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Sara Kim March 16, 2016

Poverty's Complex Impact on Health: The Validity of Poverty Driven Mortality

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Abstract

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This paper will discuss how poverty in Georgia is associated with different types of mortality, including chronic disease, infectious disease, and injury. By exploring which types of mortality are more or less strongly associated with poverty, policy makers can help address several top causes of death in Georgia, provide better health care accessibility to vulnerable populations, increase accessibility to other socioeconomic and psychosocial resources, and prioritize everyone's right to health. The hypothesis of this project is that poverty is more strongly associated with chronic disease and infectious disease related mortality than with injury related mortality because of poverty's impact on biological risk factors that lead to disease. By investigating how poverty affects disease and injury related mortality, this hypothesis can help future interventions better focus on how poverty related strategies might benefit many areas of health. This project utilizes a robust regression analysis and kitchen sink model to quantify poverty's relationship with different types of mortality and investigate whether poverty maintains its significance when other socioeconomic factors are considered. The results revealed that poverty had more significant positive relationships with mortalities in the chronic disease and infectious disease category than in the injury related mortality categories. By addressing the barriers that poverty produces, policy makers can work towards eliminating this human rights violation and better equalize access for all populations.

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Introduction

Poverty driven mortality is unjustified, inexcusable, and most importantly preventable. Policy makers around the world hold the power to help avert millions of preventable deaths by targeting broader poverty issues in society. Poverty's detrimental impact on health is an injustice to fundamental human rights. The World Health Organization defines health as a "complete state of physical, mental, and social well-being, and not merely the absence of disease or infirmity" (WHO 1948). Yet, globally 400 million individuals lack access to their right to health due to various socioeconomic barriers (World Bank 2015). While technological and medical advances have helped tackle specific diseases and injuries, poverty remains an underlying socioeconomic risk factor to many different causes of death. By targeting poverty in health interventions, policy makers can help address several top causes of death in Georgia, the focus sight of this study, provide better health care accessibility to vulnerable populations, increase accessibility to other socioeconomic and psychosocial resources, and prioritize everyone's right to health.

Diseases of poverty are commonly thought to be infectious diseases such as tuberculosis, malaria, and HIV (Rees 2015), but with the global epidemiological transition from infectious to chronic disease, researchers now clearly observe poverty's relationship to other causes of mortality. Therefore, this paper will discuss how poverty is varyingly associated with different types of mortality, including chronic disease, infectious disease, and injury. By exploring which types of mortality are more or less strongly associated with poverty, policy decisions can better target health interventions to reach as many people as possible. The hypothesis of this project is that poverty is

more strongly associated with chronic disease and infectious disease related mortality than with injury related mortality because of poverty's effect on biological risk factors that lead to disease. By investigating how poverty affects disease and injury related mortality, this hypothesis can help future interventions better focus on how poverty related strategies might benefit specific facets of health.

Social Causation Thesis v. Social Selection Thesis

Poverty can be viewed as a cause or a consequence of poor health. The Social Causation thesis describes poverty as a cause of poor health while the Social Selection thesis, also known as the Health Selection thesis, describes poverty as a consequence of poor health. The Social Causation thesis says that poverty impacts health through intermediate variables such as poor living conditions that are conducive to disease, higher anxiety and stress that have biological implications, and poor access to health services (Vaalavuo 2016). On the other hand, the Social Selection Thesis argues that poor health pushes people into poverty because of frequent unemployment and reduced earnings due to illness and injury (Vaalavuo 2016). The World Health Organization reported that in 2013, 100 million people globally were pushed below the poverty line due to healthcare expenditures alone (2013). In both circumstances, people are marginalized because of the relationship between poverty and poor health, regardless of directionality. In a literature review that was the first of its kind to compile and compare data of the two hypotheses, the authors found both theories had equal presence in research literature from 1994 to 2013 (Kroger, *et. al*. 2015). Additionally, they concluded that both theories were equally represented in studies that focused on socioeconomic factors related to the labor market while the social causation theory was

more heavily represented in studies that focused on socioeconomic factors that related to education and income (Kroger, *et. al*. 2015). While both models have valid arguable points, this project focuses on the Social Causation theory, evaluating how poverty influences health rather than how health influences poverty status.

Epidemiological Transition in United States

In the United States, the global burden of disease has seen a dramatic shift away from infectious diseases and toward an increasing burden of chronic diseases. Improvements in biomedical sciences, public health, and environmental hygiene from the end of the nineteenth century to the present transformed the global burden of disease after relatively stagnant epidemiological trends over the previous centuries (de Flora, *et. al*. 2005). Figure 1 demonstrates the striking transition in causes of mortality that occurred in the United States within less than a century. These shifts changed the way researchers studied health (Marshall Protocol Knowledge Base 2012). Poverty was once associated with increased mortality and morbidity in infectious diseases including tuberculosis, pneumonia, and diarrheal diseases. However, as other causes of mortality increased and infectious diseases became less prevalent, researchers were able to better study and understand the impact of poverty on chronic diseases and injuries. The discovery of

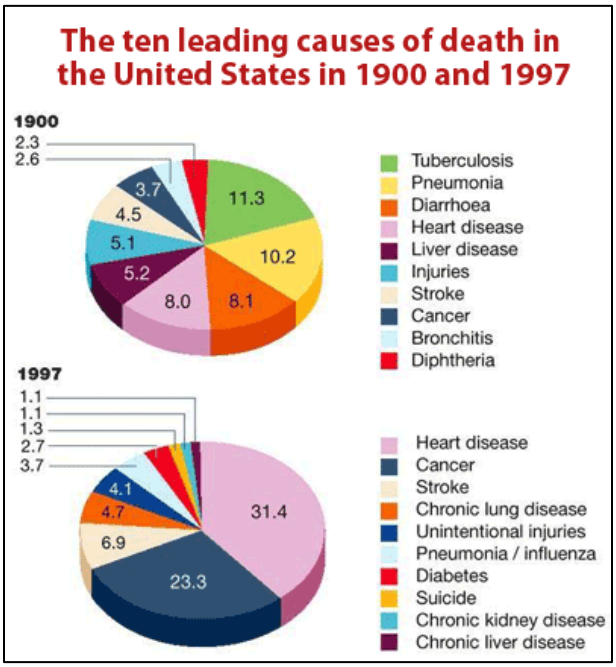

Figure 1: Comparing the top ten causes of death in 1900 and 1997 in U.S. Source: Marshall Protocol Knowledge Base 2012

bacteria and pathogens in the late nineteenth century led to a better understanding of how to combat and prevent infectious diseases; as this understanding led to a fall in infectious disease mortality, life expectancy grew and chronic disease, which becomes more prevalent with age, became the predominant cause of death (de Flora, *et. al.* 2005). Thus, lifestyle factors have become "the modern 'bacteria' of societies" (Singh and Singh 2008). Although chronic diseases are undoubtedly the biggest source of poor health in the United States, another consequence of the fall of infectious disease related mortality is that injury related mortality now rivals infectious disease related mortality. This epidemiological transition of mortality in the United States is important to consider when studying poverty's association with health. Because different types of mortality have become more prevalent overtime, how poverty affects health also may have changed. The epidemiological shift in mortality further demonstrates the need to evaluate how poverty impacts different types of mortality.

History, Trends, and the Progression of Socioeconomic Health Research

The link between non-biological risk factors and health outcomes has an extensive history. In the 1700's, reports of increased cases of breast cancer among nuns in Italy and clustered cases of scrotal cancer among chimney sweeps in Britain were some of the first pieces of evidence of the realization that a relationship between health outcomes and socioeconomic, psychosocial, behavioral, and environmental factors existed (Gibbons 2005). Thereafter, physicians throughout Europe recognized an association between common lifestyle behaviors, especially among the poor which lead to recommendations for societal level interventions to reduce differences in

mortality rates between social classes as epidemiological and scientific evidence regarding the association grew (Gibbons 2005).

The history of conducting research on non-biological factors as exposures to mortality more formally began with the Whitehall Study, which launched in 1967 and was published in 1978 (Wigger 2011). The Whitehall Study was one of the first of its kind to seriously analyze this subject through a long-term cohort study. It ignited an interest in public health to invest in researching the significance of socioeconomic and psychosocial determinants (Bartley et al. 1997). The Whitehall Study followed 18,000 male civil servants in England for 10 years and revealed the relationship between mortality and socioeconomic determinants including income, stress, and social status (Wigger 2011). This cohort study investigated the impact of a stratified environment on an individual's health, comparing the health status between lower and higher-grade civil servants (Wigger 2011). This study found that mortality rates for all causes were higher among lower grade civil servants compared to higher grade civil servants (Wigger 2011). The authors of this study opened an avenue to studying poverty in relation to health and were pioneers in health research for opening discussions regarding the non-biological determinants of disease (Bartley et al. 1997).

Because the first Whitehall Study was so impactful, a similar study derived from it, called Whitehall Study II began its research in 1985, twenty years after the first Whitehall Study began (Marmot, *et. al*. 1991). The second study followed 10,314 male and female working individuals and investigated the association between social classes and a series of specific diseases including heart disease, cancers, lung disease, gastrointestinal disease, depression, suicide, back pain, and more (Marmot, *et. al*.

1991). This research supported the first Whitehall study with more advanced analysis and further revealed the interdependent relationship between occupation, social status, stress, and health, calling on researchers and policy makers to consider job design, social environment, and income inequality when studying health (Marmot, *et. al*. 1991). Whitehall II was extremely impactful because of its long duration, which allowed researchers to better understand both the short term and long-term impacts of non-biological determinants of health.

As the topic of socioeconomic determinants and health became more normalized in public health research following the Whitehall Studies, research that focused on more specific and specialized determinants in relation to health emerged. The late 1990's and the early 2000's saw a dramatic increase in research interest for this topic. The importance of socioeconomic determinants became prominent among health research and contemporary global health issues that the World Health Organization created a Commission on Social Determinants of Health in 2005 (WHO 2015). Decades of research finally culminated in international action that sought to address health disparities through global collaboration, national policy dialogue, and decision-making. During this time, the broad topic of socioeconomic determinants became more stratified, with research shifting to focus on more concrete, specific factors, including but not limited to occupation, education, race, and income. While the United Kingdom's research trends concentrated on occupational status, sociologists in the United States highlighted how racial differences, particularly between black and white populations, contributed to health disparities among races. Between 1990 and 2008, there was a significant increase in published articles that addressed race and health disparities after

1989 (Williams and Sternthal 2010). Regarding economic determinants, income inequality became a powerful yet controversial tool for quantifying health disparities as it emphasized the unequal distribution of wealth and resources, ideal for studying differences in health but criticized for its inaccuracy and difficulty in quantifying (Wilkinson and Pickett 2005). In a literature review of the “most comprehensive list of studies yet compiled” of income determinants and health, seventy eight percent of studies supported associations between income and health (Wilkinson and Pickett 2005). From this review, we infer that most research points to statistically significant relationships between health and a variety of different socioeconomic determinants.

Original component overview:

The original component of this project includes the collection of poverty and mortality county level data in the state of Georgia and statistical analysis, interpretation, and discussion of the association between the two variables. Public health has established that specific socioeconomic determinants affect health, but does not answer how one determinant can varyingly affect different types of health problems. To the best of my knowledge, sufficient research contrasting the varying impact of specific social determinants on different types of diseases or mortalities does not exist within one piece of work. While many different socioeconomic determinants impact mortality, the scope of this paper will focus on poverty but acknowledge other determinants that might interact with poverty to affect mortality. Furthermore, while the impact of poverty on mortality is a global health issue, this project will focus on the state of Georgia. Each calculated association will be interpreted after the statistical analysis, and the following section will provide a discussion of why such associations may or may not exist. This

project strives to discover to what extent poverty matters regarding chronic disease related mortality, infectious disease related mortality, and injury related mortality and why certain types of mortality are more or less influenced by socioeconomic determinants.

Project Scope: Georgia, United States – county level

While poor socioeconomic issues are prevalent globally, this project focuses solely on the state of Georgia and uses county level data for statistical analysis to investigate associations between poverty and mortality. With 159 counties, Georgia has the second most counties of all the states in the United States. Because all data on poverty levels and mortality will be analyzed at the county level, a cross-sectional study design is most appropriate for examining county level data. Cross-sectional studies are observational and do not include time variables. Therefore, the analysis for this project cannot determine causality or directionality of exposure and outcome. However, this study design is still valuable for observing associations between poverty and mortality. This thesis will quantify the impact and significance of poverty on mortality at the population level to discuss potential reasons for why poverty varyingly impacts different types of mortality.

In 2013, twenty seven percent of families in the state of Georgia were living below the poverty line with some counties having only nine percent in poverty and others a high fifty six percent (County Health Rankings 2015). With such a wide range of families living below the poverty line across counties, Georgia serves as an interesting case study to investigate how poverty is associated with mortality. The top ten causes of mortality in Georgia are heart disease, lung cancer, lung disease, stroke,

hypertension, diabetes mellitus, Alzheimer's disease, kidney disease, blood poisoning, and influenza/pneumonia (World Life Expectancy 2015).

While the majority of these causes fall under the chronic disease related mortality category, our analysis will only compare the top three causes of mortality under each category, leading to nine causes of mortality to investigate in total: heart disease, lung cancer, Alzheimer's disease, blood poisoning, influenza/pneumonia, HIV/AIDS, motor vehicle accidents, suicide, and poisoning. This paper will study the association between poverty and heart disease, lung cancer, and Alzheimer's disease under the chronic disease related mortality category. Although lung disease, stroke, hypertension, and diabetes mellitus cause higher rates of mortality than Alzheimer's does, Alzheimer's was included to diversify the diseases under this category. Furthermore, lung disease has very similar causes and risk factors to lung cancer while stroke, hypertension, and diabetes mellitus have very similar causes and risk factors to heart disease; thus, they were not included. Under the infectious disease mortality category, this paper will include blood poisoning, influenza and pneumonia, and HIV/AIDS. These communicable diseases are ranked the top ninth, tenth, and thirty-first causes of mortality in Georgia respectively. This ranking further highlights the epidemiological shift in the United States because excluding blood poisoning and influenza/pneumonia, there are no other infectious diseases in the top thirty causes of death. Finally, the injury related mortality category will include road traffic accidents, suicide, and poisoning by noxious substance which are ranked the top thirteenth, fourteenth, and sixteenth causes of death in the U.S. respectively (World Life Expectancy 2015).

Chronic Disease Related Mortality (Rank)	**Infectious Diseases Related Mortality** (Rank)	**Injury Related Mortality** (Rank)
Heart Disease (1)	Blood Poisoning (9)	Road Traffic Accidents (13)
Lung Cancer (2)	Influenza/Pneumonia (10)	Suicide (14)
Alzheimer's Disease (6)	HIV/AIDS (31)	Poisoning (16)

Table 1: Shows causes of death included in this project under what mortality category they belong in. Next to each cause of death is its rank in the U.S. top causes of death for 2015.

Methods:

Poverty is an incredibly complex health determinant to quantify its effect on mortality. Many other determinants impact poverty, including but not limited to education, unemployment, income inequality, and insurance status. Despite its complexities, poverty has an extreme influence on one's health because it influences accessibility to essential resources, healthy lifestyle factors, and living conditions (Mukherjee 2013). Because of poverty's importance to health, we use the Census Bureau's threshold poverty level as a proxy to measure the amount of poverty in a county indicated in Figure 2 (2013). From this definition of poverty, the Center for Disease Control (CDC) calculated the poverty rate for each county in Georgia to find

Size of family unit	Weighted average thresholds	Related children under 18 years								
		None	One	Two	Three	Four	Five	Six	Seven	Eight or more
One person (unrelated individual)	11,888									
Under 65 years	12,119	12,119								
65 years and over	11,173	11,173								
Two people	15,142									
Householder under 65 years	15,679	15,600	16,057							
Householder 65 years and over	14,095	14,081	15,996							
Three people	18,552	18,222	18,751	18,769						
Four people	23,834	24,028	24,421	23,624	23,707					
Five people	28,265	28,977	29,398	28,498	27,801	27,376				
Six people	31,925	33,329	33,461	32,771	32,110	31,128	30,545			
Seven people	36,384	38,349	38,588	37,763	37,187	36,115	34,865	33,493		
Eight people	40,484	42,890	43,269	42,490	41,807	40,839	39,610	38,331	38,006	
Nine people or more	48,065	51,594	51,844	51,154	50,575	49,625	48,317	47,134	46,842	45,037

Source: U.S. Census Bureau.

Figure 2: Census Bureau's poverty threshold according to number of people in household, age, and number of dependents. Source: Census Bureau 2013

what percent of households were living under the poverty line. Additionally, education (percent of population without at least a high school education), income inequality (Gini index), unemployment rate, and insurance status (percent of population without insurance) are included in some components of the analysis to capture how these determinants may interact with poverty to impact mortality.

This project will use both linear and non-linear quadratic regression analyses to investigate the relationship between poverty, the independent variable, and mortality, the dependent variable, supporting the Social Causation theory. This investigation includes four different regression analyses. Regression 1 is a simple linear regression looking at poverty's impact on mortality. Regression 2 is a multivariable linear regression that includes two independent variables, with poverty as one of the variables and education as the other. Regression 3 is similarly a multivariable regression with poverty and education, but we analyze poverty as a quadratic non-linear variable. By squaring the variable poverty rate, we can more profoundly understand poverty's impact on mortality beyond a linear relationship, instead revealing whether or not poverty influences mortality at an increasing or decreasing rate. Regression 4 builds on Regression 3 by adding all 5 determinants as independent variables in the multivariable regression.

The calculated coefficient variable from the regressions represents the slope and the direction of the association between poverty and mortality. The interpretation of the reported coefficient is that for everyone one unit increase in the independent variable, the dependent variable increases or decreases by the value of the coefficient depending on whether or not the value is positive or negative. For example, if the coefficient for a

linear regression that shows poverty's impact on the mortality rate for heart disease is 2.1138, then for every one percent increase in poverty, there is a 2.1138 increase in the mortality rate. A p-value of alpha<0.05 under a ninety five percent confidence interval and a p-value of alpha<0.10 under a ninety percent confidence interval will indicate a statistically significant relationship between the independent and dependent variables.

In order to capture poverty's potential quadratic relationship with mortality, we utilize the poverty rate-squared variable. Squaring the variable poverty rate allows us to investigate whether or not poverty impacts mortality at an increasing or decreasing rate rather than just linearly. If the coefficient for the squared term is positive, poverty impacts mortality at an increasing rate while poverty impacts mortality a decreasing rate if that coefficient is negative. One can find at what percentage of poverty does the impact of poverty on mortality start to decrease or increase.

Additionally, this analysis will include a kitchen sink regression model to acknowledge that poverty does not act alone and investigate how other socioeconomic determinants interact with poverty to impact mortality. Because poverty is so intertwined in other socioeconomic factors, this additional layer to the analysis is important to consider as poverty is difficult to isolate as a single socioeconomic factor that impacts mortality. The kitchen sink model first incorporates all five independent variables, poverty, education, unemployment, income inequality, and insurance status in a multivariable regression analysis to investigate their collective effect on mortality. The independent variable with the largest p-value is eliminated, and another multivariable regression is run. This process of elimination followed by a new regression analysis repeats until only one independent variable, the most significant variable related to the

specific mortality, remains. The kitchen sink model helps to determine which variables are most significantly related to mortality when combined with the effects of other related socioeconomic variables.

All regressions are run as robust regressions. All nine causes of mortality included in this study are not homoscedastic but rather show heteroscedastic distributions where the variability of mortality rates is unequal across the range of poverty rates. Adding the robust component adjusts for the data's heteroscedasticity by modifying the standard errors, yielding more accurate regression results.

Results:

** Statistically significant under 95% confidence interval
* Statistically significant under 90% confidence interval

Heart Disease	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + $Poverty^2$ + Education	Poverty + $Poverty^2$ + Education + Unemployment +Income Inequality + Insurance
Poverty	2.1138**	0.5560	9.5409**	7.2427**
$Poverty^2$	-	-	-0.1809**	-0.1630**
Education	-	2.8626**	2.1575**	2.3185**
Unemployment	-	-	-	10.5433**
Income Inequality	-	-	-	-1.0799
Insurance	-	-	-	-0.7501

Table 2: Regression analyses for heart disease

In a simple regression, poverty shows a significant linear relationship with heart disease, but that relationship disappears when adding the impact of education through a multivariable regression in regression 2. However, by introducing $poverty^2$ into the multivariable regression, we see that poverty's significance is re-established in regression 3 because it captures the non-linear association between poverty and mortality. The squared term demonstrates that poverty has a positive impact on heart disease but at a decreasing rate. Regression 4 shows poverty remains a positive significant determinant at a decreasing rate on heart disease even when factoring in unemployment, income inequality, and insurance status.

Lung Cancer	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + $Poverty^2$ + Education	Poverty + $Poverty^2$ + Education + Unemployment +Income Inequality + Insurance
Poverty	0.7215**	-0.2092	1.0050	0.2545
$Poverty^2$	-	-	-0.0247	-0.0174
Education	-	1.6685**	1.5716**	1.6974**
Unemployment	-	-	-	0.6903
Income Inequality	-	-	-	84.6782
Insurance	-	-	-	-0.0464

Table 3: Regression analyses for lung cancer

Poverty demonstrates a significant linear relationship with lung cancer in the simple regression. However, education's added effect on lung cancer in regression 2 shows that poverty no longer has a significant relationship with lung cancer, even when analyzing for a potential quadratic relationship in regression 3. The multivariable regression in regression 4 shows that education continues its significant impact on lung cancer while no other independent variables show significance.

Alzheimer's	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + $Poverty^2$ + Education	Poverty + $Poverty^2$ + Education + Unemployment +Income Inequality + Insurance
Poverty	-0.0620	0.0477	0.9043**	0.9373**
$Poverty^2$	-	-	-0.0097**	-0.0104**
Education	-	0.7612**	0.9722**	0.8964*
Unemployment	-	-	-	0.3969
Income Inequality	-	-	-	75.8276
Insurance	-	-	-	-0.2755

Table 4: Regression analyses for Alzheimer's disease

In regressions 1 and 2 where the association between Alzheimer's disease and poverty is investigated through a simple regression and a multivariable regression with education respectively, poverty shows no significant linear relationship with Alzheimer's disease. On the other hand, poverty does show a non-linear relationship with Alzheimer's with a significant positive association but at a decreasing rate as shown in regression 3. Even when adding unemployment, income inequality, and insurance status into the multivariable regression, poverty still maintains its positive significance at a decreasing rate.

Blood Poisoning	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + Poverty^2 + Education	Poverty + Poverty^2 + Education + Unemployment +Income Inequality + Insurance
Poverty	0.0053	0.1101**	0.5196**	0.5882**
Poverty^2	-	-	-0.0038**	-0.0043**
Education	-	0.8558**	1.0006**	1.2362**
Unemployment	-	-	-	1.1703
Income Inequality	-	-	-	59.4240*
Insurance	-	-	-	-1.3137**

Table 5: Regression analyses for blood poisoning

In a simple linear regression, poverty does not significantly impact blood poisoning. However, when considering poverty and education's combined effect on mortality in a multivariable regression, poverty does show a significant linear relationship at a slope of 0.1101 with blood poisoning. Furthermore, when exploring poverty's non-linear relationship with blood poisoning, poverty demonstrates that it has a positive association with blood poisoning but at a decreasing rate in the multivariable regression in regression 3. Poverty's non-linear relationship continues in regression 4 even with the addition of unemployment, income inequality, and insurance status into the multivariable regression analysis.

Flu/Pneumonia	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + $Poverty^2$ + Education	Poverty + $Poverty^2$ + Education + Unemployment +Income Inequality + Insurance
Poverty	0.4794*	0.1047	1.7043	0.9232
$Poverty^2$	-	-	-0.0351	-0.0320
Education	-	0.7286**	0.5912*	0.5026**
Unemployment	-	-	-	2.5319
Income Inequality	-	-	-	109.2523*
Insurance	-	-	-	-0.6806

Table 6: Regression analyses for Flu/Pneumonia

Poverty shows a significantly positive linear relationship with flu/pneumonia related mortality in a simple regression. However, that significance no longer exists when adding the impact of other related socioeconomic determinants in multivariable regression analyses. Even when investigating a potential non-linear relationship between poverty and flu/pneumonia, no significance is found.

HIV/AIDS	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + $Poverty^2$ + Education	Poverty + $Poverty^2$ + Education + Unemployment +Income Inequality + Insurance
Poverty	0.0290	0.1403	0.7065**	0.5682**
$Poverty^2$	-	-	-0.0110**	-0.0084**
Education	-	-0.2075**	-0.2429**	-0.2390**
Unemployment	-	-	-	-0.3032
Income Inequality	-	-	-	22.2709**
Insurance	-	-	-	0.0709

Table 7: Regression analyses for HIV/AIDS

Poverty does not show a significant linear relationship with HIV/AIDS in both a simple regression as seen in regression 1 and a multivariable regression with education as seen in regression 2. In regression 3, poverty does have a significant non-linear association with HIV/AIDS mortality where it positively impacts mortality at a decreasing rate even with the influence of education. Despite the added potential influence of unemployment, income inequality, and insurance status, regression 4 demonstrates that poverty still maintains its quadratic significance on HIV/AIDS.

Motor Vehicle Accidents	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + $Poverty^2$ + Education	Poverty + $Poverty^2$ + Education + Unemployment +Income Inequality + Insurance
Poverty	0.1739	-0.1474	1.0620	1.3095
$Poverty^2$	-	-	-0.0267	-0.0318
Education	-	0.5893**	0.5157**	0.5091*
Unemployment	-	-	-	2.6377*
Income Inequality	-	-	-	-46.7574
Insurance	-	-	-	-0.7939*

Table 8: Regression analyses for motor vehicle accidents

All 4 regression analyses show that poverty does not have a significant impact on mortality due to motor vehicle accidents. Poverty does not have a linear or a non-linear association with motor vehicle accidents. Furthermore, the added influence of other socioeconomic determinants does not change the non-existing significance of poverty.

Suicide	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + $Poverty^2$ + Education	Poverty + $Poverty^2$ + Education + Unemployment +Income Inequality + Insurance
Poverty	-0.3903**	-0.3724**	0.5576	0.6580
$Poverty^2$	-	-	-0.0189**	-0.0196*
Education	-	-0.0316	-0.1024	-0.1397
Unemployment	-		-	-0.1290
Income Inequality	-		-	-15.5646
Insurance	-		-	0.1209

Table 9: Regression analyses for suicide

In a simple regression shown in regression 1, poverty has a significantly negative linear relationship with suicide. Even when adding the influence of education on suicide related mortality, poverty still maintains its negative significance. Regressions 3 and 4 show that poverty has no non-linear relationship with suicide.

Poisoning	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + $Poverty^2$ + Education	Poverty + $Poverty^2$ + Education + Unemployment +Income Inequality + Insurance
Poverty	-0.0237	0.0672*	0.0924	0.0329
$Poverty^2$	-	-	-0.0005	0.0002
Education	-	-0.1600**	-0.1623**	-0.1582**
Unemployment	-	-	-	-0.1088
Income Inequality	-	-	-	10.4312**
Insurance	-	-	-	0.0408

Table 10: Regression analyses for poisoning

Poverty does not show a significant impact on mortality due to poisoning in a simple regression shown in regression 1. On the other hand, the multivariable analysis with the added effect of education in regression 2 shows that poverty does have a significantly positive linear relationship with poisoning. Incorporating poverty as a squared term reveals that a non-linear relationship between poverty and poisoning does not exist, shown in regressions 3 and 4.

Table 11 displays the result of the kitchen sink model where all 5 socioeconomic determinants, poverty, education, unemployment, income inequality, and insurance status were used in a multivariable linear regression to determine the most significant factor that impacted mortality when all factors are considered. Utilizing the kitchen sink model to evaluate the most significant independent variable among various socioeconomic factors working together reveals that education level, specifically at the high school level, is the strongest socioeconomic determinant to impact all but three

causes of death. Poverty showed significant relationships with various mortalities in the linear, quadratic, simple, and multivariable regression analyses, but the kitchen sink model reveals that poverty is often not the single most impactful socioeconomic determinant among the five independent variables. The full kitchen sink analysis can be found in the Appendix, which shows each variable elimination until the one most significant factor remains for each cause of death.

Cause of Death	Most Significant Factor	Coefficient of Most Significant Factors
Heart Disease	Education	3.2739**
Lung Cancer	Education	1.5144**
Alzheimer's Disease	Education	0.6912**
Blood Poisoning	Education	0.6686**
Flu/Pneumonia	Education	0.7907**
HIV/AIDS	Income Inequality	28.1506**
Motor Vehicle Accidents	Unemployment Rate	2.9177**
Suicide	Poverty	-0.3903**
Poisoning	Education	-0.1100**

Table 11: Results of the kitchen sink model analysis

Poverty does not Act Alone:

The associations found between the poverty and mortality may not be solely attributable to poverty alone. Poverty is intertwined with many other non-biological factors that can also influence health such as education, income inequality, employment status, and insurance status. Interactions between poverty and other related factors do

not discount poverty's impact on mortality, rather they highlight the complexity of singling out poverty as a sole influence on mortality. Table 12 below shows the extent that poverty is related to these specific other factors in Georgia's counties. On a scale of -1 to +1, the higher the correlation coefficient is, the more that poverty and the other factor are related to one another whether positively or negatively. This calculated correlation is not a regression and implies no directionality. Rather, it represents a linear dependence between poverty and one of the other socioeconomic determinants.

Poverty's relationship with:	**Correlation Coefficient**
Education (% of county without high school education)	0.6344
Income Inequality (0-1 Gini Index)	0.6738
Unemployment Rate (% of county unemployed)	0.5781
Uninsured Rate (% of county without insurance)	0.3945

Table 12: Correlation coefficient for association between poverty and other socioeconomic determinant

The relationship between poverty and education is bidirectional, meaning that poverty influences the level of education an individual obtains while at the same time education influences poverty status (Engle and Black 2008). Education and poverty may show a high correlation coefficient of 0.6344 because education also serves as an indicator for mortality risk through income, occupation, psychosocial networks, safety, self-efficacy, and lifestyle behaviors (Montez and Zajacova 2013). In a twenty year study of non-Hispanic white women in the United States, the researchers found that education levels provided a mortality gradient for all causes of death where mortality increased for lower levels of education and decreased for higher levels of education

(Montez and Zajacova 2013). These findings help explain not only why education showed significant relationships throughout all three categories in tables 2 through 10 and why the kitchen sink model demonstrated that education was the most significant factor for 6 of 9 mortalities studied, but also why poverty may not have showed as strong an impact on certain mortalities because its effect may have been convoluted by its close relationship with education. When considering the effect of poverty on a health outcome, one must also consider that education inevitably plays a role in poverty's impact on mortality.

Income inequality puts poverty into a broader context where researchers study areas of poverty compared to wealthier areas within the same geographic region. Therefore, the high positive correlation coefficient of 0.6738 demonstrates that poverty and income inequality are intertwined with each other. While the impact of poverty on health has been widely agreed upon, the impact of income inequality on health has not yet been well established despite its relatively high positive correlation with poverty. Many researchers have found that significant relationships exist between income inequality and health, especially mental health (Lopez 2005). A national level study by Lopez found that in the United States for each one point increase on the Gini Index on a 100 point scale there was a four percent increase in fair or poor health self-reports and income inequality and depression were significantly correlated in the United States (2005). On the other hand, other studies have refuted these claims. For instance, Deaton and Lubotsky found that the relationship between income inequality and mortality of all causes was insignificant across U.S. cities if they controlled for race, specifically the proportion of black people in the population of the city (2009). Moreover,

a study by Fone, *et. al.* reported that income inequality at the neighborhood level was less important to overall health outcomes than income deprivation (2013). These conflicting conclusions may help explain why income inequality's relationship with mortality and its combined effect with poverty on mortality were varied in this analysis, where it served as a significant determinant for some causes of death and not for others. Notably, HIV/AIDS was the only mortality to indicate income inequality as its most significant socioeconomic determinants in the kitchen sink model. A study of the correlation between social structural factors and HIV among men who have sex with men found that higher income inequality was associated with higher AIDS diagnosis rates due to a plausible underinvestment of social and health resources by policy makers in areas of high income inequality (Forsyth and Valdiserri 2015). Although the debate regarding income inequality's impact on health continues, the implications of income inequality should still be considered when studying poverty and mortality because of the close relationship between poverty and income inequality.

Just as education and poverty could be considered bidirectional, employment status and poverty intuitively also influence each other as poverty can lead to less job security while unemployment can lead to poverty due to lack of income. Also, the relationship between poverty and unemployment would likely infer long term unemployment rather than temporary unemployment. Temporary unemployment is less likely to coincide with poverty because a short period without stable income is not enough to push someone into poverty. In a systematic literature review across Medline, EMBASE, and PsychInfo, researchers overall found not only that unemployment was strongly related to worse total health and greater mortality, but also that it was

especially related to mental health outcomes (Kim and von dem Knesebeck 2015). Moreover, a gender-stratified analysis concluded that men were more significantly impacted by unemployment and job insecurity than women were (Kim and von dem Knesebeck 2015). Many studies report that unemployment and motor vehicle related fatalities actually have a negative relationship where more fatalities occur when the unemployment rate is lower. For instance, one study found that less unemployment leads to more road activity which increases the probability of an accident occurring (He 2016), while another study reported that state level unemployment rates were negatively associated with motor vehicle related fatalities between 1980 and 2010 and across all age groups (Silver, *et. al.* 2013). Unemployment status as a risk factor to poorer health outcomes and its relationship with poverty is no less complex than the other socioeconomic factors.

How poverty and insurance influence each other is complex because of Medicaid in Georgia which was passed in 2014. Those who are uninsured are likely to fall in the income gap where they make too much to qualify for Medicaid, but not enough to afford insurance otherwise, assuming that insurance is not offered through their place of employment. This statistical analysis neither demonstrated that insurance status had a significant relationship with health in the multivariable regression, nor a strong correlation with poverty. The low association between insurance status and poverty could be explained by the notion that those with insurance pay less out of pocket and are thus less likely to be pushed below the poverty line according to the social selection thesis discussed in the background section of this paper. However, many peer reviewed articles not only report significant correlations between insurance and other

socioeconomic determinants but also between insurance and health outcomes. For instance using data from the National Health and Nutrition Examination Survey, McClurkin *et. al.* found that insurance status was very strongly associated with age, gender, race, education level, and unemployment (2015). Additionally, insurance coverage was found to be associated with higher vaccine coverage and timely treatment and recovery (McClurkin, *et. al.* 2015). To better understand the impact of insurance on mortality and its combined effect with poverty, future studies should focus on comparing the mortality rates before and after the Affordable Care Act was implemented.

Poverty's correlation with all of these different factors allows us to observe that poverty still remains an important risk factor to specific mortalities despite its interactions with other socioeconomic variables as seen in tables 2 through 10. Through this added layer of analysis, we see that education is most strongly associated with poverty status and would be one of the confounders of greater concern in this project.

Poverty and Chronic Disease

The relationship between poverty and chronic disease is important to explore because of the sheer prevalence of chronic disease burden worldwide after the epidemiological shift from infectious disease towards chronic disease. This section explores possible explanations for poverty's relationship with heart disease, lung cancer, and Alzheimer's disease. Because chronic conditions occur over time, they allow researchers to study how poverty influences the body in the long run. Vaalavuo cites in her study that persistent poverty more adversely influences health than temporary poverty experience does, inferring that long term income more significantly

impacts health than current income (2016). By discussing the biological causes and other risk factors for each disease, we can infer how poverty may impact these risks which lead to disease onset and better understand our results.

Heart disease is caused by damage from narrowed or blocked blood vessels that lead to heart health issues (Mayo Clinic Staff 2015). According to the National Institute of Health, biological factors that contribute to the disease are “carcinogens in cigarettes, high levels of fat and cholesterol in the blood, high blood pressure, high levels of sugar in the blood, and blood vessel inflammation” (NIH 2015). A systematic literature review from 1980 to 2007 revealed evidence that heart disease and socioeconomic determinants are correlated, a relationship largely explained by increasing levels of obesity (Lee and Carrington 2007). In Georgia alone, obesity rates have increased from 10% in 1990 to 30.5% in 2014 while the entire United States has seen similar consistent increases (State of Obesity 2015). Figure 3 shows how obesity rates have dramatically increased over 14 years by state.

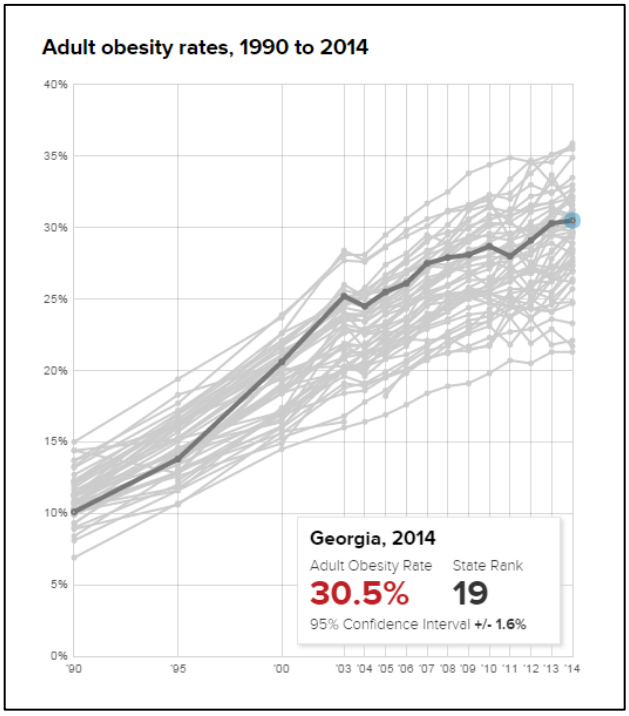

Figure 3: U.S. adult obesity rates by state from 1990 to 2014. Source: State of Obesity 2015

The significant relationships found between heart disease and poverty found in table 2 could be explained by accessibility issues that relate to obesity. Healthier choices often do not exist for those living in poverty, where food deserts diminish access to fresh produce and where the cost of healthier choices is higher than that of

fast food or processed foods (Levine 2011). Furthermore, those living in poverty often do not have the leisure time to exercise regularly because they often must work multiple jobs to keep their families financially stable (Levine 2011).

In addition to poverty's impact on obesity, poverty can influence risk of heart disease through stress. In the United States, the relationship between poverty and heart disease can also be explained by lack of economic opportunity, lower education, and social isolation (Lee and Carrington 2007). Our analysis supports this notion, showing that poverty at a decreasing rate, education, and unemployment all have a significant positive impact on mortality. Furthermore, poverty maintains its significant relationship with mortality even when considering the potential confounding effects of education and unemployment. Lower education levels are correlated with less economic opportunity and more financial hardship, and the struggle to support one's own family can be exhausting mentally and physically (Lee and Carrington 2007). Stress causes increased levels of cortisol in the body, leading to higher blood pressure and higher inflammation which are both biological causes of heart disease (Mayo Clinic Staff 2013). Cortisol can also increase blood sugar levels and alter immune system functions while adrenaline from stress increases heart rate and blood pressure (Mayo Clinic Staff 2013). In a study by Blane and Drever, the authors found a steady increase in heart disease prevalence as social class becomes lower, reporting that unskilled workers had the highest rates of heart disease which could be largely attributed to their lack of economic opportunity (1998). Because poverty impacts many different biological risk factors of heart disease, the strong relationship between poverty and heart disease found in our analysis makes sense.

Lung cancer is caused by damage to the cells in the lungs, and its risk factors include “exposure to carcinogens from smoking and second hand smoke, exposure to radon gas, exposure to asbestos and other possible carcinogens, and potentially family history” (Mayo Clinic Staff 2015). Our simple linear regression quantified poverty’s significant relationship with lung cancer mortality as a 0.7275 increase in mortality rate per one percent increase in poverty. However, multivariable regression analyses show that education’s significant impact on lung cancer invalidates poverty’s significance on lung cancer in both linear and quadratic regressions. Education’s impact on lung cancer could be explained by occupational exposures in jobs requiring less skill and offer an explanation of how lower education levels are related to poverty as seen in table 12. Many lower grade occupations have continuous exposure to various carcinogens, and seventeen to twenty nine percent of all lung cancer cases occur due to occupational exposures (Takala 2015). Because those living in poverty are more likely to have lower levels of education, they are left with little choice but to take jobs that require less skill and may have harmful exposures, leading to higher risk for lung cancer. Jobs with such occupational exposures are likely to be manual labor heavy which often pays less than higher grade jobs.

Regarding smoking, an NIH funded study found a statistically significant correlation between median income level and lung cancer incidence among men in the United States, supporting the notion that poverty is associated with the disease due to higher smoking rates among those with lower income levels (Lehrer, *et.al*. 2014). However, the relationship between median income level and lung cancer disappeared when the authors controlled for smoking, age, and race in a multivariate analysis

(Lehrer, *et. al.* 2014). This signifies that while lower incomes are associated with smoking rates, smoking may be a stronger determinant for lung cancer risk than poverty is. This finding could explain why poverty's significant impact on lung cancer disappeared once education was incorporated. Because of this result, policy makers must be aware that addressing poverty will not effectively reduce lung cancer incidence unless those individuals affected by the intervention stop smoking. While peer-reviewed studies found that a relationship between poverty and lung cancer exists, smoking certainly confounds the effect of poverty on lung cancer.

Alzheimer's disease damages and kills brain cells leading to brain shrinkage and degenerative brain function (National Institute on Aging 2015). While the exact cause of the disease is not known, risk factors include age, genetic make-up, and a combination of environmental and lifestyle factors such as education, diet, and social engagement (National Institute on Aging 2015). Additionally, "family history, sex, mild cognitive impairment, past head trauma, and heart health" have been shown to play a role in the progression of Alzheimer's disease (National Institute on Aging 2015). Because lifestyle and environmental factors can influence the onset of the disease, poverty can have a detrimental impact due to its interwoven relationship with education, diet, and social engagement. Poverty can put individuals at a higher risk for Alzheimer's disease because it typically correlates with lower education levels and consequently less mental stimulation. Furthermore, diet and physical activity, which are proven associations with Alzheimer's disease, are income level-dependent lifestyle factors (Stepkowski *et. al*. 2015). Because those living in poverty are often forced to work more to earn more income, naturally, they have less social engagement with their family and friends and

less opportunity to be involved with the community. While income is associated with Alzheimer's, age has shown to confound the relationship between the two. Knowing that Alzheimer's disease is a strongly age-dependent disease, one study demonstrated that income has a significant but decreasing influence on the onset of Alzheimer's disease as the individual ages (Stepkowski *et. al*. 2015). Ironically, a healthier population may have more incidences of mortality due to Alzheimer's. Alzheimer's is a heavily age related disease, which implies that because more people are dying from Alzheimer's disease, more people are living longer (Mayo Clinic Staff 2014). Alzheimer's disease's heavy association with age may explain why this project did not find any significant linear relationship between poverty and Alzheimer's disease but did find a quadratic association where poverty positively impacted Alzheimer's but at a decreasing rate. This finding is similar to Stepkowski, *et. al.*'s study results. Although higher incidences of Alzheimer's disease may signify a healthier population, poverty's association with the risk factors for the disease shows the potential long-term harmful effects of socioeconomic disparities.

Poverty targeted health interventions would likely help address accessibility issues related to stress and obesity that are major risk factors for heart disease. However, not all diseases were consistently impacted by poverty within the chronic disease mortality category. The main risk factors for lung cancer and Alzheimer's disease, smoking and age respectively, are less affected by poverty targeted interventions such as tax credit reward programs because they are naturally less related. Studies investigating the relationship between poverty and lung cancer have shown that smoking is the main driving factor of lung cancer regardless of poverty

status (Lehrer, *et.al*. 2014). Also, age showed to decrease the effects of poverty on Alzheimer's disease. Nonetheless, chronic diseases still provide insight into the long term impact of poverty on the body through intermediate factors. Poverty's direct influence on stress, diet, education, physical activity, and social engagement illuminate how socioeconomic determinants and chronic disease related mortality are linked.

Poverty and Infectious Disease

Historically in public health research, infectious diseases are seen as more susceptible to socioeconomic disparities at the global scale. Developing countries suffer most from infectious diseases because they lack socioeconomic resources, public health infrastructure, and modern advancements to combat such diseases. Thus, studying the impact of poverty on infectious diseases in the United States, specifically in Georgia, provides an interesting perspective on this topic as communicable diseases no longer strike this region as they once did, as seen in figure 1.

Blood poisoning or sepsis is caused by the presence of bacteria in the blood stream which triggers inflammation throughout the body, possibly leading to multiple organ failure (Mayo Clinic Staff 2014). Sepsis can occur through a variety of transmission pathways including" blood transfusions, preexisting infection complications, mother to baby, hospital infections through surgical wounds, bedsores, and invasive devices such as IV lines, catheters, and breathing tubes" (Mayo Clinic Staff 2014). Risk factors for sepsis include "age, compromised immune system, preexisting illness or injury, and use of invasive devices" (Mayo Clinic Staff 2014). The nature of hospital settings and procedures provide higher risks for sepsis. In the United States, blood poisoning occurs on average 2 of every 100 hospitalizations although not

all lead to mortality (Mayo Clinic Staff 2014). Poverty can increase the chance of blood poisoning because of its effects on compromised immune systems and preexisting infections that lead to complications. A New York neighborhood study found that those living in urban, high poverty areas are more prone to infections such as respiratory diseases, tuberculosis, and colds that make them more vulnerable to sepsis (Mendu 2012). Neighborhood poverty rates were strong predictors of bloodstream infections with an increased risk 1.3 to 1.5 times higher among those living in areas of twenty to forty percent poverty and greater than forty percent poverty compared to those living in areas of less than five percent (Mendu 2012). Both linear and quadratic multivariable regressions revealed that poverty was significantly associated with blood poisoning. Furthermore, the non-linear analysis found that poverty positively impacted blood poisoning at a decreasing rate (table 5). The psychosocial stress that comes with living in poverty can cause inflammation in the body and weaken the immune system, causing people to be more susceptible to infections in general (Mendu 2012).

Because pneumonia most commonly occurs in the United States as an accompaniment of the flu, pneumonia and influenza are characterized as one entity for the purpose of this paper (Mayo Clinic Staff 2015). Influenza is caused by a virus that travels through air droplets that can be transmitted from person to person (Mayo Clinic Staff 2015). The virus is transmitted when an individual inhales those air droplets or transfers those droplets to the eyes, nose, or mouth after touching a surface with the droplets (Mayo Clinic Staff 2015). Risk factors for influenza and pneumonia include “age, crowded and unsanitary living and working conditions, weakened immune systems from immunosuppressant drugs or diseases, preexisting chronic illnesses,

pregnancy, and obesity" (Mayo Clinic Staff 2015). Poverty's impact on obesity has already been discussed in the section regarding heart disease. Poverty's influence on risk factors such as sanitation and household hygiene and contribution towards vaccine coverage disparities relate to poverty's association with flu/pneumonia related mortality. Those in poverty are more likely to live in crowded spaces that have insufficient conditions for sustaining good health.

In a study that investigated 11,512 clinical cases of pneumonia in young children living in Brazil, the researchers explored the relationship between low income and pneumonia risk (Thorn, *et. al.* 2011). They found that specifically the income of the household head and the education level of the mother were inversely associated with the risk of developing pneumonia because they contributed to worse job opportunities and higher levels of poverty (Thorn, *et. al.* 2011). The study reported that in turn, poverty led to worse dietary practices and worse household hygiene, and the mother's low education level correlated with compliance with influenza/pneumonia preventative efforts such as hand washing (Thorn, *et. al.* 2011). Malnutrition due to insufficient income to buy substantially nutritious foods can weaken immune system functions, a direct risk factor for influenza and pneumonia (Mayo Clinic Staff 2015). These examples demonstrate how poverty can affect living conditions and lifestyle factors that are conducive to virus transmission.

Ferguson's study that investigated the relationship between poverty and influenza mortality inequalities found that accessibility to flu vaccines is the biggest impact of economic disparities regarding influenza deaths globally (2006). Additionally, Lee, *et al*. cited unequal vaccine distribution among counties in the District of Columbia

during the H1N1 outbreak in 2009, with wealthier counties receiving more doses more quickly (2011). Despite these explanations for poverty's impact on flu/pneumonia mortality rates, our analysis may not have found any linear or quadratic relationship between poverty and flu/pneumonia at the population level because developed countries have substantially increased their ability to prevent and treat infectious diseases (de Flora, *et. al.* 2005). Therefore, these measures may have caused mortality rates to decrease in spite of any change in poverty. These studies show that poverty has influences on living and working conditions, nutrition, prevention measures, and accessibility to health services, demonstrating how poverty may impact flu and pneumonia mortality.

AIDS is a chronic condition caused by HIV infection which damages the immune system and diminishes its ability to fight off other infections (Mayo Clinic Staff 2015). HIV is transmitted through "sexual contact, contact with infected blood, mother to child during birth, or breastfeeding" (Mayo Clinic Staff 2015). HIV progresses to AIDS when CD4 cell count falls below 200 cells/mm^3, while a normal CD4 count is 500-1200 cells/mm^3 (aids.gov 2015). Risk factors for contracting HIV include "unprotected sex, existence of another sexually transmitted infection, use of intravenous drugs, and uncircumcision" (Mayo Clinic Staff 2015).

Mortality due to HIV has been increasingly hard to study. Many counties in our analysis had zero cases of mortality caused by HIV/AIDS, which could be attributed to the advancement of HIV/AIDS treatment. The introduction of highly active antiretroviral therapy (HAART) in 1995 and 1996 greatly extended life expectancy for those infected with HIV/AIDS (McMahon, *et. al.* 2011). The therapy increased people's survival against

HIV/AIDS, leading them to be more likely to die of other diseases rather than HIV itself (McMahon, *et. al.* 2011). In regards to therapy adherence, one study found that mortality due to HIV correlated with transportation limitations that accompany poverty (Goswami, *et. al*. 2015). Individuals living in households without vehicle ownership showed poorer adherence to medication which affected their chances for survival (Goswami, *et. al*. 2015).

Poverty can affect many aspects of HIV morbidity and mortality both directly and indirectly, and poverty is often the difference between who dies from the disease and who survives. Homelessness, hunger, and lack of education as a result of poverty are strong predictors of HIV related mortality (McMahon, *et. al.* 2011). The state of hunger could have further weakened the immune system while homelessness and lack of education highlight the problem of accessibility. In the same study, poverty itself served as a statistically significant predictor even after controlling for CD4 cell count, HIV viral load, and albumin (McMahon, *et. al.* 2011). Our multivariable analysis found a significant quadratic relationship between poverty and HIV/AIDS where poverty positively impacted HIV/AIDS but at a decreasing rate, supporting the notion of poverty having a decreasing effect if an individual has adequate resources to manage the disease. Our analysis suggests that even with the medical advancement of HAART, poverty undermines efforts to prevent and control the disease and thwarts accessibility to regular and effective treatment.

Poverty's relationship with infectious diseases may highlight a societal accessibility problem where many prevention and treatment measures exist for these diseases, yet those who are most severely impacted by these diseases do not have

access to them. Medical advancements have created greater chances for survival from these diseases, yet those living in poverty are marginalized and are more likely to be excluded from these benefits. Policy aimed at decreasing mortality from infectious diseases should focus on increasing accessibility to such resources for those in poverty.

Poverty and Injury

Injury related mortality provides a unique insight into how poverty affects health and mortality because injury related death is often not directly related to biological risk factors that can be impacted by poverty. Therefore, there is a seemingly increased emphasis on how socioeconomic and psychosocial factors influence mortality in this category. In this category, mental health becomes an important emerging topic as it is more directly associated with suicide and substance abuse which also have biological implications but are less studied and have less definite conclusions. Overall, the injury related mortality category sheds new light on how poverty and health interact.

In 2013 alone, 1,179 motor vehicle related deaths and 116,458 non-fatal injuries occurred in the state of Georgia (GA Highway Safety 2015). These deaths include pedestrians who were struck by motor vehicles. While car accidents are triggered by a series of random events such as distracted driving, drunk driving, or running into the street, broader socioeconomic determinants can influence the risk of mortality due to car accidents. Societal risk factors for increased mortality include “reduced public awareness, lack of

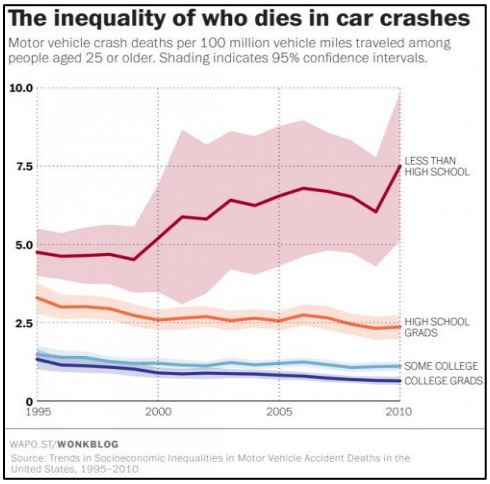

Figure 4: Relationship between education level and mortality by car accident. Source: Knockless 2015

safety measures, high levels of antisocial indices, and poverty" (Pearn 1978). Our analysis showed no significant relationship between poverty and motor vehicle accidents in both simple and multivariable regressions and linear and quadratic regressions. While our analysis did not show that poverty significantly impacted motor vehicle related deaths, many peer-reviewed studies have reported that a significant correlation does exist between the two. Areas of low income may have less safety measures such as street lights, cross walks, and safe road conditions which enhance the risk for motor vehicle related deaths. A study by Knockless found that casualties due to car accidents were higher among low income populations (2015). The study emphasized that education plays a role in car accident risk and contributes to poverty's impact on mortality because of the innate relationship between income and education (2015).

Figure 4 shows the disparity of automobile accident victims by education level, suggesting that education could affect adherence to or general knowledge of traffic safety laws for both drivers and pedestrians, leading to increased mortality among those with less than a high school education (Knockless 2015). More specifically, pedestrian casualties were associated with income of the area and income of the victim, while motor vehicle casualties not including pedestrians only related to income of the victim (Noland, *et.al.* 2013). This suggests that poverty of an area, which would affect the area's government level safety measures and safe road maintenance, more so affects pedestrians. Income of the victim could influence motor vehicle accidents by the model of the car they could afford which may or may not have additional safety measures and their overall education on and adherence to road safety regulations. Regarding motor

vehicle related mortalities, poverty impacts external factors not related to a person's or a population's biological health. Because few biological factors are associated with the risk of motor vehicle accidents, the relationship between poverty and health in this scenario is difficult to connect but is more focused on how poverty impacts external factors such as road conditions, safety measures, and car models rather than any intermediate factors that create a biological response in the body that leads to mortality.

While suicide has many causes, it can be generalized as taking one's own life because one sees it as the only solution to a personal crisis (Mayo Clinic Staff 2015). Risk factors include "social isolation, stressful life event, substance abuse problems, access to means of suicide, underlying psychiatric disorder, family history, and previous attempt" (Mayo Clinic Staff 2015). An individual's mental health status plays a crucial role in suicide. Psychiatric disorders that affect one's mental health can be attributed to biological factors including "physical changes in the brain, brain chemistry, hormones, and inherited traits" (Mayo Clinic Staff 2015). Poverty is intertwined with social isolation and stress which may influence one's vulnerability to "substance abuse, biological changes, and consequently suicide" (Lee and Carrington 2007). Authors of a Japanese study found that higher rates of suicide were associated with increased working hours, decreased leisure time, and lower income in working men (Takeuchi*, et. al.* 2014). The hypothesis of Takeuchi, *et al*.'s study regarding poverty is that poverty forces individuals to have to work more to bring in more income, leading to decreased leisure time and increased social isolation (2014). Another study raises an interesting point of suicide ideation where individuals living in low income communities are more likely to commit suicide or have thoughts of suicide because they are more likely to interact with suicidal

others (Bernburg 2009). While financial stress can have detrimental effects on an individual, it can also impact the community level because such interactions lead to the spread of suicidal ideation. Interestingly, Singh and Singh describe poverty not only as income deprivation but also as optimism deprivation and capability deprivation in their study (2008).

Despite the validity of these peer reviewed studies, our analysis found a significant negative linear relationship between poverty and suicide in both a simple and multivariable regression, suggesting that the less poverty there is in a county, the higher the suicide mortality rate is. Wealthier counties reporting higher suicides rates could be explained by interpersonal comparison which serves as a major factor for overall self-satisfaction (Daly, *et. al.* 2012) A study released by the Federal Reserve Bank of San Francisco determined that people who may be wealthy but compare themselves to their wealthier neighbors reported lower life satisfaction and lower value of future life (Daly, *et. al.* 2012). Such interpersonal comparison and self-perception of relative status has dangerous implications for one's mental well-being. In both scenarios where poverty has a positive or negative relationship with the mortality rate, suicide's connection with mental health emphasizes how both biological factors and socioeconomic environment influence self-perception and are fundamental to one's overall well-being and risk for mortality.

Poisoning is caused by an accidental or intentional overdose of a noxious substance (Mayo Clinic Staff 2015). Accidental poisoning can include "medication in reach of a child, exposure to carbon monoxide, or taking a wrong dose" while intentional overdose may include desiring a high effect (Mayo Clinic Staff 2015). The relationship

between poverty and intentional poisoning related mortality may reveal a larger societal issue that people utilize drugs and alcohol to cope with financial stress. Our analysis found that poverty had a significant positive relationship with poisoning in the linear multivariable regression with poverty and education as the independent variables, but that significance disappeared once unemployment, income inequality, and insurance status were introduced into the regression. Another study found a significant relationship between socioeconomic position and overdose mortality where there were 29.22 more deaths per 100 individuals among the lowest socioeconomic group compared to the highest (Origer 2015). The ideation theory from the suicide discussion could also apply to drug and alcohol use, where individuals in low income communities are more likely to interact with substance abusers leading to a domino effect.

Furthermore, an individual's financial situation may indirectly impact an accidental poisoning occurrence. Parents who are forced to work more cannot supervise their children adequately and may not have access to regular and safe child care, leading to an increased risk for accidents. Houses with lower values may not have safety features that prevent and detect gas leaks while water systems in poorer areas may have improper filters. Because poverty's significance disappeared when other socioeconomic determinants aside from education were added to the regression, we can infer that further research is needed to find which of these factors undermines poverty's impact on poisoning and how it relates to poverty.

Although injury related mortality differs greatly compared to disease related mortality, poverty still may be associated with increased death rates when mental health is incorporated. This evidence reveals that poverty can lead to harmful self-perceptions

and potentially highlight broader infrastructural problems. Furthermore, injury related mortalities are becoming increasingly prevalent in today's society with an increase in traumatic brain injuries, heroin usage, car accidents, homicides, and suicides (CDC Injury Data 2015). Therefore, the importance of studying poverty in relation to injury related mortality also increases.

Limitations

While the original component of this paper found that poverty tended to impact chronic disease and infectious disease more than it did the injury category, the analysis had limitations that could have affected the findings and conclusions of this project. First, the lack of a time variable in this cross sectional analysis did not allow a thorough investigation of the directionality of poverty and mortality. Had time sensitive data been available and utilized, this paper could more securely study poverty as an exposure to mortality rather than as a consequence. The way we ran regressions assumed the validity of the social causation theory and did not investigate how results may have been different if we analyzed the data through the perspective of the social selection theory. Because of the cross-sectional nature of this analysis, determining whether the social selection theory or the social causation theory was true in this scenario was beyond the scope of this project.

Furthermore, the findings may have been different had individual level data been used over county level data. Utilizing individual level data would have yielded more precise results. Some counties in Georgia such as Fulton County have very diverse demographics that could not be conveyed with county level data that generalizes such nuances.

Another limitation of this project was the varying data availability for the different categories of mortality. The chronic disease related data was available for most counties but many counties in the infectious disease category and the injury category had to be excluded. The Georgia State Health Department purposefully did not provide mortality rates for counties that only had one to fpir individual deaths because they would have yielded poor estimates of mortality rates. However, counties with zero deaths due to a specific cause were included as a mortality rate of zero. Because many counties had low counts of mortality in the infectious disease and injury categories, the findings of this project may have been skewed.

The categories of chronic disease, infectious disease, and injury related mortality could have been too broad and led to generalizations that may not apply across all causes of death in a category. Each category has several sub-categories that could be studied for a more accurate conclusion. Had the categories been more specific such as cardiovascular diseases, cancers, sexually transmitted diseases, neurological diseases, respiratory diseases, etc., the project could better investigate how poverty is associated to certain types of illnesses.

Finally, confounding may have occurred because poverty is difficult to isolate when it is intertwined with so many other socioeconomic factors such as education, unemployment, and more. Controlling for these other variables was not feasible because the data that were used was county level rather than individual level. Therefore, the impact or the lack of impact poverty had on certain causes of death may have been overestimated or underestimated. Despite the limitations and challenges faced throughout this project, the findings from this analysis can still be used to consider

how poverty is broadly related to mortality. This information can be used to mobilize further and more specific research on how poverty affects different types of mortality or to help target health policy and interventions.

If I had the opportunity to try this project again, I would make significant changes to the scope of the project and study a different socioeconomic variable instead of poverty. First, I would scale the project at the individual level rather than at the county level in an attempt to make more precise and less generalized conclusions. In order to manage individual level data, I would choose to study just one county or city in Georgia. I would also like to add a time variable to change this project from a cross-sectional analysis to a cohort study design to ensure the forward directionality of a socioeconomic exposure that affects mortality. Following individuals over time to see how their health is gradually or immediately impacted by non-biological determinants would yield a more comprehensive evaluation of the exposure to outcome relationship. Instead of poverty, I would like to study education's impact on mortality because of the findings from the regression analyses of the different socioeconomic determinants and from the kitchen sink multivariable regressions. Over and over again, education at the high school level proved to be significant throughout different categories and was the most significant independent variable in more than half of the mortalities included in this project. In addition, because many different levels of education exist, it would be interesting to include a gradient of education levels and compare how different educational achievements affect mortality. Studying an exposure to outcome relationship is much more complex than I ever would have imagined, but I learned so much about the

process and how significant studying non-biological factors is to understanding health and mortality.

Conclusions:

While investigating the varying impact of poverty on mortality, the analysis of Georgia's county level data revealed that poverty had more significant positive relationships with mortalities in the chronic disease and infectious disease category than in the injury related mortality categories. While finding significant positive relationships in the chronic disease and infectious disease categories was expected, the significant negative relationship with suicide in the injury category was surprising. These results show that health policies that are poverty focused can impact health across categories rather than vertically targeting solely one health outcome.

The relationship between poverty and mortality is largely explained by inaccessibility to resources. Resources not only include tangible items like healthy foods, gym memberships, safer jobs, and vaccines but also non-material factors such as leisure time, mental stimulation, and freedom from chronic stress. In this way, poverty drives health inequalities where some people have easier access to good health, while good health is much more challenging to attain for others. The discussions not only explored how poverty is connected to risk factors of specific mortalities but also how addressing issues of poverty could benefit more than one health outcome. Can efforts to eliminate food deserts, implement stricter safety measures for jobs with harmful exposures, or provide stronger health education to low income communities create more equal distributions of mortality? By addressing the barriers that poverty produces, policy makers can work towards eliminating this human rights violation and

better equalize access for all populations. My research shows that poverty significantly impacts many different aspects of one's accessibility, from healthy foods, to exercise, to disease preventative knowledge, to safe living and working conditions, and to quality healthcare resources. Because every individual deserves the right to health regardless of that person's income level, policy makers must work to eliminate unjust health disparities related to poverty.

Appendix

Figure 1: Marshall Protocol Knowledge Base. (2012, September 9). Incidence and prevalence of chronic disease (MPKB).

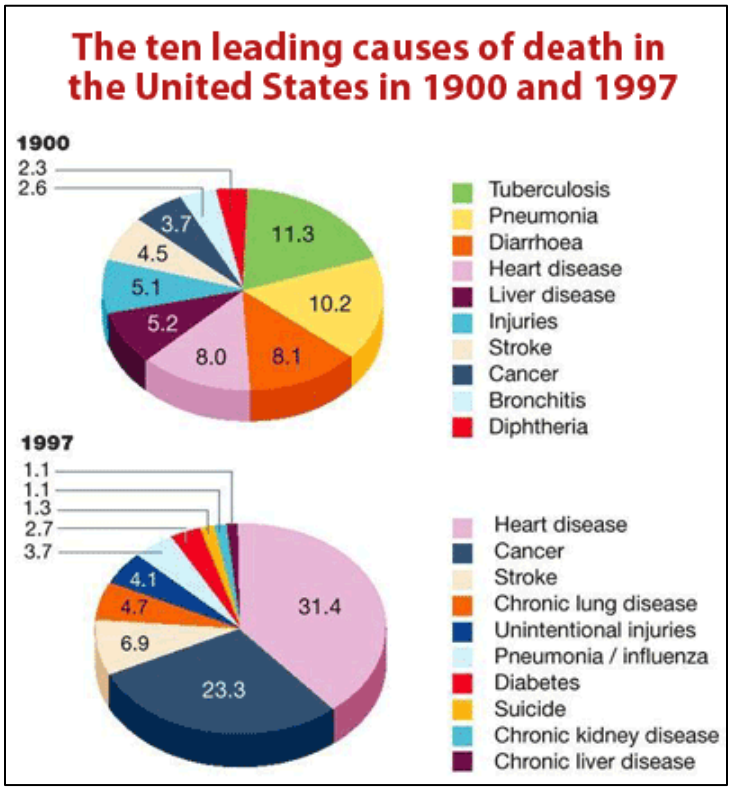

Figure 2: US Census Bureau. (2013). US Census Bureau Poverty Thresholds.

Size of family unit	Weighted average thresholds	Related children under 18 years								
		None	One	Two	Three	Four	Five	Six	Seven	Eight or more
One person (unrelated individual)	11,888									
Under 65 years	12,119	12,119								
65 years and over	11,173	11,173								
Two people	15,142									
Householder under 65 years	15,679	15,600	16,057							
Householder 65 years and over	14,095	14,081	15,996							
Three people	18,552	18,222	18,751	18,769						
Four people	23,834	24,028	24,421	23,624	23,707					
Five people	28,265	28,977	29,398	28,498	27,801	27,376				
Six people	31,925	33,329	33,461	32,771	32,110	31,128	30,545			
Seven people	36,384	38,349	38,588	37,763	37,187	36,115	34,865	33,493		
Eight people	40,484	42,890	43,269	42,490	41,807	40,839	39,610	38,331	38,006	
Nine people or more	48,065	51,594	51,844	51,154	50,575	49,625	48,317	47,134	46,842	45,037

Source: U.S. Census Bureau.

Figure 3: State of Obesity. (2015). The State of Obesity: Obesity data trends and policy analysis.

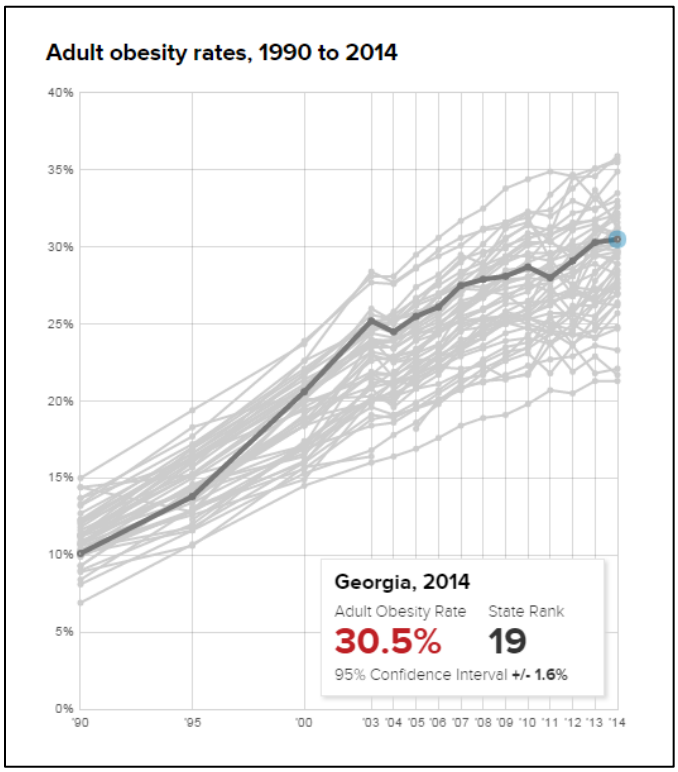

Figure 4: Knockless, T. (2015, October 15). New study shows inequality in deaths from auto accidents.

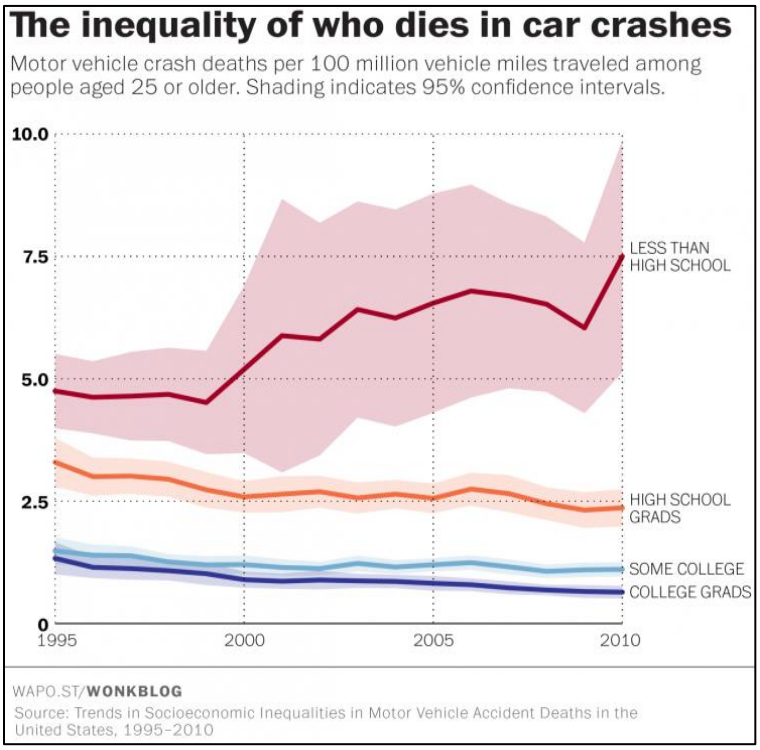

Table 1: Causes of mortality included in the project, their categories, and their rank as a top cause of death in the U.S.

Chronic Disease Related Mortality (Rank)	**Infectious Diseases Related Mortality** (Rank)	**Injury Related Mortality** (Rank)
Heart Disease (1)	Blood Poisoning (9)	Road Traffic Accidents (13)
Lung Cancer (2)	Influenza/Pneumonia (10)	Suicide (14)
Alzheimer's Disease (6)	HIV/AIDS (31)	Poisoning (16)

Table 2: Regression analyses for heart disease

Heart Disease	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + Poverty^2 + Education	Poverty + Poverty^2 + Education + Unemployment +Income Inequality + Insurance
Poverty	2.1138**	0.5560	9.5409**	7.2427**
Poverty^2	-	-	-0.1809**	-0.1630**
Education	-	2.8626**	2.1575**	2.3185**
Unemployment	-	-	-	10.5433**
Income Inequality	-	-	-	-1.0799
Insurance	-	-	-	-0.7501

Table 3: Regression analyses for lung cancer

Lung Cancer	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + $Poverty^2$ + Education	Poverty + $Poverty^2$ + Education + Unemployment +Income Inequality + Insurance
Poverty	0.7215**	-0.2092	1.0050	0.2545
$Poverty^2$	-	-	-0.0247	-0.0174
Education	-	1.6685**	1.5716**	1.6974**
Unemployment	-	-	-	0.6903
Income Inequality	-	-	-	84.6782
Insurance	-	-	-	-0.0464

Table 4: Regression analyses for Alzheimer's

Alzheimer's	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + $Poverty^2$ + Education	Poverty + $Poverty^2$ + Education + Unemployment +Income Inequality + Insurance
Poverty	-0.0620	0.0477	0.9043**	0.9373**
$Poverty^2$	-	-	-0.0097**	-0.0104**
Education	-	0.7612**	0.9722**	0.8964*
Unemployment	-	-	-	0.3969
Income Inequality	-	-	-	75.8276
Insurance	-	-	-	-0.2755

Table 5: Regression analyses for blood poisoning

Blood Poisoning	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + $Poverty^2$ + Education	Poverty + $Poverty^2$ + Education + Unemployment +Income Inequality + Insurance
Poverty	0.0053	0.1101**	0.5196**	0.5882**
$Poverty^2$	-	-	-0.0038**	-0.0043**
Education	-	0.8558**	1.0006**	1.2362**
Unemployment	-	-	-	1.1703
Income Inequality	-	-	-	59.4240*
Insurance	-	-	-	-1.3137**

Table 6: Regression analyses for Flu/Pneumonia

Flu/Pneumonia	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + $Poverty^2$ + Education	Poverty + $Poverty^2$ + Education + Unemployment +Income Inequality + Insurance
Poverty	0.4794*	0.1047	1.7043	0.9232
$Poverty^2$	-	-	-0.0351	-0.0320
Education	-	0.7286**	0.5912*	0.5026**
Unemployment	-	-	-	2.5319
Income Inequality	-	-	-	109.2523*
Insurance	-	-	-	-0.6806

Table 7: Regression analyses for HIV/AIDS

HIV/AIDS	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + $Poverty^2$ + Education	Poverty + $Poverty^2$ + Education + Unemployment +Income Inequality + Insurance
Poverty	0.0290	0.1403	0.7065**	0.5682**
$Poverty^2$	-	-	-0.0110**	-0.0084**
Education	-	-0.2075**	-0.2429**	-0.2390**
Unemployment	-	-	-	-0.3032
Income Inequality	-	-	-	22.2709**
Insurance	-	-	-	0.0709

Table 8: Regression analyses for motor vehicle accidents

Motor Vehicle Accidents	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + $Poverty^2$ + Education	Poverty + $Poverty^2$ + Education + Unemployment +Income Inequality + Insurance
Poverty	0.1739	-0.1474	1.0620	1.3095
$Poverty^2$	-	-	-0.0267	-0.0318
Education	-	0.5893**	0.5157**	0.5091*
Unemployment	-	-	-	2.6377*
Income Inequality	-	-	-	-46.7574
Insurance	-	-	-	-0.7939*

Table 9: Regression analyses for suicide

Suicide	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + Poverty^2 + Education	Poverty + Poverty^2 + Education + Unemployment +Income Inequality + Insurance
Poverty	-0.3903**	-0.3724**	0.5576	0.6580
Poverty^2	-	-	-0.0189**	-0.0196*
Education	-	-0.0316	-0.1024	-0.1397
Unemployment	-		-	-0.1290
Income Inequality	-		-	-15.5646
Insurance	-		-	0.1209

Table 10: Regression analyses for poisoning

Poisoning	Regression 1	Regression 2	Regression 3	Regression 4
	Poverty alone	Poverty + Education	Poverty + Poverty^2 + Education	Poverty + Poverty^2 + Education + Unemployment +Income Inequality + Insurance
Poverty	-0.0237	0.0672*	0.0924	0.0329
Poverty^2	-	-	-0.0005	0.0002
Education	-	-0.1600**	-0.1623**	-0.1582**
Unemployment	-	-	-	-0.1088
Income Inequality	-	-	-	10.4312**
Insurance	-	-	-	0.0408

Table 11: Results of the kitchen sink model analysis

Cause of Death	Most Significant Factor	Coefficient of Most Significant Factors
Heart Disease	Education	3.2739**
Lung Cancer	Education	1.5144**
Alzheimer's Disease	Education	0.6912**
Blood Poisoning	Education	0.6686**
Flu/Pneumonia	Education	0.7907**
HIV/AIDS	Income Inequality	28.1506**
Motor Vehicle Accidents	Unemployment Rate	2.9177**
Suicide	Poverty	-0.3903**
Poisoning	Education	-0.1100**

Complete kitchen sink model analysis:

---

heartdisease = -1.3853pctpoverty + 2.6508pcthighschl** + 12.8089unemployrate** + 45.3297inequality + 0.7531pctuninsured

heartdisease = -1.2297pctpoverty + 2.6163pcthighschl** + 12.7390unemployrate** + 0.8035pctuninsured

heartdisease = -1.1464pctpoverty + 2.7861pcthighschl** + 12.4138unemployrate**

heartdisease = 2.2273pcthighschl** + 9.7267unemployrate**

heartdisease = 3.2739pcthighschl**

---

lungcancer = -0.6645pctpoverty + 1.7350pcthighschl** + 0.9344unemployrate + 90.5064inequality + 0.1138pctuninsured

lungcancer = -0.6547pctpoverty + 1.7595pcthighschl** + 0.8946unemployrate + 91.1352inequality

lungcancer = -0.5428pctpoverty + 1.7805pcthighschl** + 90.4251inequality

lungcancer = 1.4503pcthighschl** + 43.3894inequality

lungcancer = 1.5144pcthighschl**

---

alzheimers = 0.0360pctpoverty + 0.8308pcthighschool* + -0.0261unemployrate + 51.7611inequality + -0.4913pctuninsured

alzheimers = 0.0362pctpoverty + 0.8276pcthighschool* + 51.3867inequality + -0.4899pctuninsured

alzheimers = 0.7603pcthighschool* + 55.5398inequality + -0.4506pctuninsured

alzheimers = 0.7603pcthighschool* + 55.5398inequality + -0.4506pctuninsured

alzheimers = 0.6481pcthighschool** + 47.6939inequality

alzheimers = 0.6912pcthighschool**

---

bloodpoisoning = 0.1309pctpoverty** + 1.1357pcthighschool** + 0.9029unemployrate + 42.2468inequality + -1.3157pctuninsured**

bloodpoisoning = 0.1239pctpoverty* + 1.2178pcthighschool** + 51.2762inequality + -1.3718pctuninsured**

bloodpoisoning = 0.1482pctpoverty** + 1.2870pcthighschool** + -1.2370pctuninsured*

bloodpoisoning = 0.1101pctpoverty** + 0.8558pcthighschool**

bloodpoisoning = 0.6686pcthighschool**

---

flu/pne = -0.6066pctpoverty + 0.8515pcthighschool** + 3.0242unemployrate + 109.3542inequality* + -0.4604pctuninsured

flu/pne = -0.6522pctpoverty + 0.7183pcthighschool** + 3.3117unemployrate + 103.1468inequality*

flu/pne = 0.4998pcthighschool* + 2.2467unemployrate + 48.0103inequality

flu/pne = 0.5154pcthighschool* + 2.5223unemployrate

flu/pne = 0.7907pcthighschool**

---

hivaids = 0.1237pctpoverty* + -0.2159pcthighschool** + -0.2721unemployrate + 25.4531inequality** + 0.1002pctuninsured

hivaids = 0.1186pctpoverty* + -0.1908pcthighschool** + -0.2783unemployrate + 26.6688inequality**

hivaids = 0.0603pctpoverty + -0.1836pcthighschool** + 28.2316inequality**

hivaids = -0.1497pcthighschool** + 32.3216inequality**

hivaids = 28.1506inequality**

---

caraccident = -0.2695pctpoverty* + 0.5108pcthighschool + 3.3290unemployrate** + -40.3081inequality** + -0.4712pctuninsured

caraccident = 0.4296pcthighschool + 2.8932unemployrate** + -64.7371inequality** + -0.5380pctuninsured

caraccident = 0.2510pcthighschool + 3.2249unemployrate** + -76.6199inequality**

caraccident = 3.8218unemployrate** + -76.0991inequality**

caraccident = 2.9177unemployrate**

---

suicide = -0.3967pctpoverty* + 0.1104pcthighschool + 0.2437unemployrate + -6.0946inequality** + 0.3376pctuninsured

suicide = -0.4196pctpoverty** + 0.1023pcthighschool + 0.2253unemployrate + 0.3341pctuninsured

suicide = -0.3958pctpoverty** + 0.0891pcthighschool + 0.3096pctuninsured

suicide = -0.4344pctpoverty** + 0.2434pctuninsured

suicide = -0.3903pctpoverty**

---

poisoning = 0.4432pctpoverty + -0.1586pcthighschool** + -0.1131unemployrate + 10.3851inequality** + 0.0381pctuninsured

poisoning = 0.0503pctpoverty + -0.1502pcthighschool** + -0.1386unemployrate + 10.6040inequality**

poisoning = 0.0302pctpoverty + -0.1502pcthighschool** + 11.4351inequality**

poisoning = -0.1310pcthighschool** + 13.5561inequality**

poisoning = -0.1100pcthighschool**

Table 12: Correlation coefficient for association between poverty and other socioeconomic determinant

Poverty's relationship with:	**Correlation Coefficient**
Education (% of county without high school education)	0.6344
Income Inequality (0-1 Gini Index)	0.6738
Unemployment Rate (% of county unemployed)	0.5781
Uninsured Rate (% of county without insurance)	0.3945

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