THE EFFECTS OF A BROKEN HEART

AN ANALYSIS OF HEART DISEASE AND DEPRESSION

A Thesis

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by

Morgan L. Peschko

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Morgan L. Peschko

Approved by:

_____, Committee Chair
Robert Wassmer, Ph.D.

_____, Second Reader
Sara McClellan, Ph.D.

_____
Date

Student: Morgan L. Peschko

I certify that this student has met the requirements for format contained in the University format manual, and this thesis is suitable for electronic submission to the library and credit is to be awarded for the thesis.

_____, Department Chair _____
Edward Lascher, Ph.D. Date

Department of Public Policy and Administration

Abstract

of

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The United States has the most expensive health care system of the world's developed nations. As of 2012, the U.S. spent $8,233 per person, per year on healthcare, accounting for nearly 18% of the Gross Domestic Product. In California, the healthcare spending growth from 2009 to 2014 outpaced that of the national total. Heart disease was the leading cause of death in the U.S. in 2010, accounting for 25% of all mortalities, and an estimated 17.3 million U.S. adults had at least one major depressive episode in 2017. Systemic improvements to the healthcare system would allow more individuals to get basic care, ensuring that government resources could be spent in ways that result in a higher return on investment.

Existing literature provides a detailed review of depression factors, the connection between heart disease and depression, and outcomes for heart disease patients with depression. Research indicates many factors can affect the expression of depressive symptoms, including a loss of control. Multiple studies examining heart disease and depression report that individuals with heart disease are more likely to report depression than are individuals without heart disease. Moreover, heart disease patients with

depression are more likely to visit the emergency room than are heart disease patients without depression. Early intervention may reduce costs and strain on the healthcare system. However, none of the existing research attempted to control for the endogeneity inherent between heart disease and depression. Endogeneity occurs when the change in a variable is related to other factors that influence the dependent variable and are not accounted for in the model.

I ran regressions with two models to understand the relationship between heart disease, heart failure, and depression. The first binary regressions did not account for endogeneity, and the results indicate that as heart disease worsens to heart failure, the likelihood of being depressed increases significantly. I ran additional probit regressions to account for endogeneity, and found a similar positive relationship indicating the likelihood of being depressed increases as heart disease worsens to heart failure. However, when controlling for endogeneity, the effect of the relationship between heart disease, heart failure, and depression became much smaller.

There is an inherent challenge in teasing apart the root causes for heart disease and depression due to the intricate relationship between the two diseases. I used fast food consumption and soda consumption variables to control for endogeneity in my regressions. Poor diet is correlated with higher rates of depression, but there is often not a clear distinction in the causal chain. There is a large, well-established body of work highlighting the role diet plays in heart health, and research supports that a traditional Mediterranean-type diet reduces the incidence of heart disease.

Because unhealthy lifestyle factors such as poor diet play an important role in the onset of heart disease, which is associated with an increase in the incidence of depression, it is important that policymakers think about how to help make healthier lifestyle habits accessible to all. The relationship between heart disease and depression is complex, but the lifestyle factors that increase the incidence of both are clear. I recommend an increased focus on promoting the integration of healthy lifestyle habits such as eating nutritious foods into the lives of all Californians. Consuming fruits, vegetables, whole grains, fish, olive oil, low-fat dairy, and antioxidants, and avoiding fast food and soda, should be an affordable and available option for every person in California regardless of location or circumstance.

_____, Committee Chair
Robert Wassmer, Ph.D.

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Date

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CHAPTER 1

WHY STUDY HEART DISEASE AS A CAUSE OF DEPRESSION

Introduction

The cost of health care remains a hot topic as we enter the 2020 Presidential election cycle. With drug costs and insurance premiums rising, rural hospitals closing, and nearly 30 million people remaining uninsured despite Affordable Care Act implementation, national surveys consistently find that Americans view the healthcare system as needing a major overhaul (Armour, 2019). The U.S. has the most expensive health care system of the world's developed nations, costing more than twice as much as France, Sweden, and the United Kingdom's health care systems (Kane, 2012).

As of 2012, the U.S. spent $8,233 per person, per year on healthcare, accounting for nearly 18% of the Gross Domestic Product (GDP). In 2014, California spent $7,549 per capita on healthcare (Wilson, 2017). While this is less than the U.S. national average, the spending growth in California from 2009 to 2014 outpaced that of the national total: 4.9% per year in California vs. 3.9% nationally, amounting to 4.0% per capita in California vs. 3.1% nationally (Wilson, 2017). Government actuaries predict that, if our health care spending patterns do not change, nearly 20% of the GDP will be devoted to health care by the year 2026 (Wilson, 2018). The current healthcare usage and spending model is unsustainable. It is time to identify ways of making people healthier to support individual wellbeing and bring down cost premiums. Systemic improvements to the healthcare system would allow more individuals to get basic care, ensuring that government resources would be spent in ways that result in a higher return on investment.

In 2018, the California population totals nearly 40 million, over 12% of the national total (World Population Review, 2018). California is the largest U.S. state by population, meaning changes in health policy effect U.S. spending on health care immediately and can later be adopted by other states to bring spending down even further. Therefore, the purpose of this thesis is to examine the relationship between heart disease and depression to see if a causal relationship exists. If it does, I will then offer policy suggestions regarding how to disrupt the relationship between heart disease and depression, in an effort to increase personal wellbeing and potentially reduce health care costs. What I speak of in particular is the prevalence of heart disease and how it can trigger the mental health concern of increased likelihood of minor to severe depression.

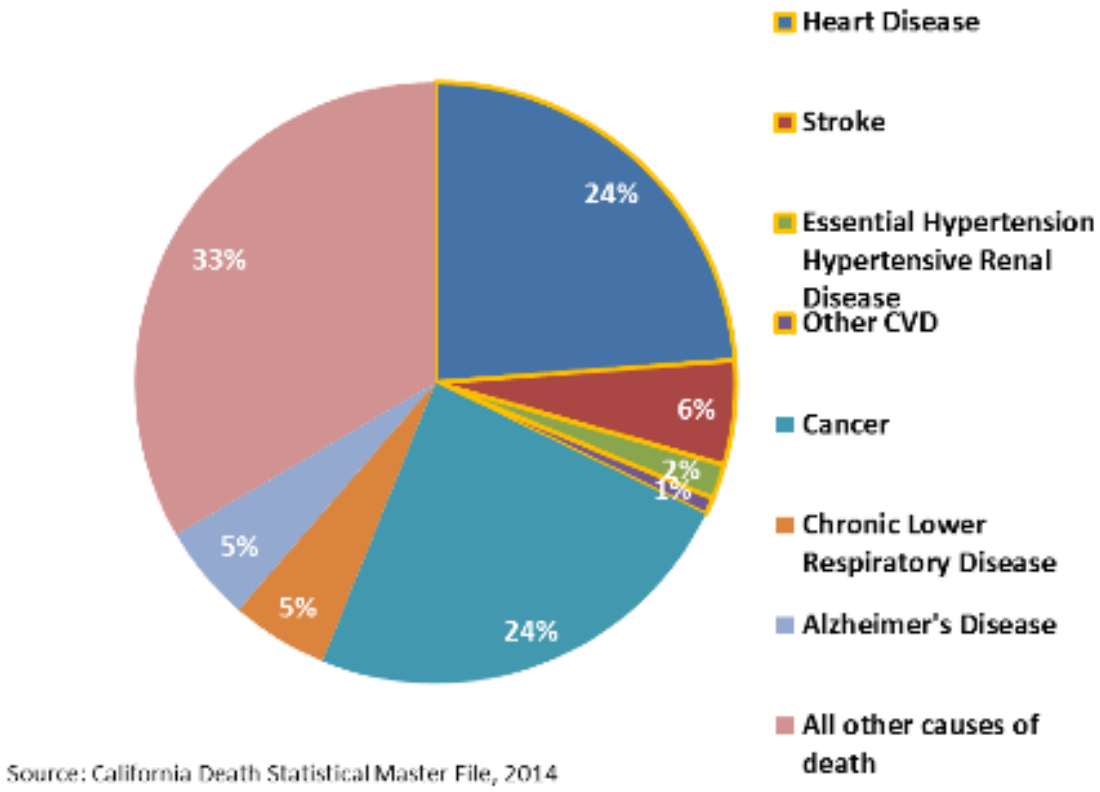
The remainder of this introductory chapter contains four sections. These further describe the relationship between heart disease and depression and outline why this topic warrants exploring. In Section One, I explain the prevalence of heart disease and forms of depression in California and the U.S. Section Two details spending in California and the U.S. to treat heart disease and depression. Section Three covers what others have said about depression resulting from heart disease. In the final Section Four, I provide an overview of the remaining four chapters in this Master's in Public Policy and Administration thesis.

The Prevalence of Heart Disease and Forms of Depression in CA and the United States

Heart disease was the leading cause of death in the U.S. in 2010, accounting for 25% of all mortalities (American Heart Association, 2013). According to the National

Institute of Mental Health, an estimated 17.3 million adults in the U.S. had at least one major depressive episode in 2017. Due to the potential for reform and cost savings, the relationship between heart disease and depression is worth examining. Matching the national trend, heart disease was also the leading cause of death in California in 2014, accounting for 24% of all mortalities (California Department of Public Health, 2016).

Figure 1: Cardiovascular Disease as a Leading Cause of Death in California, 2014



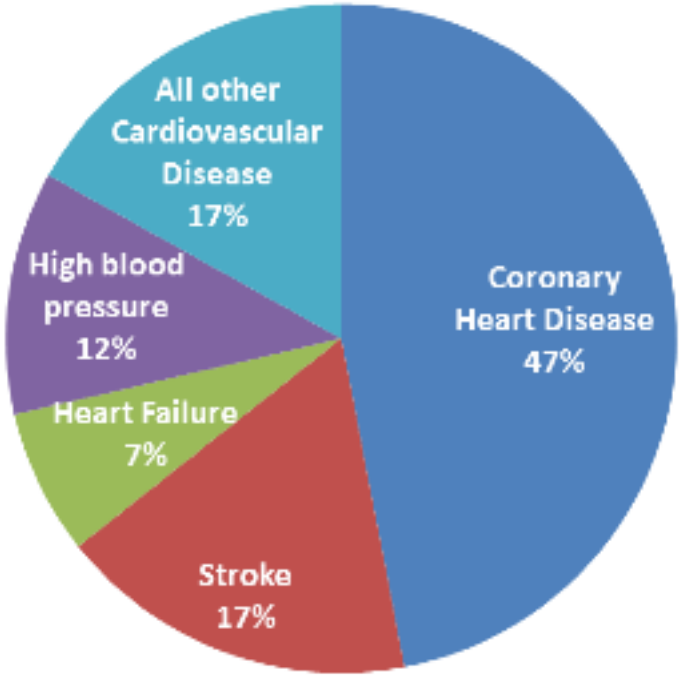
Source: California Department of Public Health. (2016). *Burden of Cardiovascular Disease in California*.

Further, the majority of deaths attributable to cardiovascular disease were caused by a combination of Coronary Heart Disease (47%) and Heart Failure (7%) (see Figure 2, California Department of Public Health, 2016). Nearly one in three adults in California have a form of cardiovascular disease, and the likelihood of developing heart disease increases with age: more than one in four Californians aged 75 years or older have been diagnosed with some form of heart disease. The term heart disease includes a range of conditions that affect the heart, including coronary heart disease, heart failure, and other forms of valvular, rheumatic, and congenital heart disease (California Department of Public Health, 2016). Heart failure, often referred to as congestive heart failure, occurs when the heart muscle is unable to pump efficiently and may occur as an end-stage of many types of heart disease (California Department of Public Health, 2016).

Coronary Heart Disease is the most common kind of heart disease, consisting of chest pain and heart attack. Nearly 10% of Californians aged 65 or older have experienced a heart attack and over 6% of people in this same age group have heart failure (California Department of Public Health, 2016). The prevalence of hospitalizations for heart attack in California has remained consistent over the last decade, and heart failure is the leading cause of hospitalization for adults aged 65 years or older. Deaths resulting from heart failure in California increased from 2000 to 2014 which is consistent with the national trend (see Figure 3, California Department of Public Health, 2016).

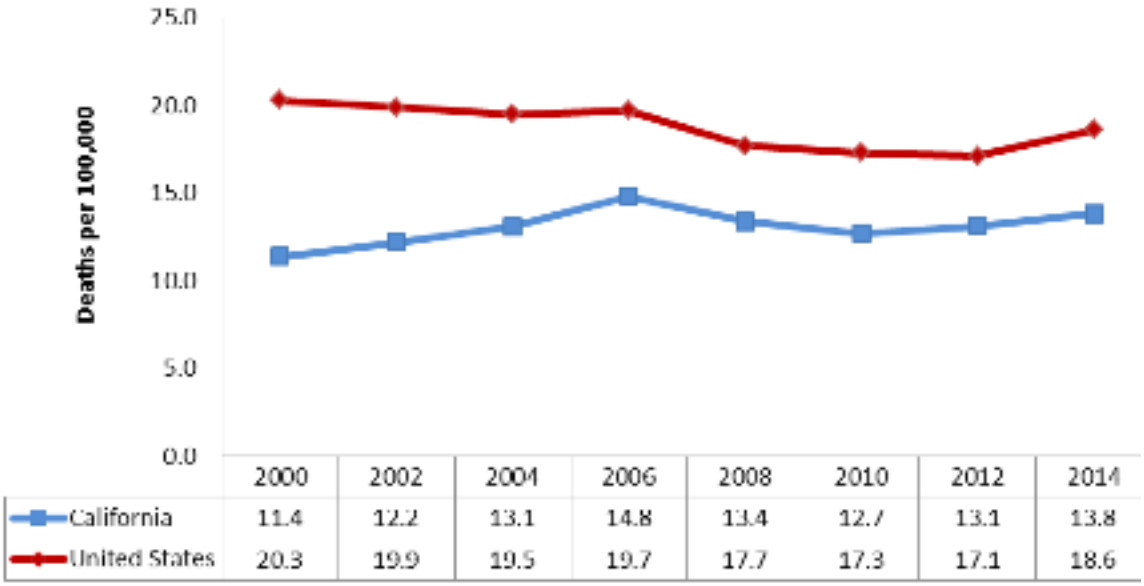
The prevalence of Coronary Heart Disease and Heart Failure in California is too significant to ignore. Depression levels in California are also high and warrant further examination.

Figure 2: Percentage Breakdown of Deaths Attributable to Cardiovascular Disease, California, 2014



Source: California Department of Public Health. (2016). *Burden of Cardiovascular Disease in California*.

Figure 3: Age-Adjusted Heart Failure Mortality in California and the United States, 2000-2014



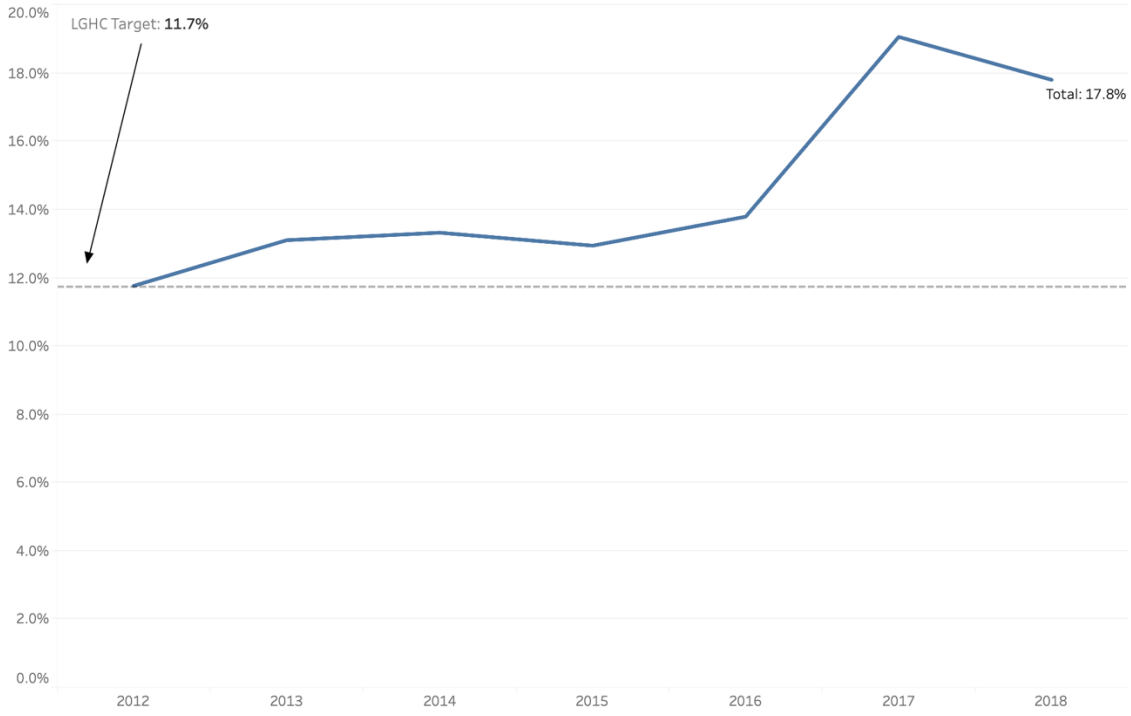
	2000	2002	2004	2006	2008	2010	2012	2014
California	11.4	12.2	13.1	14.8	13.4	12.7	13.1	13.8
United States	20.3	19.9	19.5	19.7	17.7	17.3	17.1	18.6

Source: California Department of Public Health. (2016). *Burden of Cardiovascular Disease in California*.

Depression, also known as major depressive disorder, is a serious medical illness that negatively affects how one feels, thinks and acts, and consists of experiencing prolonged symptoms such as sadness, loss of interest in activities once enjoyed, changes in appetite, trouble sleeping or sleeping too much, increased fatigue, difficulty thinking, or thoughts of suicide or death (American Psychiatric Association, 2017). Depression in California has increased over the last decade, with 11.7% adults told they had a major depressive disorder in 2012 and 17.8% in 2018 (See Figure 4, Let's Get Healthy California, 2019). While the current levels have settled after a peak at 19% in 2018, this net increase of over 6% in six years is troubling. Depression does not discriminate; it effects all adult age ranges, with a slight increase seen as people reach later adulthood. It effects all races, income and education levels. Women tend to experience more depressive episodes than men (Let's Get Healthy California, 2019).

Beyond the major effects that heart disease and depression can have on quality of life, these diseases can also have major effects on the economy. From a loss of economic productivity to budget spent on alleviating symptoms of these diseases, the costs of these diseases put a significant strain on public funds.

Figure 4: Proportion of Adults Who Were Told They Had a Depressive Disorder, Over Time



Source: Let's Get Healthy California. (2019). *Living Well / Reducing Adult Depression*.

CA and United States Health Care Spending to Treat Heart Disease and Depression

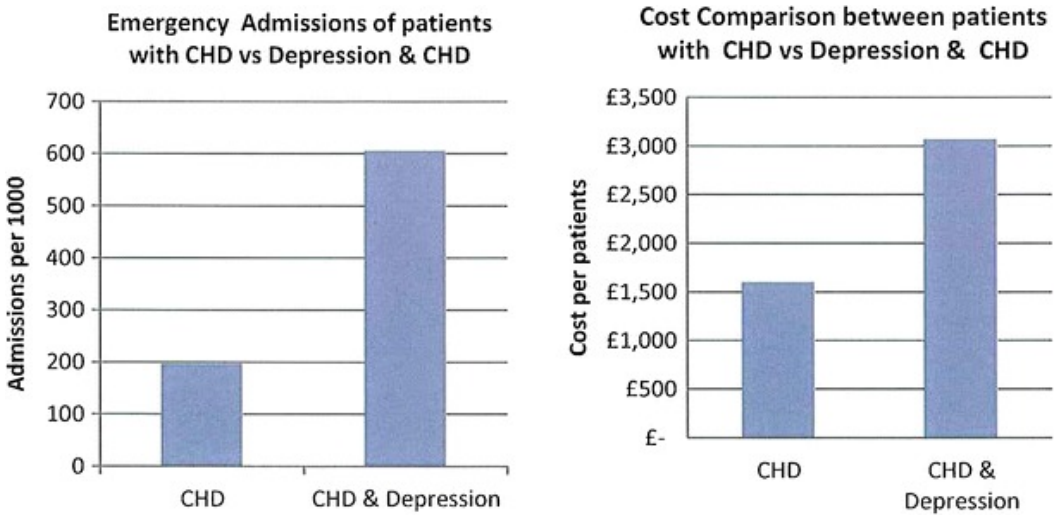
According to the Centers for Disease Control and Prevention (2019a), heart disease costs the U.S. about $200 billion each year. Approximately one in every six healthcare dollars is spent treating cardiovascular disease in the U.S. each year. The CDC Foundation estimates that by 2030, direct medical costs associated with cardiovascular disease could rise to more than $800 billion, with lost productivity rising to over $200 billion annually (Stinson, 2015). Cardiovascular disease is the costliest chronic condition in California, resulting in an estimated $37 billion in direct annual health care costs and an additional $280 billion in indirect costs (California Department of Public Health, 2016).

Depression is also an extremely costly disease, consisting of both direct and indirect costs. Published in the Scientific American, an estimate generated using a nationally representative federal survey and administrative claims data approximated that depression cost the U.S. at least $210 billion in the year 2015 (Greenberg, *et al*. 2015). Forty percent of this figure was associated with actually treating symptoms of the disease, with the other 60% representing indirect costs such as absenteeism from the workplace and reduced productivity while at work. For every dollar spent on the direct costs of major depressive disorder, $1.90 was spent on indirect costs (American Psychiatric Association Foundation, 2019). Given that the prevalence of depression in California adults has risen 6% from 2012 to 2018, it is imperative that researchers explore policy options for mitigating the effects of this disease.

What Others Have Said About Depression Resulting from Heart Disease

Researchers around the world have studied the important role heart disease plays on depression. Ivbijaro, *et al*. (2014) studied collaborative care models for treatment of patients with complex, co-morbid medical and psychiatric conditions, and produced the below bar charts with their findings. Individuals with coronary heart disease and depression were more likely than individuals with just coronary heart disease to go to the emergency room and were costlier to treat overall.

Figure 5: Emergency Admissions and Cost Comparisons between Heart Disease Patients With and Without Depression



Source: Ivbijaro, Enum, Khan, Lam, Gabzdyl. (2014). *Collaborative care: Models for treatment of patients with complex medical-psychiatric conditions*.

A key policy issue to consider is the potential outcome of reduced depression due to reduced levels of heart disease. Sandoiu (2018) writes that heart disease patients with depression were twice as likely to be admitted to the hospital and use the emergency room than those without heart disease and at a low risk for depression. Additionally, those with heart disease and depression had a 54% higher chance of being hospitalized than those without depression and were 43% more likely to use the emergency room. Emergency rooms in California are clogged and taxpayers cover the costly procedures of those who do not have health insurance (Terhune, 2018).

The American Heart Association (2019) reports that cardiovascular disease is the chief global cause of death, leading to more than 17.3 million deaths per year, and it is expected to rise to more than 23.6 million deaths by 2030. The American Heart Association further reports that cardiovascular operations and procedures in the U.S. increased approximately 28% from 2000 to 2010, representing the upward trend of heart disease prevalence due in part to an aging U.S. population. Notably, the Centers for Disease Control (2019b) reports that 11.5% of non-Hispanic white adults and 7.4% of Hispanic adults aged 18 and over had heart disease in 2017. By ethnicity, 38.8% of the total U.S. population is Hispanic, and Hispanics are the largest ethnic group in California.

Recent research suggests that the rate of depression is also increasing. In 2002, an estimated 6.6% of the adult population in the U.S. had experienced a major depressive episode during the preceding 12 months (Kessler, *et al*. 2003). As reported by the National Institute for Mental Health, in 2017 an estimated 7.1% of the adult population in the U.S. had experienced at least one major depressive episode in the preceding 12

months (2019). Given that adults make up 72% of the U.S. population, which consists of over 329 million people, this .5% increase in depression could represent more than 11 million new incidents of individuals suffering from major depressive episodes (United States Census Bureau, 2018). Since California represents more than 12% of the nation's population, there could be an increase of 2 million more people suffering from major depression in 2019 compared to 2002.

An international survey suggests that more than half of heart disease patients have experienced feelings of anxiety or depression, but many are not getting the help they need (Kettle, 2019). The survey found that 58% of respondents living with heart disease reported feeling sad, down or depressed and nearly half of these patients reported a moderate or high need for help, yet 39% of this subset reported that they had not received any help. Several aspects of the heart disease diagnosis reportedly contribute to experiencing depression symptoms, including worries relating to treatment, perceived financial strain, lack of social support, impaired physical function and pain, perception of feeling differently from peers, fear of a recurrence of cardiac events, and uncertainty about quality of life.

The Cleveland Clinic (2019) also reports that fear and uncertainty after a heart disease diagnosis may lead to feelings of depression. The new diagnosis often comes with required lifestyle changes, an increase in prescribed medication, possible surgery, feelings of being overwhelmed, and having thoughts turn more to death after experiencing a life-threatening event such as a heart attack. Patients are urged to seek care from their primary care physician if they experience symptoms of depression for

more than a few weeks, but this article suggests the impetus is on the patient to address symptoms with their doctor which can be a challenging endeavor for individuals experiencing symptoms of withdrawal, difficulty carrying out daily routines, a loss of joy, and suicidal thoughts or feelings.

Since heart disease is the leading cause of death in California, addressing large-scale trends in this population could result in cost savings to the state, changes in mortality rates, and improved public health. Given the bloated and strained health care system in California, any effort to alleviate misuse or overuse could ultimately have important policy and budgetary implications. People with heart disease and depression represent a significant public policy opportunity; effectively addressing or mitigating the effects of depression on heart disease could affect Californians in a multitude of important ways.

The Remainder of the Thesis

In this paper, Chapter 2 provides a literature review on scholarly journals regarding the three themes of (1) factors that cause depression, (2) heart disease as a specific factor in the cause of depression, and (3) outcomes for heart disease patients with depression. My literature review also highlights limitations, potential areas of future study, and what this master's thesis hopes to add to the conversation. This chapter includes a literature review summary table matrix highlighting each article's author, sample characteristics, focus of research, key variables, control variables, and research findings. The existing literature demonstrates that there is a relationship between heart disease, depression, and emergency room usage, highlighting a need to examine existing

policy in addressing depressive symptom heart disease patients and a potential opportunity in establishing a process, should one not already exist.

In Chapter 3, I describe how I use quantitative regression analyses to investigate the causal relationship between heart disease and depression with two models. In the two models, I look at heart disease and heart failure as key explanatory values for depression, the dependent variable. I then describe the variable models that are the basis of the regression analyses, describe the data I use to run the regressions, and highlight the expected direction of effect for each of the specific causes. Next, I offer a table describing each variable, a table providing descriptive statistics, and a table of correlation coefficients between all explanatory variables. I conclude by introducing the binary logistic and probit regressions that I will run in Chapter 4, a description of why I chose these two types regressions, and how I will interpret the results.

Chapter 4 includes a discussion of the binary logistic and probit regressions I run to describe the likelihood of depression in heart disease and heart failure patients. I also discuss the computation of marginal effects that is required after a probit regression in order to interpret the values comparably to the odds ratio in a binary logistic regression. Finally, I describe the role that endogeneity plays in this study and the possible reasons for the magnitude change in the relationship between heart disease and depression that occurs when a study accounts for endogeneity.

Chapter 5 concludes by tying together the results of the literature review in Chapter 2 and the quantitative analysis in Chapters 3 and 4 to address the research question, “do people with heart disease have greater depression? If so, what can be

done?" This chapter includes a summary of the findings, a regression analysis discussion about the endogeneity issue, a logistic findings comparison, and a discussion about the magnitude change when controlling for endogeneity. It concludes with a discussion of public policy implications and recommendations to work towards the ultimate goal of alleviating strain on the health care system and improving the lives of Californians.

CHAPTER 2

LITERATURE REVIEW

The literature review in this section provides context and background for the relationship between heart disease and depression. I examine peer-reviewed journal articles that aim to understand the relationship between heart disease and depression to suggest meaningful policy reforms for the state of California regarding the reduction of the occurrence of depression as it stems from an individual's diagnosis of heart disease. Table 1, contained at the end of this review, offers a condensed review of important articles I found on this subject. In this table I have chosen to draw attention to the specific categories of authors, sample characteristics, focus of research, key explanatory variables, control variables, and research findings, each covered in a column of the table. I chose these categories due to their relevance to formulating a better understand of my own work in this thesis. I refer to the articles in this table throughout this chapter in a manner based upon the three themes: depression factors, the connection between heart disease and depression, and outcomes for heart disease patients with depression. This literature review concludes by identifying lessons learned for my own research.

Depression Factors

Researchers believe two factors that can affect the expression of depressive symptoms are a loss of control and loneliness. In a study aiming to understand the relationship between control and proneness to depression, Burger (1984) administered the Beck Depression Inventory, the Desirability of Control Scale, and the Locus of Control Scales to 99 undergraduate students at a liberal arts university. Those with an internal

locus of control believe that they can influence events and outcomes, while those with an external locus of control believe outside forces control events. As referenced in the below table, statistically significant results at a 95% confidence level support that subjects with a high desire for control and a high external locus of control were 29% more likely to be depressed than subjects with a low desire for control and a high internal locus of control.

Similarly, Cacioppo, *et al.* (2006) examined the relationship between loneliness and depression by giving the Center for Epidemiologic Studies Depression Scale and the revised UCLA Loneliness Scale to a nationally representative sample of people over age 53. The Center for Epidemiologic Studies Depression and the revised UCLA Loneliness Scale indicate reported levels of depression and loneliness, respectively, and the higher the score, the more reported symptoms. When controlling for numerous demographic variables including age, gender, race/ethnicity, education, household income, and marital status, results show with 99% confidence that a one-unit increase in the Loneliness Scale results in an increase of 0.43 more reported depressive symptoms for lower income participants, meaning they have a direct, positive relationship.

Researchers at The Ohio State University obtained data from a National Health Interview Survey to study the incidence of psychological distress in individuals with various levels of heart disease as compared to those without heart disease (Ferketich & Binkley, 2005). Researchers asked participants if they had ever been diagnosed with coronary heart disease (CHD), myocardial infarction (MI), or coronary heart failure (CHF). A psychological distress tool called K6 measured whether participants felt sad,

nervous, restless, hopeless, worthless, or like everything was an effort over the last 30 days. When controlling for numerous demographic factors, a logistic regression revealed that there was a slight increase of psychological distress in patients with CHD, though results were not statistically significant. However, the authors report with 95% confidence that MI patients and CHF patients were two- and three-times as likely to report psychological distress than patients without those conditions, respectively.

Heart disease patients with a high desire for control and a high external locus of control may be especially likely to report depression if they feel their illness is out of their control. Similarly, if heart disease patients lose mobility or independence because of their illness, they may report higher rates of depression. A study examining psychological distress, incidence of loneliness, and relationship with control could illuminate whether heart disease patients who feel a loss of control or increased loneliness are more likely to report depression.

The Connection Between Heart Disease and Depression

Heart failure (HF) is advanced heart disease, and coronary artery disease is the leading cause of HF. Graven, *et al.* (2017) conducted analysis of data on heart failure symptoms, social support, social problem-solving, and depression in heart failure patients aged 55 years and older, in an effort to understand whether HF symptomology, social support, and social problem-solving effect depression symptoms. Researchers measured these characteristics by utilizing the Center for Epidemiological Studies Depression Scale (CES-D), the Heart Failure Symptom Survey, the Interpersonal Support and Evaluation List, the Graven and Grant Social Network Survey, and the Social Problem-Solving

Inventories. When controlling for demographic factors, a logistic regression showed three predictors of depression: being unmarried, high HF symptomology, and perceiving to not belong. As reported in Table 1, unmarried individuals were 2.8 times more likely to be depressed than were married individuals with HF, patients with high HF symptoms were 1.9 times more likely to report depression than those without symptoms, and for one point scored lower on the belonging scale, patients were 1.29 times more likely to be depressed. These results are all statistically significant with 95% confidence, however authors note that a limitation exists. Only 22.4% of the sample scored in the depressed range, meaning the study participants may underrepresent the prevalence of depression given the breadth of evidence that it often exists at a higher rate in HF patients.

German researchers analyzed the incidence rates and predictors of depression in 839 patients with HF (Lossnitzer, *et al.* 2013). All participants received the Patient Health Questionnaire (PHQ-9) and the Short Form Health Survey and were depression-free at the baseline. Participants retook the questionnaire and survey after 12 months, and researchers found nearly 13% of patients had developed minor or major depression during that time. Initial results supported that females had a higher incidence of depression, however a multivariate adjustment revealed this was not significant because females tended to have more advanced HF, had lower physical functioning, and more often reported having a history of depression at baseline. The regression revealed that participants who died during the study reported approximately 30% higher incidence rates of minor or major depression than HF patients who did not die during the study. Similarly, this was due to having more advanced HF, visiting the doctor more frequently,

a frequent previous history of depression, and lower physical functioning scores. As mentioned in Table 1, all results were statistically significant with at least 95% confidence.

To further understand the relationship between depression and heart disease, Vollman, LaMontague, and Hepworth (2007) used process coping theory as a basis for analyzing the effect of coping strategies on depressive symptoms in patients with HF. Seventy-five participants with HF, aged at least 27 years with no psychopathology other than depression, received the Beck Depression Inventory and Ways of Coping Questionnaire. Initial results revealed that most participants experienced moderate to severe functional impairment, and approximately 50% reported a history of clinical depression. A multiple regression analysis supported with 99% confidence that three factors predicted higher incidence depressive symptoms: escape-avoidance coping (e.g., hoping a miracle would happen), higher levels of functional impairment, and being unmarried. Researchers note that the cross-sectional design of this study makes it challenging to untangle the complex directional relationship between coping strategies and depressive symptoms.

Research shows that unmarried individuals with HF typically report higher levels of depression and more depressive symptoms. Advancement of HF, the perception of social support, and a history of depression are common characteristics among HF patients with depression. Support groups or other communication networks could change HF patients' perception of belonging and of social support, which could have the potential to effect health outcomes and health care costs. Similarly, if primary care and cardiac

doctors are aware of the strong relationship, early intervention could play an important mitigating role.

Outcomes for Heart Disease Patients with Depression

Depression in patients with heart failure is associated with adverse clinical outcomes and costlier hospital bills. Sherwood, *et al.* (2011) assessed the impact of changes in HF patients' depression symptoms over a one-year period on clinical outcomes. Researchers gave 147 HF patients the Beck Depression Inventory (CDI) and retrieved HF status from their medical records. Participants retook the BDI after 12 months and researchers reviewed updates to medical records. Researchers followed these patients' clinical outcomes for an average of five years, measuring mortality rates and hospitalizations. Results showed a relationship between change in BDI score, number of hospitalizations, and mortality. Specifically, with 95% confidence, a one-point increase in BDI score was associated with a 7% increase in risk for HF hospitalizations and mortality, independent of baseline depressive symptoms and HF advancement level. While this relationship is strong and statistically significant, researches note that this observational study lends itself to correlational conclusions.

To further understand how depression effects hospitalizations, emergency room visits, outpatient doctor visits, and mortality in HF patients, researchers gave 402 HF patients in Minnesota the PHQ-9 depression inventory and measured their clinical outcomes over three years (Moraska, *et al.* 2013). After controlling for demographic characteristics like age, gender, marital status, education level, smoking status, diabetes comorbidity, and BMI, hazard ratios revealed with 95% confidence that patients with

mild depression visited the hospital only slightly more often than HF patients without depression. But HF patients with moderate to severe visited the hospital at a rate nearly two times that of HF patients without depression. Similarly, moderate to severe depression was associated with a four-fold increased risk of death when compared to HF patients without depression. The authors note that results support the effect primary care doctors could have in early intervention for depressive symptoms.

Ramos, *et al.* (2016) also examined hospitalizations and outcomes for HF patients with depression. They gave 130 Portuguese HF patients the Beck Depression Inventory and followed hospitalization and mortality outcomes for six years. After six years, 44% of patients reported having some level of minor or major depression. After controlling for conventional risk factors and demographics, a logistic regression analysis supported with statistical significance and 95% confidence that depressive symptoms predict mortality at an odds ratio of 2.9, and that depressive symptoms were predictive of hospitalizations at an odds ratio of 3.2.

These results reflect that depressive symptoms can independently predict hospitalizations and deaths, and HF patients with depressive symptoms experience hospitalizations and death at a higher rate than the non-depressed HF population. Given the costly nature of the U.S. health care system, many patients hope to avoid hospitalizations or expensive hospital stays. Research supports the relationship between health care usage and depression in the heart disease population, meaning early intervention could potentially allow for avoiding costly bills and reducing the strain on the health system.

Conclusion

Existing research on heart disease patients and depression reveals an important and statistically supported relationship. Heart disease patients with depression are more likely to require hospitalization and have a higher rate of mortality, especially unmarried patients with heart failure. Though these studies did not directly deal with the endogeneity inherent to the relationship between heart disease and depression, they provided general categories of explanatory variables to include in the regression to predict depression, such as age, gender, and race/ethnicity. None of these studies attempted to control for the endogeneity through regression analyses. If heart disease patients were engaged early in the diagnosing process, it is possible the rate of depression in this population could be affected. Given the fact that nearly 25% of deaths in California each year are attributed to heart disease, further research into this area could reveal important policy opportunities.

Table 1: The Relationship between Heart Disease and Depression

Authors	*Sample Characteristics*	*Focus of Research*	*Key Variables*	*Control Variables*	*Research Findings*
Burger (1984)	*Sample*: 99 undergraduate students at a small liberal arts university *Surveys Used*: Beck Depression Inventory (BDI); the Desirability of Control Scale; Locus of Control Scales	The relationship between control and proneness to depression	*IV:* Desire for control score and three loci of control scores (internal, powerful other, chance) *DV*: BDI score	Age, education level (undergraduate students)	Subjects with a high desire for control and a high external locus of control were 29% more likely to be depressed than were students with a low desire for control and a high internal locus of control. Statistically significant ($p \leq .05$).
Cacioppo, *et al*. (2006)	*Sample*: Nationally representative sample of 2,193 adults aged 54+ who responded to a Health and Retirement Study *Surveys Used*: Center for Epidemiologic Studies Depression Scale (CES-D); Loneliness Scale	The relationship between loneliness and depression	*IV*: Loneliness score *DV*: CES-D score	Age, gender, race/ethnicity, education level, household income, marital status	A one-unit increase in the Loneliness Scale results in .43 more reported depressive symptoms for lower income participants, meaning as loneliness goes up, so does depression. (SS, $p \leq .01$).

Authors	*Sample Characteristics*	*Focus of Research*	*Key Variables*	*Control Variables*	*Research Findings*
Ferketich & Binkley (2005)	*Sample*: Nationally representative sample of 17,541 respondents aged 40+ who responded to a National Center for Health Statistics Survey *Surveys Used*: National Health Interview Survey, Questionnaire on Psychological Distress (K6); self-reported heart disease diagnosis	The burden of psychological distress among individuals with different forms of heart disease	*IV*: Heart disease (coronary heart disease, myocardial infarction, coronary heart failure) *DV*: Psychological distress	Age, gender, race/ethnicity, marital status, education level, self-reported hypertension, self-reported diabetes, obesity, smoking status, alcohol intake, physical activity level	MI patients were twice as likely to report psychological distress than patients without. (SS, $p \leq .05$). CHF patients were three times as likely to report psychological distress than patients without. (SS, $p \leq .05$).
Graven, *et al*. (2017)	*Sample*: 201 heart failure patients aged 55+ living in three outpatient clinics in North Florida *Surveys Used*: Center for Epidemiological Studies Depression Scale (CES-D); Heart Failure Symptom Survey; Interpersonal Support and Evaluation List; Graven and Grant Social Network Survey; Social Problem-Solving Inventory Revised-Short	Whether heart failure symptomology, social support, and social problem solving effect the likelihood of depression	*IV*: HF symptomology, perceived social support, social problem solving *DV*: Depression	Age, race/ethnicity, marital status, number of people in household, income level, education, length of time since HF diagnosis	Unmarried individuals were 2.8 times more likely to be depressed than were married individuals with HF Patients with high HF symptoms were 1.9 times more likely to report depression than those without symptoms For every point scored lower on the belonging scale, patients were 1.29 times more likely to be depressed. (SS, $p \leq .05$).

Authors	*Sample Characteristics*	*Focus of Research*	*Key Variables*	*Control Variables*	*Research Findings*
Lossnitzer, *et al*. (2013)	*Sample*: 839 HF patients free of depression at baseline, selected from the German Competence Network HF *Surveys Used*: Patient Health Questionnaire (PHQ-9); Short Form Health Survey	Incidence rates and predictors of depression in German patients with HF	*IV*: HF *DV*: Depression symptoms	Age, gender, living alone, education level, alcohol consumption, HF characteristics, HF level	Participants who died during the study reported approx. 30% higher incidence rates of depression than HF patients who did not die, due to: having more advanced HF (SS, $p \leq .001$), visiting the doctor more often (SS, $p \leq .003$), a history of depression (SS, $p \leq .002$), and lower physical functioning scores (SS, $p \leq .001$).
Moraska, *et al*. (2013)	*Sample*: 402 HF patients in Minnesota *Surveys Used*: Patient Health Questionnaire (PHQ-9)	Measure whether depression predicts hospitalizations, emergency room visits, outpatient doctor visits, or mortality	*IV*: Depression *DV*: Hospitalizations, emergency room visits, outpatient doctor visits, mortality	Age, gender, marital status, education level, current or former smoker, diabetes comorbidity, BMI	Hazard ratios reveal HF patients with depression visit the hospital 1.07x more (mild) and 1.79x more (moderate to severe) than HF patients without depression (SS, $p \leq .05$). HF patients with moderate to severe depression experienced a 4.06% increased risk of death compared to HF patients without depression (SS, $p \leq .05$).

Authors	*Sample Characteristics*	*Focus of Research*	*Key Variables*	*Control Variables*	*Research Findings*
Ramos, *et al*. (2016)	*Sample*: 130 HF patients in Portugal *Surveys Used*: Beck Depression Inventory	Rates of hospitalization and mortality in HF patients with depression	*IV*: Depression *DV*: Hospitalization and mortality	Age, marital status, education level, employment status, level of HF, comorbidities such as diabetes, hypertension, alcohol use, smoking status	A logistic regression showed depressive symptoms predict mortality at an odds ratio of 2.9, and that depressive symptoms were predictive of hospitalizations at an odds ratio of 3.2. (SS, $p \leq .05$).
Sherwood, *et al*. (2011)	*Sample*: 147 HF outpatients aged 27+ from the Duke University area *Surveys Used*: Beck Depression Inventory	The effect of changes in depression symptoms on HF patients' clinical outcomes	*IV*: Depression in HF patients *DV*: Clinical outcomes	Age, gender, race/ethnicity, Body Mass Index, HF level, medical comorbidities (diabetes, hypercholesterolemia)	A one-point increase in BDI score was associated with a 7% increase in risk for HF hospitalizations and mortality, independent of baseline depressive symptoms and HF advancement level. (SS, $p \leq .05$).
Vollman, *et al*. (2007)	*Sample*: 75 patients with HF aged 27+ with no clinical psychopathology other than depression *Surveys Used*: Beck Depression Inventory; Ways of Coping Questionnaire – Research Edition (WCQ)	Understanding how HF patient coping strategies are associated with depressive symptoms	*IV*: Ways of coping *DV*: Depressive symptoms	Age, gender, months since HF diagnosis, marital status, race/ethnicity, socioeconomic status, diagnosis of depression	Unmarried individuals with advanced HF and escape-avoidance coping are more likely to report depressive symptoms. (SS, $p \leq .01$).

CHAPTER 3

QUANTITATIVE DATA

Models

Two models will illuminate the relationship between heart disease, heart failure, and depression. The purpose of this study is to understand how an individual's self-identified depression is related to their experience with heart disease. In the first model, the key explanatory variable is heart disease and the dependent variable is depression. In the second, the key explanatory variable is heart failure, also known as advanced heart disease, and the dependent variable is depression. Because heart disease is not truly independent of depression, the regression analyses use a two-stage method to identify factors that cause heart disease but not depression.

In this model an individual's self-reported depression is caused by health factors, demographic factors, social factors, and lifestyle factors. In this model, the health factors are one of two different forms of heart disease. The demographic factors include age, gender, and race/ethnicity. The social factors are comprised of educational attainment, marital status, poverty level, and citizenship status. The lifestyle factors assumed to influence heart disease, but not depression, are soda consumption and fast food consumption (Anand, *et al*. 2015).

- **Depression** = f(Health Factors, Demographic Factors, Social Factors,)
  - **Health Factors** = f(Heart Disease or Heart Failure)
    - **Heart Disease or Heart Failure = f(Soda Consumption, Fast Food Consumption)**

- **Demographic Factors** = f(Age, Gender, Race/Ethnicity)
- **Social Factors** = f(Educational Attainment, Marital Status, Poverty Level, Citizenship Status)]

My dependent variable and all explanatory variables came from the University of California, Los Angeles (UCLA) Center for Health Policy Research's California Health Inventory Survey (CHIS) data set. CHIS (2016a), a random-dial telephone survey that asks questions on a broad range of health-related topics, is the largest state health survey in the nation. A representative sample of over 21,000 observations contribute to this robust data set, and the data was collected in a controlled, uniform manner. UCLA collected this 2016 CHIS data between January and December 2016. More than 21,000 Californians responded to the CHIS, and researchers measured three populations: adults, teenagers, and children. This study utilizes the 2016 CHIS adult survey data set.

In this study, I use depression (variable "Depressed Control Dummy") as my dependent variable in order to examine the effect various variables have on one's depression status. To measure the respondent's depression level, the CHIS questionnaire included the question, "during the past 30 days, how often did you feel so depressed that nothing could cheer you up?" with all of the time, most of the time, some of the time, a little of the time, and none of the time as possible responses (CHIS, 2016b). Depressed Control Dummy is a variable I created by combining three depression levels: "Depressed All of the Time," "Depressed Most of the Time", and "Depressed Some of the Time." I excluded "Depressed a Little of the Time" and used the "None" level as my baseline. This relates to my research question, which is "does heart disease cause depression,"

because this variable measures whether or not respondents have depression. Due to the large size of the CHIS survey, I utilized only variables that were relevant to the present study. Scholarly journal articles on heart disease and depression contained broad causal factors, three of which are included in the present study. Health, demographic, social, and lifestyle factors play an important role in health outcomes.

To proxy for the health factors heart disease and heart failure diagnoses, I used the Heart Disease variable and the Heart Failure variable in the CHIS data set. The heart disease variable on the CHIS questionnaire asked respondents, "Has a doctor ever told you that you have any kind of heart disease?" with yes and no as possible responses (CHIS, 2016b). The heart failure variable on the CHIS questionnaire asked respondents, "Has a doctor ever told you that you have heart failure or congestive heart failure?" with yes and no as possible responses. I am comparing the effects of heart disease to the effects of heart failure.

To proxy for demographic factors, I included age, gender, and race/ethnicity. Respondents self-reported age, which fell into fifteen categories: 18 to 25, 26 to 29, 30 to 34, 35 to 39, 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64 65 to 69, 70 to 74, 75 to 79, 80 to 84, and 85 and over. The 18 to 25 category is the baseline for this variable. That means the reported findings for other ages are relative to the youngest group. Respondents also self-reported binary gender, either male or female, and male is the baseline. The race/ethnicity variable is data convention drawn from the Federal Office of Management and Budget and the California Department of Finance, and measures Hispanic, White, African American, American Indian, Asian, and Multi race levels.

White is the race/ethnicity baseline in this study. These variables paint a robust picture of an individual's demography, and the scholarly journals included these variables.

Social factors such as educational attainment, marital status, poverty level, and citizenship status proxy for an individual's social lifestyle and the scholarly journals included these variables as well. Educational Attainment is a measure of the respondent's highest earned education level, and is categorized as No Education, Grade 9-11 Education, High School Diploma, Some College, Vocational School, Associate Degree, Bachelor's Degree, Master's Degree, and PhD. No education is the baseline in this study. Respondents answered in respect to their marital status, and reported being either Married, Living with a Partner, Widowed/Separated/Divorced, or Never Married. Married is the baseline in the present study. Poverty level is a measure of the federal poverty level, and respondents reported being either zero to 99 percent below, 100 to 199 percent below, 200 to 299 percent below, or 300 percent below the federal poverty level. Zero to 99 percent below the federal poverty level is the baseline in this study. Respondents reported citizenship status as either being a U.S.-Born Citizen, Naturalized Citizen, or a Non-Citizen, with U.S.-Born Citizen as the baseline.

To proxy for lifestyle factors that influence heart disease but not depression, I included soda consumption and fast food consumption. Respondents self-reported soda consumption, defined as the number of times they drank soda per week, which fell into seven categories: 0 times, 1 time, 2-3 times, 4-6 times, 7-13 times, 14-20 times, or 21+ times. The zero times per week level is the baseline for this variable. Respondents also self-reported fast food consumption, defined as the number of times they ate fast food in

the past week. This variable consisted of ten levels: 0 times per week, 1 time, 2 times, 3 times, 4 times, 5 times, 6 times, 7 times, 8 times, or 9 times per week. The zero times per week level is the baseline. The scholarly journals included these variables when constructing the image of participants' lifestyle factors.

I expect both heart disease and heart failure to have positive directional effects on the dependent variable, depression. If the odds ratio of depression is higher in heart failure patients than in heart disease patients, one could draw the conclusion that depression becomes more likely as heart disease advances, thus isolating heart disease as the cause of depression in these patients. I hypothesize that the odds ratio of depression is higher in heart failure patients than in heart disease patients.

Data

The CHIS data set is the largest health inventory in the nation (CHIS, 2016a). The UCLA Center for Health Policy research in collaboration with the California Department of Public Health and the California Department of Health Care Services leads the data collection effort. The large sample size (n = 21,055) and random selection process ensure that the data set represents the entire state's diverse population. CHIS researchers divided the state into 44 geographic areas (sampling strata) and computers randomly selected individuals within those areas to ensure a representative sample. CHIS is a telephone survey conducted in all 58 California counties. CHIS is widely known as a comprehensive health inventory, and researchers collect data on a litany of topics ranging from physical health status, mental health status, neighborhood and housing, access to food and health care, pubic program eligibility, income, BMI, and

much more. Statewide leaders, policymakers, state agencies, advocacy groups, local health departments, and other public and private entities use this publicly-available data set.

UCLA collected data on three populations, adult, teenagers, and children. When the computer selected a household, researchers randomly selected one adult within a household to answer the adult data set, and one teenager aged 12 to 17 and/or one child aged 11 and under to answer the teenager and child data sets, respectively, depending on the household composition. To ensure that the data captured California's diverse population, researchers administered the CHIS survey in English, Spanish, Cantonese, Mandarin, Korean, Tagalog, and Vietnamese. To promote transparency and accountability, UCLA posted a complete list of organizations that fund CHIS data collection. CHIS funders range from large public entities like California state agencies to large private organizations like Susan G. Komen for the Cure, various county health agencies, and other public health entities.

Below, Table 2 provides a variable description for each variable used in this study. Columns include the variable name, variable description, and each variable's expected effect on the dependent variable. The description comes from the CHIS 2016 Data Dictionary. Note that the excluded category is in parenthesis. Table 3 provides descriptive statistics for each of the variables, and contains columns with variable name, mean, standard deviation, and the maximum and minimum possible values. Because all of the variables are binary dummy variables, meaning the possible responses are yes and no, each maximum is 1 and each minimum is 0. Finally, Table 4 contains the simple

correlation coefficients between all of the explanatory variables. A correlation coefficient with an absolute value of 1.0 means that two variables have a perfect relationship and a coefficient of 0.0 means that there is no correlation between two variables. If two variables have a correlation coefficient with an absolute value of 0.8 or higher, multicollinearity could be present. Multicollinearity indicates that the relationship between two independent variables is not in fact independent, which would present a problem for the regression. No two independent variables in Table 4 have a correlation coefficient of 0.8 or higher except when a variable is measured against itself, which is indicated by the 1.0 at the top of each column. A statistically significant correlation is one in which the correlation coefficient is 0.10 or less, meaning one could say with 90 percent confidence that the effect between variables is not by chance.

Regressions Overview

Chapter 4 contains statistical regressions that depict the relationships between the variables. Also included is the reasoning behind selecting these regressions, and what the results tell us about the relationship between heart disease, heart failure, and depression. In the regression analysis that follows I will run one in which depression is considered endogenous, and another in which it is not. When depression is not considered endogenous I am able to run a logistic and probit analysis; when depression is considered endogenous, I am only able to run a probit. The regression that does not control for endogeneity allows us to interpret the likelihood that someone with heart disease will also report depression. Because this regression does not control for endogeneity, I run another regression that does control for endogeneity. However, the second regression results

cannot be interpreted the same way as the first. Therefore, I will run a third regression that will allow me to interpret the second regression in a matter more similar to the first.

Table 2: Expected Variable Effects (baseline measures in [ ])

CHIS 2016 Data Set		
Variable Name	**Variable Description**	**Expected Effect**
Depression Status	**Respondent's self-reported depression status**	
Depressed Control Dummy	Includes Depressed all of the time, Depressed most of the time, and Depressed	N/A
Health Factors		
Heart Disease Status	**Respondent's heart disease status**	
[No Heart Disease Dummy]	Doctor has not told you have any kind of HD	N/A
Heart Disease Dummy	Doctor ever told you have any kind of HD	+
Heart Failure Status	**Respondent's heart failure status**	
[No Heart Failure Dummy]	Doctor has not told you have HF	N/A
Heart Failure Dummy	Doctor ever told you have HF	+
Demographic Factors		
Age	**Age Group**	
[Eighteen to Twenty-Five Dummy]	Aged 18-25	N/A
Twenty-Six to Twenty-Nine Dummy	Aged 26-29	–
Thirty to Thirty-Four Dummy	Aged 30-34	–
Thirty-Five to Thirty-Nine Dummy	Aged 35-39	–
Forty to Forty-Four Dummy	Aged 40-44	–
Forty-Five to Forty-Nine Dummy	Aged 45-49	–
Fifty to Fifty-Four Dummy	Aged 50-54	–
Fifty-Five to Fifty-Nine Dummy	Aged 55-59	–
Sixty to Sixty-Four Dummy	Aged 60-64	–
Sixty-Five to Sixty-Nine Dummy	Aged 65-69	+
Seventy to Seventy-Four Dummy	Aged 70-74	+
Seventy-Five to Seventy-Nine Dummy	Aged 75-79	+
Eighty to Eighty-Four Dummy	Aged 80-84	+
Eighty-Five and Up Dummy	Aged 85+	+
Gender	**Gender**	
[Male Dummy]	Male	N/A
Female Dummy	Female	+
Race/Ethnicity	**Race/Ethnicity**	
[White Dummy]	White Race/Ethnicity	N/A
Hispanic Dummy	Hispanic Race/Ethnicity	**?**
African American Dummy	African American Race/Ethnicity	**?**
American Indian Dummy	American Indian Race/Ethnicity	**?**
Asian Dummy	Asian Race/Ethnicity	**?**
Multiple Races/Ethnicities Dummy	Multiple Races/Ethnicities Dummy	**?**
Social Factors		
Educational Attainment	**Highest Educational Attainment Level**	
[No Education Dummy]	Does not possess a formal education	N/A
Grade 9 through 11 Dummy	Posseses Grade 9 through 11 education	+
High School Diploma Dummy	Possesses High School Diploma	+
Some College Dummy	Possesses Some College Education	+
Vocational School Dummy	Possesses Vocational School Education	+
Associate's Degree Dummy	Possesses AA Degree	+
Bachelor's Degree Dummy	Possesses BA Degree	–
Master's Degree Dummy	Possesses MA Degree	–
Doctorate Dummy	Possesses PhD Degree	–

Marital Status	**Marital Status**	
[Married Dummy]	Is married	N/A
Live With Partner Dummy	Living with a Partner	–
Widowed/Separated/Divorced Dummy	Is Widowed, Separated, or Divorced	+
Never Married Dummy	Has Never Been Married	+
Poverty Level	**Percentage below the Federal Poverty Level**	
[Federal Poverty Level - 0 to 99 Dummy]	Falls within 0-99 percent below FPL	N/A
Federal Poverty Level - 100 to 199 Dummy	Falls within 100-199 percent below FPL	+
Federal Poverty Level - 200 to 299 Dummy	Falls within 200-299 percent below FPL	+
Federal Poverty Level - 300 and Up Dummy	Falls within 300-399 percent below FPL	+
Citizenship Status	**Citizenship Status**	
[US-Born Citizen]	Born in the US	N/A
Naturalized Citizen Dummy	Naturalized Citizen	–
Non-Citizen Dummy	Not a US Citizen	+
Lifestyle Factors		
Soda Consumption	**Number of times drinking soda per week**	
[0 Times Soda Dummy]	Drink soda 0 times per week	N/A
1 Time Soda Dummy	Drink soda 1 time per week	-
2-3 Times Soda Dummy	Drink soda 2 to 3 times per week	+
4-6 Times Soda Dummy	Drink soda 4 to 6 times per week	+
7-13 Times Soda Dummy	Drink soda 7 to 13 times per week	+
14-20 Times Soda Dummy	Drink soda 14 to 20 times per week	+
21+ Times Soda Dummy	Drink soda 21+ times per week	+
Fast Food Consumption	**Number of times eating fast food per week**	
[0 Times Fast Food Dummy]	Consume fast food 0 times per week	N/A
1 Time Fast Food Dummy	Consume fast food 1 time per week	-
2 Times Fast Food Dummy	Consume fast food 2 times per week	+
3 Times Fast Food Dummy	Consume fast food 3 times per week	+
4 Times Fast Food Dummy	Consume fast food 4 times per week	+
5 Times Fast Food Dummy	Consume fast food 5 times per week	+
6 Times Fast Food Dummy	Consume fast food 6 times per week	+
7 Times Fast Food Dummy	Consume fast food 7 times per week	+
8 Times Fast Food Dummy	Consume fast food 8 times per week	+
9 Times Fast Food Dummy	Consume fast food 9 times per week	+

Table 3: Descriptive Statistics

CHIS 2016 Data Set					
Variable Name	**Observations**	**Mean**	**Standard Deviation**	**Max**	**Min**
Depression Status					
Depressed Control Dummy	21,055	0.090	0.286	1	0
Health Factor					
Heart Disease Status					
Heart Disease Dummy	21,055	0.107	0.309	1	0
Heart Failure Status					
Heart Failure Dummy	21,055	0.032	0.175	1	0
Demographic Factors					
Age					
Twenty-Six to Twenty-Nine Dummy	21,055	0.038	0.191	1	0
Thirty to Thirty-Four Dummy	21,055	0.052	0.221	1	0
Thirty-Five to Thirty-Nine Dummy	21,055	0.051	0.218	1	0
Forty to Forty-Four Dummy	21,055	0.055	0.228	1	0
Forty-Five to Forty-Nine Dummy	21,055	0.061	0.239	1	0
Fifty to Fifty-Four Dummy	21,055	0.083	0.276	1	0
Fifty-Five to Fifty-Nine Dummy	21,055	0.092	0.289	1	0
Sixty to Sixty-Four Dummy	21,055	0.105	0.306	1	0
Sixty-Five to Sixty-Nine Dummy	21,055	0.116	0.320	1	0
Seventy to Seventy-Four Dummy	21,055	0.087	0.282	1	0
Seventy-Five to Seventy-Nine Dummy	21,055	0.068	0.251	1	0
Eighty to Eighty-Four Dummy	21,055	0.052	0.221	1	0
Eighty-Five and Up Dummy	21,055	0.046	0.211	1	0
Gender					
Female Dummy	21,055	0.558	0.497	1	0
Race/Ethnicity					
Hispanic Dummy	21,055	0.253	0.435	1	0
African American Dummy	21,055	0.049	0.215	1	0
American Indian Dummy	21,055	0.009	0.096	1	0
Asian Dummy	21,055	0.131	0.338	1	0
Multiple Races/Ethnicities Dummy	21,055	0.025	0.156	1	0

Social Factors					
Educational Attainment					
Grade 9 through 11 Dummy	21,055	0.496	0.217	1	0
High School Diploma Dummy	21,055	0.234	0.423	1	0
Some College Dummy	21,055	0.147	0.354	1	0
Vocational School Dummy	21,055	0.025	0.156	1	0
Associate's Degree Dummy	21,055	0.082	0.275	1	0
Bachelor's Degree Dummy	21,055	0.237	0.425	1	0
Master's Degree Dummy	21,055	0.116	0.321	1	0
Doctorate Dummy	21,055	0.041	0.199	1	0
Marital Status					
Live With Partner Dummy	21,055	0.056	0.229	1	0
Widowed/Separated/Divorced Dummy	21,055	0.276	0.447	1	0
Never Married Dummy	21,055	0.210	0.407	1	0
Poverty Level					
Federal Poverty Level - 100 to 199 Dummy	21,055	0.185	0.388	1	0
Federal Poverty Level - 200 to 299 Dummy	21,055	0.128	0.334	1	0
Federal Poverty Level - 300 and Up Dummy	21,055	0.521	0.499	1	0
Citizenship Status					
Naturalized Citizen Dummy	21,055	0.161	0.368	1	0
Non-Citizen Dummy	21,055	0.106	0.308	1	0
Lifestyle Factors					
Soda Consumption					
1 Time Soda Dummy	21,055	0.121	0.326	1	0
2-3 Times Soda Dummy	21,055	0.086	0.279	1	0
4-6 Times Soda Dummy	21,055	0.024	0.154	1	0
7-13 Times Soda Dummy	21,055	0.057	0.232	1	0
14-20 Times Soda Dummy	21,055	0.019	0.135	1	0
21+ Times Soda Dummy	21,055	0.016	0.127	1	0
Fast Food Consumption					
1 Time Fast Food Dummy	21,055	0.241	0.427	1	0
2 Times Fast Food Dummy	21,055	0.141	0.347	1	0
3 Times Fast Food Dummy	21,055	0.084	0.277	1	0
4 Times Fast Food Dummy	21,055	0.039	0.196	1	0
5 Times Fast Food Dummy	21,055	0.277	0.164	1	0
6 Times Fast Food Dummy	21,055	0.007	0.084	1	0
7 Times Fast Food Dummy	21,055	0.018	0.132	1	0
8 Times Fast Food Dummy	21,055	0.002	0.039	1	0
9 Times Fast Food Dummy	21,055	0.012	0.111	1	0

Table 4: Correlation Coefficients

Variables	Depressed Control Dummy	Heart Disease Dummy	Heart Failure Dummy	Twenty-Six to Twenty-Nine Dummy	Thirty to Thirty-Four Dummy	Thirty-Five to Thirty-Nine Dummy	Forty to Forty-Four Dummy	Forty-Five to Forty-Nine Dummy	Fifty to Fifty-Four Dummy	Fifty-Five to Fifty-Nine Dummy	Sixty to Sixty-Four Dummy	Sixty-Five to Sixty-Nine Dummy
Depressed Control Dummy	1.0000											
Heart Disease Dummy	0.0322	1.0000										
Heart Failure Dummy	0.0332	0.5220	1.0000									
Twenty-Six to Twenty-Nine Dummy	0.0022	-0.0569	-0.0360	1.0000								
Thirty to Thirty-Four Dummy	0.0045	-0.0647	-0.0348	-0.0465	1.0000							
Thirty-Five to Thirty-Nine Dummy	-0.0132	-0.0620	-0.0341	-0.0458	-0.0537	1.0000						
Forty to Forty-Four Dummy	0.0006	-0.0631	-0.0340	-0.0480	-0.0562	-0.0554	1.0000					
Forty-Five to Forty-Nine Dummy	0.0181	-0.0555	-0.0279	-0.0508	-0.0595	-0.0587	-0.0615	1.0000				
Fifty to Fifty-Four Dummy	0.0528	-0.0420	-0.0190	-0.0600	-0.0703	-0.0693	-0.0726	-0.0769	1.0000			
Fifty-Five to Fifty-Nine Dummy	0.0216	-0.0281	-0.0142	-0.0634	-0.0742	-0.0732	-0.0767	-0.0811	-0.0959	1.0000		
Sixty to Sixty-Four Dummy	0.0044	-0.0055	0.0011	-0.0682	-0.0798	-0.0787	-0.0825	-0.0873	-0.1031	-0.1089	1.0000	
Sixty-Five to Sixty-Nine Dummy	-0.0208	0.0331	0.0236	-0.0722	-0.0845	-0.0833	-0.0873	-0.0924	-0.1092	-0.1152	-0.1239	1.0000
Seventy to Seventy-Four Dummy	-0.0284	0.0845	0.0338	-0.0615	-0.0720	-0.0710	-0.0744	-0.0788	-0.0931	-0.0982	-0.1057	-0.1119
Seventy-Five to Seventy-Nine Dummy	-0.0274	0.0977	0.0454	-0.0537	-0.0629	-0.0620	-0.0649	-0.0687	-0.0812	-0.0857	-0.0922	-0.0976
Eighty to Eighty-Four Dummy	-0.0176	0.1227	0.0691	-0.0466	-0.0546	-0.0538	-0.0564	-0.0597	-0.0705	-0.0744	-0.0801	-0.0848
Eighty-Five and Up Dummy	-0.0285	0.1427	0.0866	-0.0440	-0.0515	-0.0508	-0.0532	-0.0563	-0.0665	-0.0702	-0.0755	-0.0799
Female Dummy	0.0361	-0.0452	-0.0421	-0.0208	-0.0119	0.0047	0.0172	-0.0010	0.0142	-0.0029	-0.0089	0.0046
Hispanic Dummy	0.0698	-0.0846	-0.0289	0.0739	0.0835	0.0982	0.0885	0.0514	0.0200	-0.0119	-0.0440	-0.0838
African American Dummy	0.0189	-0.0112	0.0121	0.0055	0.0000	0.0126	0.0084	-0.0043	0.0212	0.0181	-0.0018	-0.0103
American Indian Dummy	0.0104	0.0154	0.0160	0.0010	-0.0028	0.0045	-0.0106	0.0079	0.0079	0.0029	0.0130	0.0106
Asian Dummy	-0.0054	-0.0251	-0.0106	-0.0143	-0.0188	-0.0262	0.0064	0.0126	-0.0152	-0.0228	-0.0029	0.0008
Multiple Races/Ethnicities Dummy	0.0186	-0.0043	0.0024	0.0284	0.0135	0.0021	0.0054	0.0023	0.0012	0.0016	-0.0012	-0.0182
Grade 9 through 11 Dummy	0.0924	-0.0061	0.0000	0.0002	0.0070	0.0356	0.0083	0.0121	0.0341	0.0008	-0.0096	-0.0253
High School Diploma Dummy	0.0379	-0.0025	0.0062	0.0177	-0.0010	0.0025	-0.0153	-0.0190	-0.0157	-0.0090	-0.0244	-0.0654
Some College Dummy	0.0090	0.0240	0.0087	0.0055	-0.0289	-0.0322	-0.0293	-0.0341	-0.0138	-0.0015	-0.0010	0.0194
Vocational School Dummy	0.0093	0.0148	0.0252	0.0079	0.0151	0.0065	0.0083	0.0102	0.0059	-0.0033	-0.0069	-0.0141
Associate's Degree Dummy	-0.0226	-0.0026	-0.0038	0.0069	0.0026	-0.0144	0.0066	-0.0101	-0.0035	0.0188	0.0254	-0.0061
Bachelor's Degree Dummy	-0.0678	-0.0147	-0.0196	0.0148	0.0274	0.0026	0.0005	0.0084	-0.0083	-0.0022	0.0035	0.0279
Master's Degree Dummy	-0.0698	-0.0111	-0.0198	-0.0322	-0.0098	-0.0029	0.0074	0.0039	0.0106	0.0008	0.0111	0.0502
Doctorate Dummy	-0.0314	0.0158	0.0046	-0.0216	-0.0206	-0.0108	0.0042	0.0106	-0.0067	-0.0060	-0.0013	0.0168
Live With Partner Dummy	0.0135	-0.0288	-0.0248	0.0870	0.0700	0.0439	0.0217	0.0066	-0.0010	-0.0111	-0.0261	-0.0328
Widowed/Separated/Divorced Dummy	0.0603	0.1097	0.0694	-0.0993	-0.0990	-0.0799	-0.0701	-0.0432	-0.0332	-0.0131	0.0358	0.0555
Never Married Dummy	0.0468	-0.1023	-0.0485	0.1539	0.0803	0.0147	-0.0261	-0.0396	-0.0357	-0.0471	-0.0841	-0.1064
Federal Poverty Level - 100 to 199 Dummy	0.0618	0.0156	0.0328	0.0129	0.0154	0.0164	0.0011	0.0005	-0.0103	-0.0051	-0.0189	-0.0152
Federal Poverty Level - 200 to 299 Dummy	0.0048	0.0002	0.0039	0.0133	0.0017	0.0028	-0.0057	-0.0100	-0.0251	-0.0118	-0.0111	-0.0280
Federal Poverty Level - 300 and Up Dummy	-0.1712	-0.0118	-0.0453	-0.0455	-0.0340	-0.0401	-0.0226	-0.0091	0.0124	0.0106	0.0194	0.0760
Naturalized Citizen Dummy	0.0407	-0.0019	0.0014	-0.0347	-0.0427	-0.0292	0.0186	0.0247	0.0255	0.0180	0.0086	0.0216
Non-Citizen Dummy	0.0634	-0.0581	-0.0218	0.0285	0.1074	0.1095	0.1149	0.0830	0.0315	-0.0106	-0.0417	-0.0750
1 Time Soda Dummy	0.0075	-0.0311	-0.0128	0.0440	0.0281	0.0435	0.0361	0.0010	0.0012	0.0112	-0.0245	-0.0446
2-3 Times Soda Dummy	0.0210	-0.0329	-0.0174	0.0559	0.0436	0.0251	0.0313	0.0211	-0.0026	-0.0245	-0.0289	-0.0462
4-6 Times Soda Dummy	0.0238	-0.0085	-0.0073	0.0154	0.0498	0.0090	0.0190	0.0063	-0.0072	-0.0106	-0.0176	-0.0243
7-13 Times Soda Dummy	0.0322	-0.0054	0.0049	0.0334	0.0289	0.0214	0.0173	0.0161	0.0143	0.0021	-0.0158	-0.0262
14-20 Times Soda Dummy	0.0376	-0.0090	-0.0068	0.0239	0.0282	0.0069	0.0208	0.0060	0.0132	-0.0037	-0.0012	-0.0170
21+ Times Soda Dummy	0.0706	-0.0094	0.0067	0.0212	0.0173	0.0355	0.0183	0.0203	0.0032	0.0044	-0.0050	-0.0163
1 Time Fast Food Dummy	0.0017	-0.0145	-0.0195	0.0052	0.0121	0.0219	0.0339	-0.0077	0.0029	0.0075	0.0041	-0.0153
2 Times Fast Food Dummy	0.0152	-0.0056	0.0092	0.0359	0.0226	0.0248	0.0210	0.0192	0.0041	-0.0044	-0.0091	-0.0266
3 Times Fast Food Dummy	0.0174	-0.0186	-0.0134	0.0498	0.0248	0.0105	0.0190	0.0188	0.0082	-0.0059	-0.0189	-0.0313
4 Times Fast Food Dummy	0.0145	-0.0181	-0.0008	0.0340	0.0192	0.0174	0.0072	0.0016	0.0017	-0.0020	-0.0200	-0.0225
5 Times Fast Food Dummy	0.0054	-0.0163	-0.0074	0.0101	0.0155	0.0207	0.0152	0.0028	-0.0017	-0.0097	-0.0210	-0.0214
6 Times Fast Food Dummy	0.0053	-0.0144	-0.0087	0.0040	0.0112	0.0093	-0.0003	0.0118	0.0117	-0.0012	-0.0065	-0.0109
7 Times Fast Food Dummy	0.0182	-0.0032	0.0088	0.0222	0.0143	0.0071	0.0009	0.0034	0.0000	-0.0002	0.0000	-0.0193
8 Times Fast Food Dummy	0.0085	-0.0059	-0.0003	0.0109	0.0016	-0.0036	0.0168	-0.0051	-0.0032	0.0123	-0.0096	-0.0031
9 Times Fast Food Dummy	0.0264	-0.0109	-0.0005	0.0136	0.0303	0.0176	-0.0062	0.0128	0.0130	0.0091	-0.0158	-0.0230

Seventy to Seventy-Four Dummy	Seventy-Five to Seventy-Nine Dummy	Eighty to Eighty-Four Dummy	Eighty-Five and Up Dummy	Female Dummy	Hispanic Dummy	African American Dummy	American Indian Dummy	Asian Dummy	Multiple Races/Ethnicities Dummy	Grade 9 through 11 Dummy	High School Diploma Dummy	Some College Dummy	Vocational School Dummy
1.0000													
-0.0832	1.0000												
-0.0723	-0.0630	1.0000											
-0.0682	-0.0595	-0.0516	1.0000										
0.0086	0.0232	0.0108	0.0256	1.0000									
-0.0968	-0.0920	-0.0859	-0.0999	0.0108	1.0000								
-0.0167	-0.0118	-0.0152	-0.0196	0.0136	-0.1317	1.0000							
-0.0162	-0.0048	-0.0007	-0.0099	-0.0129	-0.0568	-0.0221	1.0000						
0.0088	0.0253	0.0315	0.0119	-0.0228	-0.2261	-0.0879	-0.0379	1.0000					
-0.0171	-0.0178	-0.0197	-0.0180	-0.0013	-0.0932	-0.0363	-0.0157	-0.0622	1.0000				
-0.0310	-0.0154	-0.0140	-0.0005	-0.0015	0.1474	0.0042	0.0161	-0.0272	-0.0100	1.0000			
-0.0534	-0.0058	0.0003	0.0115	-0.0130	0.1024	0.0262	0.0122	-0.0506	-0.0001	-0.1261	1.0000		
0.0070	0.0201	0.0251	0.0053	0.0257	-0.0538	0.0469	0.0135	-0.0654	0.0306	-0.0948	-0.2291	1.0000	
-0.0093	-0.0006	-0.0099	0.0183	0.0249	0.0080	0.0035	0.0096	-0.0133	0.0115	-0.0365	-0.0882	-0.0663	1.0000
0.0097	-0.0010	-0.0079	-0.0137	0.0238	-0.0406	0.0124	0.0100	-0.0346	0.0150	-0.0685	-0.1655	-0.1244	-0.0479
0.0109	-0.0093	-0.0076	0.0006	-0.0062	-0.1667	-0.0198	-0.0152	0.1020	0.0008	-0.1273	-0.3078	-0.2313	-0.0891
0.0486	0.0059	-0.0002	-0.0084	-0.0066	-0.1408	-0.0251	-0.0171	0.0550	-0.0070	-0.0829	-0.2005	-0.1507	-0.0580
0.0430	0.0273	0.0136	0.0118	-0.0622	-0.0992	-0.0172	-0.0031	0.0440	-0.0135	-0.0475	-0.1149	-0.0864	-0.0332
-0.0344	-0.0406	-0.0362	-0.0466	0.0062	0.0736	0.0010	0.0085	-0.0647	-0.0017	0.0297	0.0235	-0.0139	0.0025
0.0808	0.1168	0.1374	0.1957	0.1558	-0.0871	0.0368	0.0264	-0.0594	0.0016	0.0287	0.0040	0.0632	0.0213
-0.1109	-0.0991	-0.0955	-0.0961	-0.0994	0.0966	0.0771	-0.0010	0.0099	0.0419	0.0083	0.1038	0.0233	-0.0016
-0.0383	0.0002	0.0103	0.0204	0.0217	0.1583	0.0149	0.0179	-0.0221	0.0027	0.0658	0.1083	0.0223	0.0189
-0.0055	0.0319	0.0172	0.0288	0.0120	0.0269	0.0003	0.0169	-0.0256	0.0113	-0.0117	0.0626	0.0335	0.0245
0.0726	0.0150	0.0072	-0.0024	-0.0605	-0.3014	-0.0430	-0.0390	0.0293	-0.0119	-0.1747	-0.1993	-0.0279	-0.0378
0.0159	0.0352	0.0232	-0.0188	0.0040	0.0927	-0.0728	-0.0415	0.4096	-0.0396	0.0177	-0.0319	-0.0548	-0.0186
-0.0711	-0.0734	-0.0579	-0.0667	-0.0042	0.3993	-0.0631	-0.0337	0.0220	-0.0514	0.1070	0.0053	-0.0880	-0.0205
-0.0431	-0.0465	-0.0388	-0.0409	-0.0311	0.1152	0.0183	0.0135	-0.0179	0.0003	0.0140	0.0323	0.0068	0.0110
-0.0373	-0.0332	-0.0311	-0.0297	-0.0682	0.1068	0.0277	-0.0106	-0.0299	0.0053	0.0419	0.0407	0.0110	-0.0021
-0.0289	-0.0252	-0.0146	-0.0186	-0.0476	0.0540	0.0160	-0.0058	-0.0310	0.0123	0.0181	0.0342	-0.0025	0.0046
-0.0286	-0.0278	-0.0113	-0.0230	-0.0658	0.0887	0.0206	0.0247	-0.0553	0.0040	0.0468	0.0441	0.0081	0.0016
-0.0288	-0.0189	-0.0275	-0.0170	-0.0507	0.0476	0.0308	0.0083	-0.0369	-0.0108	0.0349	0.0402	-0.0075	-0.0062
-0.0252	-0.0273	-0.0251	-0.0231	-0.0384	0.0198	0.0126	0.0106	-0.0323	0.0081	0.0465	0.0377	0.0037	0.0083
0.0075	-0.0115	-0.0127	-0.0289	0.0278	0.0142	-0.0001	0.0049	-0.0009	-0.0025	0.0023	0.0011	-0.0030	-0.0056
-0.0359	-0.0151	-0.0378	-0.0280	-0.0201	0.0813	0.0179	-0.0013	-0.0106	0.0027	0.0193	0.0418	0.0017	0.0040
-0.0398	-0.0350	-0.0174	-0.0358	-0.0355	0.0836	0.0264	0.0024	-0.0174	0.0119	0.0202	0.0398	-0.0024	0.0045
-0.0304	-0.0338	-0.0226	-0.0266	-0.0487	0.0558	0.0236	-0.0049	-0.0183	0.0201	0.0003	0.0374	0.0180	0.0156
-0.0142	-0.0225	-0.0239	-0.0235	-0.0675	0.0281	0.0142	0.0104	-0.0048	0.0044	0.0027	0.0161	0.0075	0.0027
-0.0139	-0.0159	-0.0171	-0.0132	-0.0350	0.0282	0.0232	-0.0082	-0.0209	-0.0026	-0.0009	0.0180	0.0181	0.0012
-0.0184	-0.0203	-0.0070	-0.0090	-0.0512	0.0381	0.0132	0.0093	-0.0169	0.0201	0.0175	0.0146	0.0116	0.0110
-0.0122	-0.0059	-0.0039	-0.0087	-0.0203	0.0184	-0.0034	-0.0039	-0.0012	-0.0063	0.0020	0.0037	-0.0063	0.0014
-0.0254	-0.0216	-0.0145	-0.0247	-0.0425	0.0299	0.0166	0.0024	-0.0231	0.0096	0.0101	0.0125	0.0058	0.0097

Associate's Degree Dummy	Bachelor's Degree Dummy	Master's Degree Dummy	Doctorate Dummy	Live With Partner Dummy	Widowed/Separated/Divorced Dummy	Never Married Dummy	Federal Poverty Level - 100 to 199 Dummy	Federal Poverty Level - 200 to 299 Dummy	Federal Poverty Level - 300 and Up Dummy	Naturalized Citizen Dummy	Non-Citizen Dummy	1 Time Soda Dummy	2-3 Times Soda Dummy
1.0000													
-0.1671	1.0000												
-0.1088	-0.2024	1.0000											
-0.0624	-0.1160	-0.0756	1.0000										
0.0050	-0.0235	-0.0247	-0.0089	1.0000									
0.0183	-0.0552	-0.0409	-0.0210	-0.1498	1.0000								
-0.0051	-0.0100	-0.0699	-0.0635	-0.1251	-0.3188	1.0000							
0.0119	-0.1080	-0.1227	-0.0765	0.0308	0.0628	0.0204	1.0000						
0.0312	-0.0270	-0.0701	-0.0513	-0.0117	0.0395	0.0135	-0.1827	1.0000					
0.0058	0.2139	0.2365	0.1543	-0.0531	-0.1065	-0.1184	-0.4968	-0.3998	1.0000				
-0.0431	0.0157	0.0044	0.0312	-0.0549	-0.0125	-0.0939	0.0464	-0.0092	-0.0646	1.0000			
-0.0687	-0.0954	-0.0730	-0.0409	0.0683	-0.0717	-0.0076	0.1024	-0.0199	-0.2331	-0.1512	1.0000		
-0.0046	-0.0236	-0.0328	-0.0326	0.0158	-0.0592	0.0695	0.0452	0.0070	-0.0641	-0.0054	0.0512	1.0000	
0.0020	-0.0386	-0.0508	-0.0305	0.0303	-0.0461	0.0774	0.0359	0.0121	-0.0716	-0.0271	0.0759	-0.1135	1.0000
0.0101	-0.0232	-0.0225	-0.0142	0.0293	-0.0220	0.0431	0.0148	0.0292	-0.0449	-0.0304	0.0137	-0.0584	-0.0482
-0.0065	-0.0588	-0.0527	-0.0347	0.0300	-0.0115	0.0288	0.0482	0.0101	-0.0956	-0.0357	0.0761	-0.0910	-0.0752
0.0060	-0.0388	-0.0325	-0.0181	0.0387	-0.0136	0.0298	0.0303	0.0018	-0.0669	-0.0298	0.0539	-0.0510	-0.0422
0.0009	-0.0348	-0.0328	-0.0193	0.0211	0.0042	0.0273	0.0177	-0.0046	-0.0669	-0.0279	0.0102	-0.0478	-0.0395
0.0086	0.0120	-0.0082	-0.0216	0.0114	-0.0205	-0.0162	0.0074	0.0153	-0.0164	-0.0052	0.0303	0.0360	-0.0103
0.0038	-0.0273	-0.0396	-0.0278	0.0096	-0.0350	0.0327	0.0218	0.0027	-0.0418	-0.0147	0.0367	0.0590	0.0587
0.0110	-0.0323	-0.0199	-0.0199	0.0233	-0.0434	0.0654	0.0224	0.0077	-0.0337	-0.0107	0.0069	0.0400	0.0808
0.0040	-0.0118	-0.0340	-0.0255	0.0024	-0.0334	0.0773	0.0126	0.0116	-0.0308	-0.0235	-0.0052	0.0404	0.0744
-0.0033	-0.0030	-0.0144	-0.0091	0.0083	-0.0319	0.0520	-0.0030	0.0192	0.0034	-0.0347	-0.0039	0.0146	0.0289
-0.0046	-0.0188	-0.0040	-0.0090	0.0069	-0.0088	0.0277	-0.0020	0.0069	-0.0058	-0.0183	0.0060	0.0246	0.0189
-0.0101	-0.0112	-0.0217	-0.0153	-0.0026	0.0018	0.0476	0.0141	0.0068	-0.0287	-0.0146	0.0016	0.0078	0.0195
0.0143	-0.0051	-0.0069	0.0038	0.0009	-0.0057	0.0061	0.0059	-0.0080	-0.0029	-0.0010	0.0058	0.0185	0.0093
0.0056	-0.0098	-0.0245	-0.0060	0.0086	-0.0152	0.0510	0.0021	-0.0030	-0.0116	-0.0256	-0.0009	0.0034	0.0119

4-6 Times Soda Dummy	7-13 Times Soda Dummy	14-20 Times Soda Dummy	21+ Times Soda Dummy	1 Time Fast Food Dummy	2 Times Fast Food Dummy	3 Times Fast Food Dummy	4 Times Fast Food Dummy	5 Times Fast Food Dummy	6 Times Fast Food Dummy	7 Times Fast Food Dummy	8 Times Fast Food Dummy	9 Times Fast Food Dummy
1.0000												
-0.0387	1.0000											
-0.0217	-0.0338	1.0000										
-0.0203	-0.0317	-0.0178	1.0000									
-0.0155	-0.0046	-0.0149	-0.0128	1.0000								
0.0156	0.0160	0.0264	0.0041	-0.2269	1.0000							
0.0271	0.0457	0.0269	0.0151	-0.1699	-0.1221	1.0000						
0.0404	0.0315	0.0311	0.0272	-0.1147	-0.0824	-0.0617	1.0000					
0.0580	0.0384	0.0174	0.0284	-0.0949	-0.0682	-0.0511	-0.0345	1.0000				
0.0385	0.0063	0.0179	0.0116	-0.0473	-0.0340	-0.0254	-0.0172	-0.0142	1.0000			
0.0258	0.0729	0.0429	0.0339	-0.0754	-0.0542	-0.0405	-0.0274	-0.0227	-0.0113	1.0000		
0.0172	0.0006	-0.0055	0.0044	-0.0223	-0.0160	-0.0120	-0.0081	-0.0067	-0.0033	-0.0053	1.0000	
0.0411	0.0282	0.0450	0.0908	-0.0628	-0.0452	-0.0338	-0.0228	-0.0189	-0.0094	-0.0150	-0.0044	1.0000

CHAPTER 4

QUANTITATIVE RESULTS

In this chapter, I will describe the binary logistic regressions, probit regressions, and margins commands I conducted to describe the likelihood of depression in heart disease and heart failure patients. I will also discuss what we can infer from the results, as well as the endogeneity inherent to the variables in this study.

Regressions

Binary Logistic Regressions

Table 5 displays the results of my binary logistic regression with heart disease as the independent variable. Table 6 displays the results of my binary logistic regression with heart failure as the independent variable. A P-value equal to or less than 0.1 is considered statistically significant with a 90 percent degree of confidence in a two-tailed test that the detected effect is different than zero. To interpret the results of the reported odds ratios in Tables 5 and 6, subtract the odds ratio values by one and then multiply by 100. Table 5 describes that individuals with heart disease are 94.3% more likely to report depression than those who do not have heart disease, with all other variables held constant. Table 6 shows that individuals with heart failure are 156.3% more likely to report depression than those who do not have heart failure. These results indicate that as heart disease worsens to heart failure, the likelihood of being depressed increases an additional 62%. However, these simple binary logistic regressions do not control for the endogeneity of heart disease and heart failure to the other explanatory variables, and to the dependent variable of depression. Endogeneity occurs when the values of a variable

may be effected by their relationship with other variables within the study. Endogeneity effects the ability of a regression to illustrate a definitive causal relationship between the independent and dependent variables because the regression coefficient calculated for the endogenous variable is biased.

Probit Regressions with Endogenous Covariates

The only way to address endogeneity in an explanatory variable included in a regression that uses a dichotomous dependent is to switch from running a logistic regression to a probit logistic regression. This switch is necessary because the intricacies of the logistic regression do not allow for an endogenous estimation. But, when switching to probit estimation, there is an additional step of using the "margins" command in STATA to allow for a comparable interpretation with the logistic findings. Table 7 displays the results of my probit regression with heart disease as the independent variable. Table 8 displays the results of my probit regression with heart failure as the independent variable.

In Table 7, the positive probit regression coefficient for heart disease (3.39) describes with 90% confidence that the presence of depression in individuals with heart disease is greater than in individuals without heart disease. Table 8 indicates that the presence of depression in individuals with heart failure (5.79) is greater than individuals without heart failure. The presence of depression in individuals with heart failure is greater than in individuals with heart disease. In order to interpret these probit regression results and control for endogeneity, I ran a computation of marginal effects after each probit regression in STATA.

Computation of Marginal Effects

Running a computation of marginal effects after a probit regression provides interpretable values that are comparable to the odds ratios in a binary logistic regression. The results indicate the marginal effects that the presence of heart disease and heart failure have on depression, with 90% confidence. The marginal effect of having heart disease increases the probability of depression by 3.6%. The marginal effect of having heart failure increases the probability of depression by 3.9%. The effect is still positive and indicates that the probability of depression increases as heart disease worsens to heart failure, but the effect is much smaller. This is not surprising because the probit model accounts for endogeneity. Endogeneity occurs when the change in a variable is related to other factors that influence the dependent variable and are not accounted for in the model.

Endogeneity

Endogenous variables can present an issue for a study because results may not accurately reflect a causal relationship between explanatory and dependent variables. To account for endogeneity, I looked for variables in the CHIS data that cause heart disease but do not cause depression. Heart disease causes depression, and lifestyle factors such as poor diet are known to negatively affect heart health (Anand, *et al*. 2015). Therefore, out of the variables choices in the CHIS data set, I selected fast food and soda consumption as variables that could cause heart disease but not depression. However, there is also the possibility that diet causes not only heart disease but also depression.

If the progression of the causal chain begins with poor diet, leads to heart disease, which ultimately leads to depression, the analysis is correct. There is a large, well-

established body of work highlighting the role diet plays in heart health. For example, a report published by scholars with the World Heart Federation concluded that "our understanding of foods and macronutrients in relationship to cardiovascular disease is broadly clear…based on the current evidence, the traditional Mediterranean-type diet, including plant foods/emphasizing plant protein sources, provides a well-tested healthy dietary pattern to reduce cardiovascular disease" (Anand, *et al*. 2015).

But, if diet directly impacts depression, then there could be an issue with showing causation for heart disease (Akbaraly, Brunner, Ferrie, & Marmot, 2009). There is often not a clear distinction in the causal chain, only that poor diet is correlated with higher depression. As noted in a study by Akbaraly, Brunner, Ferrie, and Marmot (2009), "several lines of investigation have suggested that coronary heart disease and inflammation are involved in the pathogenesis of depression. However, further studies are needed to improve our understanding of the association between processed food intake, the inflammation process, and depression" (p. 411).

Since the CHIS survey data is fixed in time, it cannot be used to investigate the different causal chains. Therefore, this study assumes that if a diet does influence depression, it does so through heart disease. But there is also the possibility that diet influences other physiological functions, besides heart disease, that induce depression. A Harvard Health Blog post details the difficulty in determining a directional relationship between diet and depression but concludes that "a dietary pattern characterized by a high intake of fruit, vegetables, whole grain, fish, olive oil, low-fat dairy and antioxidants and low intakes of animal foods was apparently associated with a decreased risk of

depression" (Tello, 2018). The present study is an example of the difficulty of sorting out causality in a complex system and a lesson for public policy analysis that, in conventional thinking, often ignores endogeneity.

Table 5: Binary Logistic Regression – Heart Disease

DepressedControlDummy	Odds Ratio	Linearized Std. Err.	t	P-Value	90% Conf. Interval	
Heart Disease Dummy	1.943	0.326	3.960	0.000	1.475	2.561
Twenty-Six to Twenty-Nine Dummy	0.889	0.221	-0.470	0.635	0.590	1.338
Thirty to Thirty-Four Dummy	1.176	0.266	0.720	0.473	0.811	1.707
Thirty-Five to Thirty-Nine Dummy	0.741	0.181	-1.230	0.220	0.495	1.108
Forty to Forty-Four Dummy	0.693	0.165	-1.540	0.124	0.469	1.026
Forty-Five to Forty-Nine Dummy	0.946	0.220	-0.240	0.810	0.645	1.386
Fifty to Fifty-Four Dummy	1.873	0.449	2.620	0.009	1.262	2.779
Fifty-Five to Fifty-Nine Dummy	0.948	0.195	-0.260	0.796	0.676	1.330
Sixty to Sixty-Four Dummy	1.009	0.233	0.040	0.969	0.690	1.475
Sixty-Five to Sixty-Nine Dummy	0.669	0.173	-1.550	0.120	0.437	1.024
Seventy to Seventy-Four Dummy	0.438	0.117	-3.100	0.002	0.283	0.679
Seventy-Five to Seventy-Nine Dummy	0.567	0.198	-1.620	0.104	0.319	1.007
Eighty to Eighty-Four Dummy	0.378	0.127	-2.910	0.004	0.218	0.655
Eighty-Five and Up Dummy	0.386	0.149	-2.470	0.014	0.205	0.728
Female Dummy	1.399	0.148	3.190	0.001	1.177	1.664
Hispanic Dummy	0.705	0.103	-2.400	0.016	0.554	0.896
African American Dummy	0.948	0.185	-0.280	0.783	0.687	1.307
American Indian Dummy	0.466	0.166	-2.140	0.032	0.259	0.838
Asian Dummy	0.746	0.149	-1.470	0.143	0.538	1.036
Multiple Races/Ethnicities Dummy	1.039	0.273	0.140	0.885	0.674	1.601
Grade 9 through 11 Dummy	1.163	0.235	0.750	0.454	0.834	1.623
High School Diploma Dummy	0.564	0.097	-3.320	0.001	0.424	0.749
Some College Dummy	0.682	0.146	-1.780	0.074	0.480	0.970
Vocational School Dummy	0.478	0.131	-2.700	0.007	0.305	0.750
Associate's Degree Dummy	0.396	0.101	-3.610	0.000	0.260	0.604
Bachelor's Degree Dummy	0.376	0.081	-4.540	0.000	0.264	0.536
Master's Degree Dummy	0.295	0.095	-3.790	0.000	0.174	0.501
Doctorate Dummy	0.569	0.268	-1.200	0.231	0.263	1.234
Live With Partner Dummy	1.421	0.302	1.650	0.098	1.002	2.016
Widowed/Separated/Divorced Dummy	2.614	0.408	6.160	0.000	2.022	3.379
Never Married Dummy	1.852	0.264	4.330	0.000	1.465	2.341
Federal Poverty Level - 100 to 199 Dummy	0.951	0.129	-0.370	0.708	0.761	1.188
Federal Poverty Level - 200 to 299 Dummy	0.623	0.104	-2.840	0.005	0.473	0.819
Federal Poverty Level - 300 and Up Dummy	0.447	0.071	-5.060	0.000	0.344	0.581
Naturalized Citizen Dummy	1.430	0.223	2.290	0.022	1.106	1.848
Non-Citizen Dummy	0.937	0.157	-0.390	0.700	0.711	1.235

Table 6: Binary Logistic Regression – Heart Failure

DepressedControlDummy	Odds Ratio	Linearized Std. Err.	t	P-Value	90% Conf. Interval	
Heart Failure Dummy	2.564	0.594	4.060	0.000	1.751	3.753
Twenty-Six to Twenty-Nine Dummy	0.892	0.222	-0.460	0.647	0.593	1.343
Thirty to Thirty-Four Dummy	1.185	0.269	0.750	0.456	0.815	1.722
Thirty-Five to Thirty-Nine Dummy	0.740	0.181	-1.230	0.219	0.495	1.107
Forty to Forty-Four Dummy	0.700	0.166	-1.500	0.133	0.473	1.034
Forty-Five to Forty-Nine Dummy	0.960	0.223	-0.180	0.861	0.655	1.407
Fifty to Fifty-Four Dummy	1.901	0.452	2.710	0.007	1.287	2.810
Fifty-Five to Fifty-Nine Dummy	0.972	0.199	-0.140	0.891	0.695	1.361
Sixty to Sixty-Four Dummy	1.035	0.236	0.150	0.881	0.711	1.506
Sixty-Five to Sixty-Nine Dummy	0.694	0.177	-1.430	0.152	0.457	1.056
Seventy to Seventy-Four Dummy	0.462	0.123	-2.890	0.004	0.298	0.717
Seventy-Five to Seventy-Nine Dummy	0.664	0.262	-1.040	0.299	0.347	1.270
Eighty to Eighty-Four Dummy	0.415	0.133	-2.750	0.006	0.245	0.702
Eighty-Five and Up Dummy	0.416	0.157	-2.330	0.020	0.224	0.774
Female Dummy	1.402	0.148	3.210	0.001	1.179	1.667
Hispanic Dummy	0.693	0.102	-2.500	0.012	0.544	0.882
African American Dummy	0.921	0.183	-0.410	0.679	0.665	1.276
American Indian Dummy	0.464	0.166	-2.140	0.032	0.257	0.836
Asian Dummy	0.741	0.147	-1.510	0.132	0.535	1.028
Multiple Races/Ethnicities Dummy	1.043	0.272	0.160	0.873	0.678	1.602
Grade 9 through 11 Dummy	1.201	0.243	0.900	0.366	0.861	1.676
High School Diploma Dummy	0.568	0.098	-3.290	0.001	0.429	0.754
Some College Dummy	0.686	0.146	-1.770	0.077	0.483	0.974
Vocational School Dummy	0.475	0.130	-2.730	0.006	0.304	0.744
Associate's Degree Dummy	0.398	0.102	-3.610	0.000	0.261	0.606
Bachelor's Degree Dummy	0.376	0.081	-4.560	0.000	0.264	0.535
Master's Degree Dummy	0.294	0.094	-3.810	0.000	0.173	0.498
Doctorate Dummy	0.575	0.268	-1.190	0.235	0.267	1.238
Live With Partner Dummy	1.427	0.302	1.680	0.093	1.007	2.022
Widowed/Separated/Divorced Dummy	2.635	0.406	6.280	0.000	2.044	3.395
Never Married Dummy	1.853	0.262	4.370	0.000	1.469	2.338
Federal Poverty Level - 100 to 199 Dummy	0.942	0.128	-0.440	0.660	0.753	1.178
Federal Poverty Level - 200 to 299 Dummy	0.611	0.102	-2.950	0.003	0.464	0.804
Federal Poverty Level - 300 and Up Dummy	0.441	0.070	-5.140	0.000	0.339	0.573
Naturalized Citizen Dummy	1.432	0.222	2.320	0.021	1.110	1.849
Non-Citizen Dummy	0.936	0.157	-0.400	0.692	0.710	1.233

Table 7: Probit Regression – Heart Disease

Variable	Coef.	Std. Err.	z	P>z	90% Conf. Interval	
Heart Disease Dummy	3.392	0.023	149.280	0.000	3.355	3.429
Twenty-Six to Twenty-Nine Dummy	-0.011	0.043	-0.240	0.807	-0.082	0.061
Thirty to Thirty-Four Dummy	-0.016	0.040	-0.390	0.693	-0.082	0.051
Thirty-Five to Thirty-Nine Dummy	-0.047	0.042	-1.110	0.265	-0.117	0.023
Forty to Forty-Four Dummy	-0.042	0.041	-1.040	0.300	-0.110	0.025
Forty-Five to Forty-Nine Dummy	-0.065	0.041	-1.580	0.114	-0.133	0.003
Fifty to Fifty-Four Dummy	-0.123	0.043	-2.860	0.004	-0.194	-0.052
Fifty-Five to Fifty-Nine Dummy	-0.188	0.038	-4.930	0.000	-0.251	-0.125
Sixty to Sixty-Four Dummy	-0.271	0.037	-7.430	0.000	-0.331	-0.211
Sixty-Five to Sixty-Nine Dummy	-0.406	0.036	-11.250	0.000	-0.465	-0.346
Seventy to Seventy-Four Dummy	-0.609	0.039	-15.670	0.000	-0.673	-0.545
Seventy-Five to Seventy-Nine Dummy	-0.710	0.042	-16.760	0.000	-0.780	-0.640
Eighty to Eighty-Four Dummy	-0.868	0.044	-19.550	0.000	-0.941	-0.795
Eighty-Five and Up Dummy	-1.013	0.050	-20.380	0.000	-1.095	-0.931
Female Dummy	0.149	0.016	9.400	0.000	0.123	0.175
Hispanic Dummy	0.070	0.023	3.040	0.002	0.032	0.108
African American Dummy	0.056	0.034	1.650	0.098	0.000	0.111
American Indian Dummy	-0.106	0.073	-1.450	0.148	-0.226	0.014
Asian Dummy	0.126	0.026	4.920	0.000	0.084	0.168
Multiple Races/Ethnicities Dummy	-0.004	0.047	-0.070	0.941	-0.081	0.074
Grade 9 through 11 Dummy	0.019	0.043	0.440	0.659	-0.052	0.089
High School Diploma Dummy	-0.045	0.037	-1.200	0.229	-0.107	0.017
Some College Dummy	-0.057	0.041	-1.400	0.161	-0.124	0.010
Vocational School Dummy	-0.131	0.056	-2.320	0.020	-0.223	-0.038
Associate's Degree Dummy	-0.045	0.050	-0.910	0.365	-0.127	0.037
Bachelor's Degree Dummy	-0.039	0.046	-0.830	0.405	-0.115	0.037
Master's Degree Dummy	-0.016	0.055	-0.300	0.767	-0.107	0.075
Doctorate Dummy	-0.039	0.055	-0.720	0.472	-0.129	0.050
Live With Partner Dummy	0.032	0.035	0.930	0.355	-0.025	0.090
Widowed/Separated/Divorced Dummy	0.042	0.030	1.410	0.157	-0.007	0.091
Never Married Dummy	0.092	0.031	2.990	0.003	0.041	0.143
Federal Poverty Level - 100 to 199 Dummy	0.039	0.027	1.430	0.153	-0.006	0.083
Federal Poverty Level - 200 to 299 Dummy	0.098	0.034	2.850	0.004	0.041	0.154
Federal Poverty Level - 300 and Up Dummy	0.083	0.049	1.710	0.087	0.003	0.164
Naturalized Citizen Dummy	0.036	0.028	1.270	0.206	-0.011	0.083
Non-Citizen Dummy	0.034	0.030	1.160	0.246	-0.014	0.083

Table 8: Probit Regression – Heart Failure

Variable	Coef.	Std. Err.	z	P>z	90% Conf. Interval	
Heart Failure Dummy	5.794	0.054	108.250	0.000	5.706	5.883
Twenty-Six to Twenty-Nine Dummy	-0.007	0.043	-0.170	0.864	-0.079	0.064
Thirty to Thirty-Four Dummy	-0.042	0.041	-1.030	0.304	-0.109	0.025
Thirty-Five to Thirty-Nine Dummy	-0.068	0.043	-1.590	0.113	-0.138	0.003
Forty to Forty-Four Dummy	-0.061	0.041	-1.480	0.138	-0.129	0.007
Forty-Five to Forty-Nine Dummy	-0.074	0.042	-1.770	0.077	-0.142	-0.005
Fifty to Fifty-Four Dummy	-0.101	0.044	-2.280	0.023	-0.174	-0.028
Fifty-Five to Fifty-Nine Dummy	-0.137	0.039	-3.550	0.000	-0.201	-0.074
Sixty to Sixty-Four Dummy	-0.197	0.037	-5.370	0.000	-0.258	-0.137
Sixty-Five to Sixty-Nine Dummy	-0.287	0.036	-7.940	0.000	-0.346	-0.227
Seventy to Seventy-Four Dummy	-0.348	0.039	-8.920	0.000	-0.412	-0.284
Seventy-Five to Seventy-Nine Dummy	-0.412	0.043	-9.650	0.000	-0.482	-0.342
Eighty to Eighty-Four Dummy	-0.530	0.045	-11.870	0.000	-0.603	-0.456
Eighty-Five and Up Dummy	-0.648	0.050	-12.850	0.000	-0.731	-0.565
Female Dummy	0.129	0.016	8.050	0.000	0.103	0.155
Hispanic Dummy	-0.008	0.023	-0.370	0.715	-0.046	0.030
African American Dummy	-0.061	0.034	-1.800	0.071	-0.117	-0.005
American Indian Dummy	-0.125	0.073	-1.700	0.088	-0.246	-0.004
Asian Dummy	0.023	0.026	0.890	0.376	-0.020	0.065
Multiple Races/Ethnicities Dummy	-0.040	0.048	-0.840	0.399	-0.119	0.038
Grade 9 through 11 Dummy	0.089	0.043	2.060	0.039	0.018	0.159
High School Diploma Dummy	0.013	0.038	0.340	0.734	-0.050	0.076
Some College Dummy	0.020	0.041	0.490	0.624	-0.048	0.088
Vocational School Dummy	-0.130	0.057	-2.300	0.022	-0.223	-0.037
Associate's Degree Dummy	0.007	0.051	0.130	0.894	-0.077	0.091
Bachelor's Degree Dummy	0.010	0.048	0.210	0.835	-0.069	0.089
Master's Degree Dummy	0.020	0.058	0.350	0.724	-0.075	0.116
Doctorate Dummy	0.003	0.056	0.060	0.955	-0.089	0.095
Live With Partner Dummy	0.068	0.035	1.900	0.057	0.009	0.126
Widowed/Separated/Divorced Dummy	0.035	0.031	1.100	0.270	-0.017	0.087
Never Married Dummy	0.054	0.032	1.680	0.094	0.001	0.107
Federal Poverty Level - 100 to 199 Dummy	0.008	0.028	0.280	0.781	-0.038	0.053
Federal Poverty Level - 200 to 299 Dummy	0.067	0.036	1.890	0.058	0.009	0.126
Federal Poverty Level - 300 and Up Dummy	0.079	0.052	1.520	0.130	-0.007	0.165
Naturalized Citizen Dummy	0.061	0.029	2.100	0.036	0.013	0.109
Non-Citizen Dummy	0.055	0.030	1.840	0.065	0.006	0.104

CHAPTER 5

CONCLUSION

The purpose of this thesis was to examine the important relationship between heart disease and depression. As discussed, the U.S. has the most expensive health care system of the world's developed nations (Kane, 2012). Heart disease was the leading cause of death in the U.S. in 2010 and an estimated 17.3 million adults in the U.S., more than 7% of the population, had at least one major depressive episode in 2017 (American Heart Association, 2013; National Institute of Mental Health, 2017). Following the national trend, deaths resulting from heart failure in California and adults diagnosed with a major depressive disorder have both increased in recent years (California Department of Public Health, 2016; Let's Get Healthy California, 2019).

Heart disease and depression cost the U.S. about $200 billion and $210 billion each year, respectively (Centers for Disease Control and Prevention, 2015; Greenberg, 2015). In addition to the effects these diagnoses have on quality of life, heart disease and depression also have major direct and indirect economic impacts, ranging from budget spent on alleviating systems to a loss of economic productivity. The existing body of academic research supports the complex and significant relationship between heart disease and depression, and highlights some of the practical societal implications. For example, individuals diagnosed with both heart disease and depression are twice as likely to be admitted to the hospital and use the emergency room, contributing to the strain on emergency services and taxpayer dollars (Sandoiu, 2018). The complex interplay between heart disease and depression is also evident in the magnitude change that occurs

when a study controls for the inherent endogeneity between the two variables. Mitigating the effects of these diseases represents a significant public policy opportunity. This is true especially if the greater prevalence of heart disease in the U.S. is also a causal factor in the occurrence of depression. If so, a successful policy effort to reduce heart disease would reduce health care dollars currently spent on both diseases.

Regression Analysis Discussion

Endogeneity Issue

My regression results show that as heart disease worsens to heart failure, the rate of depression increases, implying that heart disease exacerbates depression and supporting the existing body of research. The relationship between heart disease and depression is very complex because there is an inherent challenge in teasing apart the root causes for each disease. As discussed in Chapter 2, many researchers have examined depression factors, the connection between heart disease and depression, and outcomes for heart disease patients with depression. Though the academic papers did not explicitly address the endogeneity inherent with heart disease and depression, most included control variables such as age, gender, marital status, education level, and race/ethnicity (Burger, 1984; Cacioppo, *et al*. 2006; Graven, *et al*. 2017). Others included additional control variables such as smoking status, alcohol intake, physical activity level, BMI, comorbidities, and socioeconomic status (Ferketich & Binkley, 2005; Lossnitzer, *et al*. 2013; Moraska, *et al*. 2013; Ramos, *et al*. 2016; Sherwood, *et al*. 2011).

To account for endogeneity, this thesis included fast food consumption and soda consumption from the CHIS data set as instrumental variables in a two-stage regression

process that assumes heart disease is caused by these forms of "bad" food consumption, but depression is not. But before accounting for this endogeneity, my first two regressions in Chapter 4 are binary logistic regressions which did not contain fast food consumption or soda consumption variables as instrumental variables used to predict heart disease, and thus did not control for endogeneity. The second two regressions are probit regressions that do control for endogeneity in this manner.

Logistic Findings Comparison

My binary logistic regressions show that with all other variables held constant, individuals with heart disease are 94.3% more likely to report depression than those who do not have heart disease, and individuals with heart failure are 156.3% more likely to report depression than those who do not have heart failure. Others that similarly did not account for endogeneity found similar results. Coronary heart failure patients were 300% more likely to report psychological distress than patients without heart failure (Ferketich & Binkley, 2005), and patients with high heart failure symptoms were 190% times more likely to report depression than those without symptoms (Graven, *et al*. 2017). One study examining outcomes for heart disease patients with depression reported that depressive symptoms predict mortality at 290% greater than those that do not have either, and hospitalizations at 320% greater (Ramos, *et al*. 2016), while another found that heart failure patients who died during the course of the study had a 30% higher incidence rate of depression than heart failure patients who did not die during the study (Lossnitzer, *et al*. 2013). For the purpose of interpreting these findings for public policy, it is important

to call out that these studies did not explicitly control for the endogeneity of depression and heart disease as discussed above.

The probit regressions, which included fast food consumption and soda consumption as instrumental variables to control for endogeneity found that individuals with heart disease had a higher incidence of depression than individuals without heart disease (at about 3.4% greater), and the incidence of depression increased further for individuals with heart failure (at 3.9% greater). The effect is still positive and supports that the incidence of depression is higher as heart depressions worsens to heart failure, but the magnitude is much smaller than when not controlling for endogeneity. This finding is important to consider when assessing the public policy benefits of reducing heart disease in a manner that does not also reduce fast food or soda consumption (such as a drug regimen).

Magnitude Change when Controlling for Endogeneity

The initial binary logistic regressions support the findings that there is a high correlation between heart disease and depression, and a higher correlation between heart failure and depression. The findings reveal that individuals with heart disease are 94.3% more likely to report depression than those who do not have heart disease, and individuals with heart failure are 156.3% more likely to report depression than those who do not have heart failure. These results are consistent with existing scholarly articles on the subject of heart disease and depression. But, after controlling for endogeneity in my regressions, the magnitude of the relationship between heart disease and depression and heart failure and depression falls significantly: having heart disease increases the

likelihood of depression by 3.6%, and heart failure increases the likelihood of depression by 3.9%. Endogeneity can prevent a study from accurately reflecting a causal relationship between explanatory and dependent variables. Using survey data that is fixed in time to depict a causal chain between inherently interconnected and complex variables like heart disease and depression can be challenging. It requires the assumption that if diet does influence depression, it does so through heart disease.

The role diet plays in heart health is clear, and research supports that a traditional Mediterranean-type diet reduces the incidence of heart disease (Anand, *et al*. 2015). However, a diet of fruit, vegetables, whole grain, fish, olive oil, low-fat dairy, and antioxidants is also associated with a reduced incidence of depression (Tello, 2018). Previous research supports that heart disease and inflammation play a key role in depression (Akbaraly, *et al*. 2009). Inflammation is a byproduct of lifestyle factors such as processed food intake, but more research is needed to enhance our understanding between the inflammation process and disease. It is possible that the magnitude change of the relationship between heart disease and depression when controlling for endogeneity is due to the complex role that lifestyle factors like food and soda consumption play in an individual's holistic health.

Two things are clear: the incidence of depression is higher in individuals with heart disease, and food and soda consumption play a key role in the incidence of heart disease and depression. Absent genetic factors, lifestyle factors that cause inflammation such as poor diet, stress, and lack of exercise are the underlying issues that yield heart disease and depression. Depression occurs with these lifestyle factors even before heart

disease is diagnosed, but the onset of a heart disease diagnosis increases the incidence of depression, though not by much.

Public Policy Implications

The regressions in this thesis support that the incidence of depression is higher in individuals with heart disease than in those without, and the incidence of depression increases as heart disease worsens to heart failure. The magnitude of the effect is still positive, but decreases, when lifestyle factors such as fast food and soda consumption are included to control for endogeneity. Because lifestyle factors such as poor diet play an important role in the onset of heart disease, which increases the incidence of depression, it is important that policymakers think about reducing these underlying causes.

I recommend an increased focus on promoting the integration of healthy lifestyle habits into the lives of all Californians. Eating healthy foods including fruit, vegetables, whole grain, fish, olive oil, low-fat dairy, and antioxidants, and avoiding fast food and soda, should be an affordable and available option for every person regardless of physical location or socioeconomic status. Public policy should incentivize food providers to make these kinds of foods available and also incentivize consumers to choose these healthy options. If patients come to doctors with heart disease, there should be an incentive for doctors to provide a healthy eating plan to address the root of the problem rather than solely prescribe medication to alleviate symptoms. If individuals are able to build healthy patterns and lifestyle habits earlier, heart disease and depression may never become an issue. This would result in a higher quality of life for Californians and an extreme cost savings for taxpayers who fund the health care system.

Conclusion

This final chapter of my thesis included a summary of findings, a regression analysis discussion that addressed endogeneity and the logistic findings, and public policy implications. Because the relationship between heart disease and depression is complex, but the lifestyle factors that increase the incidence of both are clear, it is important that public policymakers focus on making healthy food choices available and accessible for all Californians. I am hopeful that this paper contributes to the conversation that healthy food choices are imperative for living healthy lives free from heart disease and depression, and for alleviating an expensive and overburdened healthcare system.

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