0.023	-20.915	4212913	<0.001
Yr 1978	Yr 1995	-0.04	-0.028	-0.045	-0.034	-28.791	4245876	<0.001
Yr 1978	Yr 1996	-0.042	-0.03	-0.048	-0.037	-30.642	4248837	<0.001
Yr 1978	Yr 1997	-0.032	-0.022	-0.038	-0.027	-23.307	4248211	<0.001
Yr 1978	Yr 1998	-0.033	-0.023	-0.038	-0.027	-23.527	4271333	<0.001
Yr 1978	Yr 1999	-0.094	-0.066	-0.099	-0.089	-68.151	4325495	<0.001
Yr 1978	Yr 2000	-0.024	-0.016	-0.029	-0.019	-17.003	4337818	<0.001
Yr 1978	Yr 2001	-0.022	-0.015	-0.027	-0.017	-15.497	4350585	<0.001
Yr 1978	Yr 2002	-0.014	-0.009	-0.02	-0.009	-10.145	4377421	<0.001
Yr 1978	Yr 2003	0.006	0.004	0	0.011	4.022	4382779	<0.001
Yr 1978	Yr 2004	0.031	0.021	0.025	0.036	21.122	4332025	<0.001
Yr 1978	Yr 2005	0.061	0.041	0.056	0.067	42.324	4383131	<0.001
Yr 1979	Yr 1980	0.013	0.009	0.007	0.019	9.335	3909911	<0.001
Yr 1979	Yr 1982	0.02	0.015	0.014	0.025	14.239	3894735	<0.001
Yr 1979	Yr 1983	0.038	0.028	0.033	0.044	27.355	3938964	<0.001
Yr 1979	Yr 1984	0.052	0.038	0.046	0.057	37.025	3959078	<0.001
Yr 1979	Yr 1985	0.06	0.043	0.054	0.065	43.289	4006152	<0.001
Yr 1979	Yr 1986	0.056	0.04	0.051	0.062	40.729	4025158	<0.001
Yr 1979	Yr 1987	0.061	0.044	0.056	0.067	44.256	4043116	<0.001
Yr 1979	Yr 1988	0.056	0.04	0.051	0.062	40.846	4087970	<0.001
Yr 1979	Yr 1989	0.041	0.029	0.035	0.046	29.327	4070633	<0.001
Yr 1979	Yr 1990	0.018	0.013	0.013	0.024	12.921	4068664	<0.001
Yr 1979	Yr 1991	-0.005	-0.004	-0.01	0.001	-3.356	4089834	0.001
Yr 1979	Yr 1992	-0.021	-0.015	-0.026	-0.015	-14.932	4095961	<0.001
Yr 1979	Yr 1993	-0.048	-0.034	-0.053	-0.042	-34.581	4188721	<0.001
Yr 1979	Yr 1994	-0.053	-0.037	-0.058	-0.047	-37.89	4199062	<0.001

Yr 1979	Yr 1995	-0.063	-0.044	-0.069	-0.058	-45.764	4232025	<0.001
Yr 1979	Yr 1996	-0.066	-0.046	-0.071	-0.061	-47.568	4234986	<0.001
Yr 1979	Yr 1997	-0.056	-0.039	-0.061	-0.051	-40.186	4234360	<0.001
Yr 1979	Yr 1998	-0.056	-0.039	-0.062	-0.051	-40.406	4257482	<0.001
Yr 1979	Yr 1999	-0.118	-0.082	-0.123	-0.112	-84.89	4311644	<0.001
Yr 1979	Yr 2000	-0.048	-0.033	-0.053	-0.042	-33.597	4323967	<0.001
Yr 1979	Yr 2001	-0.046	-0.031	-0.051	-0.04	-32.05	4336734	<0.001
Yr 1979	Yr 2002	-0.038	-0.026	-0.043	-0.033	-26.635	4363570	<0.001
Yr 1979	Yr 2003	-0.018	-0.012	-0.023	-0.013	-12.452	4368928	<0.001
Yr 1979	Yr 2004	0.007	0.005	0.002	0.012	4.74	4318174	<0.001
Yr 1979	Yr 2005	0.038	0.025	0.032	0.043	25.877	4369280	<0.001
Yr 1980	Yr 1982	0.007	0.005	0.001	0.012	4.998	3971096	<0.001
Yr 1980	Yr 1983	0.025	0.018	0.02	0.031	18.22	4015325	<0.001
Yr 1980	Yr 1984	0.039	0.028	0.033	0.044	27.994	4035439	<0.001
Yr 1980	Yr 1985	0.047	0.034	0.042	0.052	34.281	4082513	<0.001
Yr 1980	Yr 1986	0.043	0.031	0.038	0.049	31.672	4101519	<0.001
Yr 1980	Yr 1987	0.048	0.035	0.043	0.054	35.238	4119477	<0.001
Yr 1980	Yr 1988	0.043	0.031	0.038	0.049	31.763	4164331	<0.001
Yr 1980	Yr 1989	0.028	0.02	0.023	0.033	20.262	4146994	<0.001
Yr 1980	Yr 1990	0.005	0.004	0	0.011	3.675	4145025	<0.001
Yr 1980	Yr 1991	-0.018	-0.013	-0.023	-0.012	-12.81	4166195	<0.001
Yr 1980	Yr 1992	-0.034	-0.024	-0.039	-0.028	-24.504	4172322	<0.001
Yr 1980	Yr 1993	-0.061	-0.043	-0.066	-0.055	-44.478	4265082	<0.001
Yr 1980	Yr 1994	-0.065	-0.046	-0.071	-0.06	-47.784	4275423	<0.001
Yr 1980	Yr 1995	-0.076	-0.054	-0.082	-0.071	-55.773	4308386	<0.001
Yr 1980	Yr 1996	-0.079	-0.056	-0.084	-0.074	-57.578	4311347	<0.001
Yr 1980	Yr 1997	-0.069	-0.048	-0.074	-0.064	-50.069	4310721	<0.001
Yr 1980	Yr 1998	-0.069	-0.048	-0.075	-0.064	-50.297	4333843	<0.001
Yr 1980	Yr 1999	-0.131	-0.092	-0.136	-0.125	-95.349	4388005	<0.001
Yr 1980	Yr 2000	-0.061	-0.042	-0.066	-0.055	-43.255	4400328	<0.001
Yr 1980	Yr 2001	-0.059	-0.04	-0.064	-0.053	-41.666	4413095	<0.001
Yr 1980	Yr 2002	-0.051	-0.034	-0.056	-0.046	-36.141	4439931	<0.001
Yr 1980	Yr 2003	-0.031	-0.021	-0.036	-0.026	-21.74	4445289	<0.001
Yr 1980	Yr 2004	-0.006	-0.004	-0.011	-0.001	-4.238	4394535	<0.001
Yr 1980	Yr 2005	0.025	0.017	0.019	0.03	17.183	4445641	<0.001
Yr 1982	Yr 1983	0.018	0.013	0.013	0.024	13.145	4000149	<0.001
Yr 1982	Yr 1984	0.032	0.023	0.026	0.037	22.875	4020263	<0.001
Yr 1982	Yr 1985	0.04	0.029	0.035	0.046	29.109	4067337	<0.001
Yr 1982	Yr 1986	0.036	0.026	0.031	0.042	26.498	4086343	<0.001
Yr 1982	Yr 1987	0.041	0.029	0.036	0.047	30.047	4104301	<0.001
Yr 1982	Yr 1988	0.036	0.026	0.031	0.042	26.571	4149155	<0.001
Yr 1982	Yr 1989	0.021	0.015	0.016	0.027	15.195	4131818	<0.001
Yr 1982	Yr 1990	-0.002	-0.001	-0.007	0.004	-1.317	4129849	0.188
Yr 1982	Yr 1991	-0.025	-0.018	-0.03	-0.019	-17.743	4151019	<0.001
Yr 1982	Yr 1992	-0.041	-0.029	-0.046	-0.035	-29.379	4157146	<0.001
Yr 1982	Yr 1993	-0.068	-0.048	-0.073	-0.062	-49.317	4249906	<0.001
Yr 1982	Yr 1994	-0.072	-0.051	-0.078	-0.067	-52.586	4260247	<0.001
Yr 1982	Yr 1995	-0.083	-0.058	-0.089	-0.078	-60.549	4293210	<0.001

Yr 1982	Yr 1996	-0.086	-0.06	-0.091	-0.08	-62.336	4296171	<0.001
Yr 1982	Yr 1997	-0.076	-0.053	-0.081	-0.071	-54.837	4295545	<0.001
Yr 1982	Yr 1998	-0.076	-0.053	-0.081	-0.071	-55.066	4318667	<0.001
Yr 1982	Yr 1999	-0.138	-0.096	-0.143	-0.132	-99.937	4372829	<0.001
Yr 1982	Yr 2000	-0.068	-0.046	-0.073	-0.062	-47.966	4385152	<0.001
Yr 1982	Yr 2001	-0.066	-0.045	-0.071	-0.06	-46.37	4397919	<0.001
Yr 1982	Yr 2002	-0.058	-0.039	-0.063	-0.053	-40.846	4424755	<0.001
Yr 1982	Yr 2003	-0.038	-0.025	-0.043	-0.033	-26.485	4430113	<0.001
Yr 1982	Yr 2004	-0.013	-0.009	-0.018	-0.008	-9.01	4379359	<0.001
Yr 1982	Yr 2005	0.018	0.012	0.013	0.023	12.325	4430465	<0.001
Yr 1983	Yr 1984	0.013	0.009	0.008	0.019	9.766	4064492	<0.001
Yr 1983	Yr 1985	0.022	0.016	0.016	0.027	15.957	4111566	<0.001
Yr 1983	Yr 1986	0.018	0.013	0.013	0.024	13.304	4130572	<0.001
Yr 1983	Yr 1987	0.023	0.017	0.018	0.028	16.864	4148530	<0.001
Yr 1983	Yr 1988	0.018	0.013	0.013	0.024	13.329	4193384	<0.001
Yr 1983	Yr 1989	0.003	0.002	-0.002	0.008	2.101	4176047	0.036
Yr 1983	Yr 1990	-0.02	-0.014	-0.025	-0.015	-14.478	4174078	<0.001
Yr 1983	Yr 1991	-0.043	-0.03	-0.048	-0.037	-31.011	4195248	<0.001
Yr 1983	Yr 1992	-0.059	-0.042	-0.064	-0.053	-42.681	4201375	<0.001
Yr 1983	Yr 1993	-0.086	-0.061	-0.091	-0.08	-62.853	4294135	<0.001
Yr 1983	Yr 1994	-0.091	-0.064	-0.096	-0.085	-66.08	4304476	<0.001
Yr 1983	Yr 1995	-0.101	-0.071	-0.107	-0.096	-74.112	4337439	<0.001
Yr 1983	Yr 1996	-0.104	-0.073	-0.109	-0.099	-75.88	4340400	<0.001
Yr 1983	Yr 1997	-0.094	-0.066	-0.099	-0.089	-68.289	4339774	<0.001
Yr 1983	Yr 1998	-0.094	-0.066	-0.1	-0.089	-68.525	4362896	<0.001
Yr 1983	Yr 1999	-0.156	-0.109	-0.161	-0.151	-113.667	4417058	<0.001
Yr 1983	Yr 2000	-0.086	-0.059	-0.091	-0.08	-61.178	4429381	<0.001
Yr 1983	Yr 2001	-0.084	-0.057	-0.089	-0.078	-59.543	4442148	<0.001
Yr 1983	Yr 2002	-0.076	-0.051	-0.081	-0.071	-53.931	4468984	<0.001
Yr 1983	Yr 2003	-0.056	-0.037	-0.061	-0.051	-39.437	4474342	<0.001
Yr 1983	Yr 2004	-0.031	-0.021	-0.036	-0.026	-21.738	4423588	<0.001
Yr 1983	Yr 2005	0	0	-0.006	0.005	-0.27	4474694	0.787
Yr 1984	Yr 1985	0.008	0.006	0.003	0.014	6.142	4131680	<0.001
Yr 1984	Yr 1986	0.005	0.004	-0.001	0.01	3.463	4150686	0.001
Yr 1984	Yr 1987	0.01	0.007	0.004	0.015	7.021	4168644	<0.001
Yr 1984	Yr 1988	0.005	0.004	-0.001	0.01	3.45	4213498	0.001
Yr 1984	Yr 1989	-0.011	-0.008	-0.016	-0.005	-7.64	4196161	<0.001
Yr 1984	Yr 1990	-0.033	-0.023	-0.039	-0.028	-24.225	4194192	<0.001
Yr 1984	Yr 1991	-0.056	-0.04	-0.062	-0.051	-40.794	4215362	<0.001
Yr 1984	Yr 1992	-0.072	-0.051	-0.078	-0.067	-52.459	4221489	<0.001
Yr 1984	Yr 1993	-0.099	-0.07	-0.105	-0.094	-72.752	4314249	<0.001
Yr 1984	Yr 1994	-0.104	-0.073	-0.109	-0.099	-75.94	4324590	<0.001
Yr 1984	Yr 1995	-0.115	-0.081	-0.12	-0.11	-84.002	4357553	<0.001
Yr 1984	Yr 1996	-0.117	-0.082	-0.123	-0.112	-85.752	4360514	<0.001
Yr 1984	Yr 1997	-0.108	-0.075	-0.113	-0.102	-78.113	4359888	<0.001
Yr 1984	Yr 1998	-0.108	-0.075	-0.113	-0.103	-78.355	4383010	<0.001
Yr 1984	Yr 1999	-0.169	-0.118	-0.175	-0.164	-123.576	4437172	<0.001
Yr 1984	Yr 2000	-0.099	-0.067	-0.104	-0.094	-70.849	4449495	<0.001

Yr 1984	Yr 2001	-0.097	-0.066	-0.102	-0.092	-69.188	4462262	<0.001
Yr 1984	Yr 2002	-0.09	-0.06	-0.095	-0.084	-63.529	4489098	<0.001
Yr 1984	Yr 2003	-0.069	-0.046	-0.075	-0.064	-48.977	4494456	<0.001
Yr 1984	Yr 2004	-0.045	-0.03	-0.05	-0.039	-31.16	4443702	<0.001
Yr 1984	Yr 2005	-0.014	-0.009	-0.019	-0.009	-9.655	4494808	<0.001
Yr 1985	Yr 1986	-0.004	-0.003	-0.009	0.002	-2.709	4197760	0.007
Yr 1985	Yr 1987	0.001	0.001	-0.004	0.007	0.866	4215718	0.386
Yr 1985	Yr 1988	-0.004	-0.003	-0.009	0.002	-2.747	4260572	0.006
Yr 1985	Yr 1989	-0.019	-0.013	-0.024	-0.014	-13.811	4243235	<0.001
Yr 1985	Yr 1990	-0.042	-0.03	-0.047	-0.037	-30.488	4241266	<0.001
Yr 1985	Yr 1991	-0.065	-0.046	-0.07	-0.059	-47.169	4262436	<0.001
Yr 1985	Yr 1992	-0.081	-0.057	-0.086	-0.075	-58.895	4268563	<0.001
Yr 1985	Yr 1993	-0.108	-0.076	-0.113	-0.102	-79.378	4361323	<0.001
Yr 1985	Yr 1994	-0.112	-0.079	-0.118	-0.107	-82.562	4371664	<0.001
Yr 1985	Yr 1995	-0.123	-0.086	-0.129	-0.118	-90.69	4404627	<0.001
Yr 1985	Yr 1996	-0.126	-0.088	-0.131	-0.121	-92.44	4407588	<0.001
Yr 1985	Yr 1997	-0.116	-0.081	-0.121	-0.111	-84.732	4406962	<0.001
Yr 1985	Yr 1998	-0.116	-0.081	-0.121	-0.111	-84.981	4430084	<0.001
Yr 1985	Yr 1999	-0.178	-0.124	-0.183	-0.172	-130.509	4484246	<0.001
Yr 1985	Yr 2000	-0.108	-0.073	-0.113	-0.102	-77.348	4496569	<0.001
Yr 1985	Yr 2001	-0.106	-0.072	-0.111	-0.1	-75.665	4509336	<0.001
Yr 1985	Yr 2002	-0.098	-0.066	-0.103	-0.093	-69.948	4536172	<0.001
Yr 1985	Yr 2003	-0.078	-0.052	-0.083	-0.073	-55.276	4541530	<0.001
Yr 1985	Yr 2004	-0.053	-0.035	-0.058	-0.048	-37.282	4490776	<0.001
Yr 1985	Yr 2005	-0.022	-0.015	-0.027	-0.017	-15.629	4541882	<0.001
Yr 1986	Yr 1987	0.005	0.004	0	0.01	3.586	4234724	<0.001
Yr 1986	Yr 1988	0	0	-0.005	0.005	-0.027	4279578	0.979
Yr 1986	Yr 1989	-0.015	-0.011	-0.021	-0.01	-11.159	4262241	<0.001
Yr 1986	Yr 1990	-0.038	-0.027	-0.044	-0.033	-27.881	4260272	<0.001
Yr 1986	Yr 1991	-0.061	-0.043	-0.066	-0.056	-44.599	4281442	<0.001
Yr 1986	Yr 1992	-0.077	-0.054	-0.082	-0.072	-56.36	4287569	<0.001
Yr 1986	Yr 1993	-0.104	-0.074	-0.109	-0.099	-76.871	4380329	<0.001
Yr 1986	Yr 1994	-0.109	-0.077	-0.114	-0.104	-80.079	4390670	<0.001
Yr 1986	Yr 1995	-0.12	-0.084	-0.125	-0.114	-88.224	4423633	<0.001
Yr 1986	Yr 1996	-0.122	-0.085	-0.127	-0.117	-89.985	4426594	<0.001
Yr 1986	Yr 1997	-0.112	-0.078	-0.118	-0.107	-82.269	4425968	<0.001
Yr 1986	Yr 1998	-0.113	-0.079	-0.118	-0.107	-82.52	4449090	<0.001
Yr 1986	Yr 1999	-0.174	-0.121	-0.179	-0.169	-128.168	4503252	<0.001
Yr 1986	Yr 2000	-0.104	-0.071	-0.109	-0.099	-74.919	4515575	<0.001
Yr 1986	Yr 2001	-0.102	-0.069	-0.107	-0.097	-73.239	4528342	<0.001
Yr 1986	Yr 2002	-0.094	-0.063	-0.1	-0.089	-67.52	4555178	<0.001
Yr 1986	Yr 2003	-0.074	-0.049	-0.079	-0.069	-52.818	4560536	<0.001
Yr 1986	Yr 2004	-0.049	-0.033	-0.055	-0.044	-34.796	4509782	<0.001
Yr 1986	Yr 2005	-0.019	-0.013	-0.024	-0.013	-13.082	4560888	<0.001
Yr 1987	Yr 1988	-0.005	-0.004	-0.01	0	-3.628	4297536	<0.001
Yr 1987	Yr 1989	-0.02	-0.014	-0.025	-0.015	-14.716	4280199	<0.001
Yr 1987	Yr 1990	-0.043	-0.03	-0.048	-0.038	-31.447	4278230	<0.001
Yr 1987	Yr 1991	-0.066	-0.047	-0.071	-0.06	-48.185	4299400	<0.001

Yr 1987	Yr 1992	-0.082	-0.058	-0.087	-0.077	-59.949	4305527	<0.001
Yr 1987	Yr 1993	-0.109	-0.077	-0.114	-0.104	-80.517	4398287	<0.001
Yr 1987	Yr 1994	-0.114	-0.08	-0.119	-0.108	-83.715	4408628	<0.001
Yr 1987	Yr 1995	-0.124	-0.087	-0.13	-0.119	-91.877	4441591	<0.001
Yr 1987	Yr 1996	-0.127	-0.089	-0.132	-0.122	-93.634	4444552	<0.001
Yr 1987	Yr 1997	-0.117	-0.081	-0.122	-0.112	-85.899	4443926	<0.001
Yr 1987	Yr 1998	-0.117	-0.081	-0.123	-0.112	-86.153	4467048	<0.001
Yr 1987	Yr 1999	-0.179	-0.124	-0.184	-0.174	-131.859	4521210	<0.001
Yr 1987	Yr 2000	-0.109	-0.074	-0.114	-0.104	-78.502	4533533	<0.001
Yr 1987	Yr 2001	-0.107	-0.072	-0.112	-0.102	-76.814	4546300	<0.001
Yr 1987	Yr 2002	-0.099	-0.066	-0.104	-0.094	-71.077	4573136	<0.001
Yr 1987	Yr 2003	-0.079	-0.053	-0.084	-0.074	-56.345	4578494	<0.001
Yr 1987	Yr 2004	-0.054	-0.036	-0.059	-0.049	-38.267	4527740	<0.001
Yr 1987	Yr 2005	-0.023	-0.015	-0.029	-0.018	-16.526	4578846	<0.001
Yr 1988	Yr 1989	-0.015	-0.011	-0.021	-0.01	-11.184	4325053	<0.001
Yr 1988	Yr 1990	-0.038	-0.027	-0.043	-0.033	-27.982	4323084	<0.001
Yr 1988	Yr 1991	-0.061	-0.043	-0.066	-0.056	-44.778	4344254	<0.001
Yr 1988	Yr 1992	-0.077	-0.054	-0.082	-0.072	-56.595	4350381	<0.001
Yr 1988	Yr 1993	-0.104	-0.073	-0.109	-0.099	-77.217	4443141	<0.001
Yr 1988	Yr 1994	-0.109	-0.076	-0.114	-0.104	-80.45	4453482	<0.001
Yr 1988	Yr 1995	-0.12	-0.084	-0.125	-0.114	-88.644	4486445	<0.001
Yr 1988	Yr 1996	-0.122	-0.085	-0.127	-0.117	-90.419	4489406	<0.001
Yr 1988	Yr 1997	-0.112	-0.078	-0.117	-0.107	-82.671	4488780	<0.001
Yr 1988	Yr 1998	-0.113	-0.078	-0.118	-0.107	-82.93	4511902	<0.001
Yr 1988	Yr 1999	-0.174	-0.121	-0.179	-0.169	-128.836	4566064	<0.001
Yr 1988	Yr 2000	-0.104	-0.071	-0.109	-0.099	-75.332	4578387	<0.001
Yr 1988	Yr 2001	-0.102	-0.069	-0.107	-0.097	-73.649	4591154	<0.001
Yr 1988	Yr 2002	-0.094	-0.063	-0.099	-0.089	-67.907	4617990	<0.001
Yr 1988	Yr 2003	-0.074	-0.049	-0.079	-0.069	-53.12	4623348	<0.001
Yr 1988	Yr 2004	-0.049	-0.033	-0.055	-0.044	-34.987	4572594	<0.001
Yr 1988	Yr 2005	-0.019	-0.013	-0.024	-0.013	-13.141	4623700	<0.001
Yr 1989	Yr 1990	-0.023	-0.016	-0.028	-0.018	-16.57	4305747	<0.001
Yr 1989	Yr 1991	-0.046	-0.032	-0.051	-0.04	-33.103	4326917	<0.001
Yr 1989	Yr 1992	-0.062	-0.043	-0.067	-0.056	-44.772	4333044	<0.001
Yr 1989	Yr 1993	-0.089	-0.062	-0.094	-0.083	-64.999	4425804	<0.001
Yr 1989	Yr 1994	-0.093	-0.064	-0.099	-0.088	-68.245	4436145	<0.001
Yr 1989	Yr 1995	-0.104	-0.072	-0.109	-0.099	-76.309	4469108	<0.001
Yr 1989	Yr 1996	-0.107	-0.074	-0.112	-0.102	-78.088	4472069	<0.001
Yr 1989	Yr 1997	-0.097	-0.067	-0.102	-0.092	-70.497	4471443	<0.001
Yr 1989	Yr 1998	-0.097	-0.067	-0.102	-0.092	-70.754	4494565	<0.001
Yr 1989	Yr 1999	-0.159	-0.109	-0.164	-0.154	-116.028	4548727	<0.001
Yr 1989	Yr 2000	-0.089	-0.06	-0.094	-0.083	-63.471	4561050	<0.001
Yr 1989	Yr 2001	-0.087	-0.058	-0.092	-0.081	-61.842	4573817	<0.001
Yr 1989	Yr 2002	-0.079	-0.052	-0.084	-0.074	-56.23	4600653	<0.001
Yr 1989	Yr 2003	-0.059	-0.039	-0.064	-0.054	-41.677	4606011	<0.001
Yr 1989	Yr 2004	-0.034	-0.022	-0.039	-0.029	-23.874	4555257	<0.001
Yr 1989	Yr 2005	-0.003	-0.002	-0.008	0.002	-2.305	4606363	0.021
Yr 1990	Yr 1991	-0.023	-0.016	-0.028	-0.017	-16.48	4324948	<0.001

Yr 1990	Yr 1992	-0.039	-0.027	-0.044	-0.034	-28.165	4331075	<0.001
Yr 1990	Yr 1993	-0.066	-0.046	-0.071	-0.061	-48.199	4423835	<0.001
Yr 1990	Yr 1994	-0.071	-0.049	-0.076	-0.065	-51.514	4434176	<0.001
Yr 1990	Yr 1995	-0.081	-0.056	-0.087	-0.076	-59.536	4467139	<0.001
Yr 1990	Yr 1996	-0.084	-0.058	-0.089	-0.079	-61.348	4470100	<0.001
Yr 1990	Yr 1997	-0.074	-0.051	-0.079	-0.069	-53.831	4469474	<0.001
Yr 1990	Yr 1998	-0.074	-0.051	-0.08	-0.069	-54.079	4492596	<0.001
Yr 1990	Yr 1999	-0.136	-0.093	-0.141	-0.131	-99.273	4546758	<0.001
Yr 1990	Yr 2000	-0.066	-0.044	-0.071	-0.061	-47.061	4559081	<0.001
Yr 1990	Yr 2001	-0.064	-0.043	-0.069	-0.059	-45.472	4571848	<0.001
Yr 1990	Yr 2002	-0.056	-0.037	-0.061	-0.051	-39.932	4598684	<0.001
Yr 1990	Yr 2003	-0.036	-0.024	-0.041	-0.031	-25.451	4604042	<0.001
Yr 1990	Yr 2004	-0.011	-0.007	-0.016	-0.006	-7.818	4553288	<0.001
Yr 1990	Yr 2005	0.02	0.013	0.014	0.025	13.735	4604394	<0.001
Yr 1991	Yr 1992	-0.016	-0.011	-0.021	-0.011	-11.737	4352245	<0.001
Yr 1991	Yr 1993	-0.043	-0.03	-0.048	-0.038	-31.645	4445005	<0.001
Yr 1991	Yr 1994	-0.048	-0.033	-0.053	-0.043	-35.041	4455346	<0.001
Yr 1991	Yr 1995	-0.059	-0.041	-0.064	-0.053	-43.047	4488309	<0.001
Yr 1991	Yr 1996	-0.061	-0.042	-0.066	-0.056	-44.898	4491270	<0.001
Yr 1991	Yr 1997	-0.051	-0.035	-0.057	-0.046	-37.431	4490644	<0.001
Yr 1991	Yr 1998	-0.052	-0.036	-0.057	-0.046	-37.671	4513766	<0.001
Yr 1991	Yr 1999	-0.113	-0.078	-0.118	-0.108	-82.939	4567928	<0.001
Yr 1991	Yr 2000	-0.043	-0.029	-0.048	-0.038	-30.899	4580251	<0.001
Yr 1991	Yr 2001	-0.041	-0.027	-0.046	-0.036	-29.344	4593018	<0.001
Yr 1991	Yr 2002	-0.033	-0.022	-0.039	-0.028	-23.859	4619854	<0.001
Yr 1991	Yr 2003	-0.013	-0.009	-0.018	-0.008	-9.4	4625212	<0.001
Yr 1991	Yr 2004	0.012	0.008	0.006	0.017	8.127	4574458	<0.001
Yr 1991	Yr 2005	0.042	0.027	0.037	0.047	29.741	4625564	<0.001
Yr 1992	Yr 1993	-0.027	-0.019	-0.032	-0.022	-19.756	4451132	<0.001
Yr 1992	Yr 1994	-0.032	-0.022	-0.037	-0.026	-23.198	4461473	<0.001
Yr 1992	Yr 1995	-0.042	-0.029	-0.048	-0.037	-31.168	4494436	<0.001
Yr 1992	Yr 1996	-0.045	-0.031	-0.05	-0.04	-33.042	4497397	<0.001
Yr 1992	Yr 1997	-0.035	-0.024	-0.04	-0.03	-25.633	4496771	<0.001
Yr 1992	Yr 1998	-0.035	-0.024	-0.041	-0.03	-25.868	4519893	<0.001
Yr 1992	Yr 1999	-0.097	-0.067	-0.102	-0.092	-71.048	4574055	<0.001
Yr 1992	Yr 2000	-0.027	-0.018	-0.032	-0.022	-19.29	4586378	<0.001
Yr 1992	Yr 2001	-0.025	-0.017	-0.03	-0.02	-17.765	4599145	<0.001
Yr 1992	Yr 2002	-0.017	-0.011	-0.022	-0.012	-12.334	4625981	<0.001
Yr 1992	Yr 2003	0.003	0.002	-0.002	0.008	2.066	4631339	0.039
Yr 1992	Yr 2004	0.028	0.018	0.023	0.033	19.465	4580585	<0.001
Yr 1992	Yr 2005	0.058	0.038	0.053	0.064	41.058	4631691	<0.001
Yr 1993	Yr 1994	-0.005	-0.003	-0.01	0	-3.565	4554233	<0.001
Yr 1993	Yr 1995	-0.016	-0.011	-0.021	-0.01	-11.58	4587196	<0.001
Yr 1993	Yr 1996	-0.018	-0.012	-0.023	-0.013	-13.517	4590157	<0.001
Yr 1993	Yr 1997	-0.008	-0.006	-0.013	-0.003	-6.107	4589531	<0.001
Yr 1993	Yr 1998	-0.009	-0.006	-0.014	-0.003	-6.334	4612653	<0.001
Yr 1993	Yr 1999	-0.07	-0.048	-0.075	-0.065	-51.978	4666815	<0.001
Yr 1993	Yr 2000	0	0	-0.005	0.005	0.011	4679138	0.991

Yr 1993	Yr 2001	0.002	0.001	-0.003	0.007	1.509	4691905	0.131
Yr 1993	Yr 2002	0.01	0.007	0.005	0.015	6.925	4718741	<0.001
Yr 1993	Yr 2003	0.03	0.02	0.025	0.035	21.429	4724099	<0.001
Yr 1993	Yr 2004	0.055	0.036	0.049	0.06	38.855	4673345	<0.001
Yr 1993	Yr 2005	0.085	0.056	0.08	0.09	60.724	4724451	<0.001
Yr 1994	Yr 1995	-0.011	-0.008	-0.016	-0.006	-7.975	4597537	<0.001
Yr 1994	Yr 1996	-0.013	-0.009	-0.019	-0.008	-9.911	4600498	<0.001
Yr 1994	Yr 1997	-0.003	-0.002	-0.009	0.002	-2.545	4599872	0.011
Yr 1994	Yr 1998	-0.004	-0.003	-0.009	0.001	-2.769	4622994	0.006
Yr 1994	Yr 1999	-0.065	-0.044	-0.07	-0.06	-48.231	4677156	<0.001
Yr 1994	Yr 2000	0.005	0.003	0	0.01	3.499	4689479	<0.001
Yr 1994	Yr 2001	0.007	0.005	0.002	0.012	4.984	4702246	<0.001
Yr 1994	Yr 2002	0.014	0.009	0.009	0.019	10.369	4729082	<0.001
Yr 1994	Yr 2003	0.035	0.023	0.03	0.04	24.812	4734440	<0.001
Yr 1994	Yr 2004	0.059	0.039	0.054	0.065	42.148	4683686	<0.001
Yr 1994	Yr 2005	0.09	0.059	0.085	0.095	63.954	4734792	<0.001
Yr 1995	Yr 1996	-0.003	-0.002	-0.008	0.002	-1.957	4633461	0.05
Yr 1995	Yr 1997	0.007	0.005	0.002	0.012	5.396	4632835	<0.001
Yr 1995	Yr 1998	0.007	0.005	0.002	0.012	5.177	4655957	<0.001
Yr 1995	Yr 1999	-0.054	-0.037	-0.06	-0.049	-40.377	4710119	<0.001
Yr 1995	Yr 2000	0.016	0.011	0.011	0.021	11.347	4722442	<0.001
Yr 1995	Yr 2001	0.018	0.012	0.013	0.023	12.819	4735209	<0.001
Yr 1995	Yr 2002	0.025	0.017	0.02	0.03	18.19	4762045	<0.001
Yr 1995	Yr 2003	0.045	0.03	0.04	0.05	32.648	4767403	<0.001
Yr 1995	Yr 2004	0.07	0.046	0.065	0.075	49.959	4716649	<0.001
Yr 1995	Yr 2005	0.101	0.066	0.096	0.106	71.837	4767755	<0.001
Yr 1996	Yr 1997	0.01	0.007	0.005	0.015	7.33	4635796	<0.001
Yr 1996	Yr 1998	0.01	0.007	0.005	0.015	7.114	4658918	<0.001
Yr 1996	Yr 1999	-0.052	-0.035	-0.057	-0.047	-38.349	4713080	<0.001
Yr 1996	Yr 2000	0.018	0.012	0.013	0.023	13.246	4725403	<0.001
Yr 1996	Yr 2001	0.02	0.013	0.015	0.025	14.711	4738170	<0.001
Yr 1996	Yr 2002	0.028	0.019	0.023	0.033	20.067	4765006	<0.001
Yr 1996	Yr 2003	0.048	0.032	0.043	0.053	34.494	4770364	<0.001
Yr 1996	Yr 2004	0.073	0.048	0.068	0.078	51.758	4719610	<0.001
Yr 1996	Yr 2005	0.104	0.068	0.099	0.109	73.604	4770716	<0.001
Yr 1997	Yr 1998	0	0	-0.005	0.005	-0.221	4658292	0.825
Yr 1997	Yr 1999	-0.062	-0.042	-0.067	-0.057	-45.534	4712454	<0.001
Yr 1997	Yr 2000	0.008	0.005	0.003	0.013	5.993	4724777	<0.001
Yr 1997	Yr 2001	0.01	0.007	0.005	0.015	7.469	4737544	<0.001
Yr 1997	Yr 2002	0.018	0.012	0.013	0.023	12.833	4764380	<0.001
Yr 1997	Yr 2003	0.038	0.025	0.033	0.043	27.236	4769738	<0.001
Yr 1997	Yr 2004	0.063	0.041	0.058	0.068	44.508	4718984	<0.001
Yr 1997	Yr 2005	0.094	0.061	0.089	0.099	66.28	4770090	<0.001
Yr 1998	Yr 1999	-0.061	-0.041	-0.067	-0.056	-45.35	4735576	<0.001
Yr 1998	Yr 2000	0.009	0.006	0.004	0.014	6.218	4747899	<0.001
Yr 1998	Yr 2001	0.011	0.007	0.006	0.016	7.695	4760666	<0.001
Yr 1998	Yr 2002	0.018	0.012	0.013	0.023	13.065	4787502	<0.001
Yr 1998	Yr 2003	0.038	0.025	0.033	0.043	27.485	4792860	<0.001

Yr 1998	Yr 2004	0.063	0.041	0.058	0.068	44.775	4742106	<0.001
Yr 1998	Yr 2005	0.094	0.061	0.089	0.099	66.578	4793212	<0.001
Yr 1999	Yr 2000	0.07	0.046	0.065	0.075	50.976	4802061	<0.001
Yr 1999	Yr 2001	0.072	0.048	0.067	0.077	52.369	4814828	<0.001
Yr 1999	Yr 2002	0.08	0.053	0.075	0.085	57.604	4841664	<0.001
Yr 1999	Yr 2003	0.1	0.065	0.095	0.105	71.927	4847022	<0.001
Yr 1999	Yr 2004	0.125	0.081	0.12	0.13	88.857	4796268	<0.001
Yr 1999	Yr 2005	0.155	0.1	0.15	0.16	110.785	4847374	<0.001
Yr 2000	Yr 2001	0.002	0.001	-0.003	0.007	1.472	4827151	0.141
Yr 2000	Yr 2002	0.01	0.006	0.005	0.015	6.802	4853987	<0.001
Yr 2000	Yr 2003	0.03	0.019	0.025	0.035	21.08	4859345	<0.001
Yr 2000	Yr 2004	0.055	0.035	0.05	0.06	38.232	4808591	<0.001
Yr 2000	Yr 2005	0.085	0.054	0.08	0.09	59.815	4859697	<0.001
Yr 2001	Yr 2002	0.008	0.005	0.003	0.013	5.325	4866754	<0.001
Yr 2001	Yr 2003	0.028	0.018	0.023	0.033	19.585	4872112	<0.001
Yr 2001	Yr 2004	0.053	0.034	0.047	0.058	36.723	4821358	<0.001
Yr 2001	Yr 2005	0.083	0.053	0.078	0.088	58.273	4872464	<0.001
Yr 2002	Yr 2003	0.02	0.013	0.015	0.025	14.237	4898948	<0.001
Yr 2002	Yr 2004	0.045	0.028	0.04	0.05	31.377	4848194	<0.001
Yr 2002	Yr 2005	0.076	0.048	0.071	0.081	52.868	4899300	<0.001
Yr 2003	Yr 2004	0.025	0.016	0.02	0.03	17.224	4853552	<0.001
Yr 2003	Yr 2005	0.056	0.035	0.051	0.061	38.633	4904658	<0.001
Yr 2004	Yr 2005	0.031	0.019	0.026	0.036	21.177	4853904	<0.001