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IMPACT OF CHRONIC DISEASES ON GENERAL HEALH IN AMERICAN ADULTS

A Thesis in

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ABSTRACT

The goal of this thesis is to develop a multi-criteria weighting factor to highlight the importance of the effect of various chronic diseases on the health of American adults. A Multivariate logistic regression model is used to determine the odds ratio which represents the impact of each of the chronic diseases considered, controlling for socio-demographic factors and other conditions. The other criteria which is critical in establishing the effect of a chronic disease is the prevalence of the disease. A normalized bi-criteria additive weighting scheme is developed to show the importance of the chronic disease in terms of both prevalence and impact. The motivation behind developing such a weighting factor is to aid decision makers in making allocation decisions across several domains that influence health care needs, public policy, and research priorities.

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I would like to thank Dr.Griffin for his continued support, guidance, advice and patience through the course of this thesis. I thank Bristol Myers Squibb Company for their assistance in providing awareness and information about prevalence and impact of chronic diseases and the current research priorities within the industry. It greatly contributed towards the research. Last but not least, I would like to thank my family and friends for their help and support throughout my education.

Chapter 1 INTRODUCTION

The objective of this thesis consists two parts. The First part explores the impact of various chronic diseases on general health in American Adults. The National Health and Nutrition Examination Survey (NHANES) was used for the statistical analyses. NHANES is a survey research program conducted by the National Center for Health Statistics (NCHS) to assess the health and nutritional status of adults and children in the United States. It conducts a combination of examinations, laboratory measures, and questionnaires for each person across a large and representative population group. The 10-year dataset (1999 to 2008) has a total sample size of 51,623. The sampling strategy is such that it represents people of all ages and of different race/ethnicities.

The challenge here is to develop a method that is able to quantify the impact or severity of different health conditions. It is rather natural to assume that this factor alone would be enough to ascertain the importance of the various health conditions in terms of medical budgeting or research prioritization, but it should be noted that it would be of minimal use if the particular health condition was to occur in a negligible number of people. Therefore, the dimension of disease prevalence is also brought in, to come up with a single factor that would appropriately quantify the importance of these health conditions, which is what the second part of the thesis focuses on.

The second part of this thesis involves estimating the importance of each health condition through a weighting factor based on the prevalence and severity. If one were to allocate funds towards various chronic diseases, such a weighting factor would give the

person allocating the funds a clearer picture as to which conditions need more attention and which ones need less. Also, during optimal allocation of medical resources, these weights could be strategically used, subject to various risk factors in a portfolio optimization framework. The overall results will aid decision makers in making productive decisions in several domains influencing health care needs, public policy, and research priorities.

The thesis is organized in four discrete chapters, namely, literature survey, problem description and Methodology, results, and conclusions. The literature survey discusses the state of research pertaining to various aspects associated with the thesis topic. It has four sections out of which the first three synthesize the three critical aspects of this thesis and the fourth one explains the contribution of this thesis. The First section "Chronic Diseases and Quality of Life" presents a thorough review of all previous research that touches upon the impact of one or more chronic diseases one or more dimensions of life. The second section "Measure of disease burden" describes the different methods that were used to measure the impact of diseases on human health. The third section "Weighting factor for Chronic Diseases" outlines the several methodologies used in developing a weighting factor to represent the severity of chronic diseases.

Problem description and methodology is divided into two parts. The first one is the Problem description which indicates the objectives of this thesis in a specific sense and the second part explains in detail the methodology used in developing the results. This section explains the data set used, the case definition for each chronic disease considered, calculation of prevalence, and the quantitative methods used in determining the weighting factor.

The results section presents all the results of this research in a clear and succinct way. The conclusion section summarizes all the different results obtained through this research while discussing some of the possible applications and also presents the future research opportunities in this area.

Chapter 2 LITERATURE SURVEY

2.1 Chronic Diseases and Quality of Life

Research in the area of chronic diseases and their impact on quality of life (QOL) has been performed extensively across sample sets from various countries. Many common and uncommon chronic diseases have been considered and their impact on the multiple dimensions associated with general health and quality of life has been examined. Early researchers (1980s) devoted most of their time and effort in analyzing the impact of chronic diseases on general health within a small sample set that only covered a few regions or at most a few countries. Therefore, it is quite difficult to generalize the results. Also, most previous research did not adjust for co-morbidities or other risk factors such as social income or race/ethnicity.

A very critical part of assessing the health of a person is a tool to measure the quality of life or well-being of an individual. Many tools have been developed over the years to measure what is commonly called in literature as "Health Related Quality of Life", abbreviated in most cases as HRQoL and in some cases as just HRQL. Initially, many of the researchers used their own form of assessing the quality of life of a person, by developing their own set of questions. In time, as researchers started to realize the importance of assessment tools, many standard HRQoL tools started to emerge. These are most often than not, simply patient questionnaires, which try to cover physical, psychological, emotional, cognitive, social, work or role related aspects. They also collect the disease related symptoms, side effects, financial impact etc. The most common

HRQoL measures which are currently used are the Short-Form Health Survey (SF-36), SF-12, Manchester Short Assessment of Quality of Life (MANSA), EQ 5D and EQ 15D. The numbers observed in the names of the questionnaire often indicate the number of questions. SF-36 is a widely-used questionnaire assessing physical, social, and mental HRQoL, used in clinical trials. The SF-12 is a shorter form of the SF-36. Manchester Short Assessment of Quality of Life is used for psychiatric populations andEQ-5D& EQ-15D are all simple quality of life questionnaires. Interestingly, most of the HRQoL measures found in literature are directed towards adults and the lesser age group, namely children and infants, has not been looked at in detail. The reason behind this is that, there are not many well developed quality of life assessment tools like those available for adults.

The impact of chronic diseases on general health is often analyzed using the common statistical methods such as a student's *t*-test, analysis of variance, and multivariate regression. Since general health or the variables associated with health are mostly dichotomous or in some cases polychotomous, logistic regression models are employed to find the impact through a parameter called an odds ratio. The predictor or independent variables used in these models were the various chronic conditions along with the risk factors if any, while the dependent variable were the ones associated to quality of life.

Deyo et al. [1982] examined the impact of rheumatoid arthritis on physical and psychosocial behavior[1]. Sickness Impact Profile (SIP) was introduced as a QOL assessment tool and was self-administered on 79 patients with rheumatoid arthritis.[1] There was significant impact observed in both physical and psychosocial aspects. Mason

et al. [1983] conducted a research study to find out the effects of mainly rheumatoid arthritis along with hypertension, cancer, diabetes, cardiac disease and pulmonary disease.[2] A self-administered survey examining 11 different aspects of health was used and the results they found were not in complete agreement with those of Deyo et al. [1982] Rheumatoid arthritis and pulmonary diseases had serious negative impact on the 'physical functioning and pain' aspect of QOL, but there was not much impact found in the anxiety and depression aspect.

Cassileth et al. [1984] compared the psychological status of 758 patients with arthritis, cancer, diabetes, renal disease, dermatological disorders, and depression.[3] No significant differences in the psychological status were observed in the patients with these chronic conditions when compared to those without these conditions. However, these results were in contradiction to the report published by Stewart et al. [1989].[4] In fact, the results showed that there is a severe negative impact in physical, psychological and general well-being of the patients with these conditions.

One of the few research studies conducted for the elderly (sometimes classified as retired) age group was by Kempen et al. [1997]. They analyzed the impact of eight chronic diseases on HRQoL among 5279 'community-based Dutch Elderly'.[5] The chronic conditions considered were asthma/chronic bronchitis, heart condition, hypertension, diabetes, Back problem, Rheumatoid arthritis, Migraine and dermatological disorders and QOL aspects considered were physical functioning, social role functioning, somatic sensation and subjective well-being. The impact of these chronic conditions on HRQoL was analyzed by means of a student's *t*-tests, analysis of variance, and multiple regression analyses. The results show that Rheumatoid arthritis and Back problems were

the two chronic conditions that affected HRQoL most and Mental health was the QOL aspect that was least affected by these chronic conditions.

Ferrer et al. [1997] examined the effect of chronic obstructive pulmonary disease (COPD) and self-reported co-morbid conditions on physical, social and psychosocial dimensions of HRQoL.[6] The sample set included was 321 consecutive male patients with COPD. Statistical analysis involved the use of Kruskal-Wallis test to compare HRQoL scores with clinical and functional aspects of COPD. The Spearman correlation coefficient was calculated to assess the association between HRQoL scores and clinical or functional variables. The differences in HRQoL scores and other continuous variables according to the presence of co-morbid conditions were tested by using the student's t-test. The results showed that even patients with mild disease showed substantially compromised HRQoL.

Following extensive research on common chronic conditions, Schlenk et al. [1998], came up with research finding on chronic conditions such as urinary incontinence, prostate cancer, AIDS, fibromyalgia, hyperlipidaemia and COPD.[7] They used the SF-36 HRQoL questionnaire to assess the impact of these conditions on HRQoL. Prostate cancer and hyperlipidaemia had the lowest HRQoL score for physical functioning when compared to normal patients. AIDS had the lowest HRQoL score general health and social functioning while COPD was the lowest for bodily pain and vitality.

While in adults quality of life assessment tools were well developed, QOL measurement tools in children was a relatively new research field. Sieberer and Bullinger [1998] developed a German generic quality of life instrument for children (KINDL)

which was used to assess the HRQoL in chronically ill children.[8] The research work describes the application of KINDL in a group of 45 chronically ill children suffering from asthma and diabetes. The results interestingly showed that there were no significant differences in impact of asthma and diabetes on children with and without these conditions. But, the results were inconclusive due to many reasons such as small sample set, selection bias, etc. The main aim of this paper was to develop a QOL tool for children.

Lam and Lauder [1999] investigated the effects of chronic diseases on HRQoL on 760 Chinese patients who were in a clinic under primary care.[9] The questionnaire given to the patients consisted of questions in demographic and morbidity data and the Chinese version of Functional health assessment charts. The scores obtained for each disease group were compared to patients without any chronic conditions and the difference in proportion between them was tested by the chi-square test. The effects of gender, age, social class, marital status, education and diagnosis on the scores were analyzed using a multivariate forward logistic regression model. Depression was observed to be the most disabling condition while osteoarthritis of the knee had the most impact on HRQoL. A result which was a bit contrary to those observed previously in literature was that diabetes and heart diseases did not have too much impact on overall health.

Sprangers et al [2000] employed the SF-36 to compare the QOL across a wide range of patients with chronic conditions.[10] The data included over 15,000 patients from all over Netherlands and the chronic conditions considered were cancer, cardiovascular disease (CVD), cerebrovascular, endocrinologic, gastrointestinal, musculoskeletal conditions and psychiatric disorders. The analysis was controlled for Age, Sex, Education

level, marital status and prevalence of co-morbid conditions. Hearing was not impacted too much due to the presence of chronic conditions, while cerebrovascular, renal and musculoskeletal conditions were the ones which had the maximum impact on QOL. Cancer, CVD, endocrinologic conditions, visual impairment and chronic respiratory diseases had an intermediary impact on QOL.

Obesity research started to proliferate in the early 2000s in health services and health care policy. Sturm [2002] compared the effects of obesity, smoking, and drinking on health care use and health status after controlling for gender, race, household income, and education.[11] The data set had 10,000 individuals from a national survey data, Health Care for Communities (HCC). The analysis only included adults within the age group of 18 to 65. The dependent variables used were two measures for health status and two measures for health care use. Measures for health care use take into account inpatient and outpatient spending while the health status is measured using he scores from the SF-12. The results indicate a 36% increase in inpatient and outpatient spending for obese people and a 21% increase for the smoking segment. Also a startling 77% increase in medications was observed for obese people while there was only a 28% increase for smokers. There were relatively smaller effects observed for drinkers.

Very few studies have set out to explore the effects of chronic diseases on HRQoL across a general population in a global framework. The International Quality of life assessment (IQOLA) project began in 1991 with the goal of translating and validating the SF-36 Health Survey for international use.[12] Alonso et al. [2004] utilized the data from the IQOLA project to compare the impact of seven chronic diseases (allergies, arthritis, chronic lung disease, hypertension, is- chemic heart disease, congestive heart

failure, and diabetes) in eight countries (Denmark, France, Germany, Italy, Japan, the Netherlands, Norway and the United States) on HRQoL.[13]To test whether there were differences in the prevalence of reported chronic conditions by country, multivariate logistic models were built and adjusted for age, gender, education, and marital status. Arthritis had the most negative impact on HRQoL in the general population of countries. Ischemic heart disease and diabetes followed arthritis in terms of negative impact.

The inconsistent research findings of the impact of chronic medical conditions on different aspects of quality of life has driven researchers to come up with creditable and conclusive research findings. Within the last 5 years plenty of research has gone into finding the impact of patients with chronic conditions on HRQoL. Erica Lubetkin et al. [2005] investigated the influence of demographic and socioeconomic and chronic conditions on the HRQoL of a representative U.S. sample consisting of 13,646 adults.[14] Their study established the fact that socio demographic factors are strongly associated with general health. Samuli Saarni et al. [2006] investigated the impact of 29 chronic conditions on HRQoL in a representative sample of Finns.[15] Both the aforementioned studies utilized the EQ-5D. According to the study, Parkinson's disease had the largest impact on HRQoL and was followed by anxiety disorders, depression and arthritis. This study confidently emphasizes that musculoskeletal disorders impact general health the most and is followed closely by psychiatric conditions.

Griffin et al. [2009] examined the oral health needs among US adults with chronic diseases.[16] They calculated the prevalence of untreated dental disease, number of missing teeth and self-reported oral disease for US adults with chronic diseases (arthritis, rheumatoid arthritis, asthma, obesity, bronchitis, cancer, CVD, diabetes, uncontrolled

diabetes, emphysema, HCV, HIV, liver condition, stroke, and thyroid condition). Multivariate statistical analyses were performed to determine whether these conditions were associated with indicators of dental disease after controlling for common risk factors such as age, gender, race/ethnicity, income level and smoking status. Respondents with rheumatoid arthritis, diabetes and liver conditions were twice as likely to have dental needs when compared to those who did not have these conditions. The study clearly established the fact that chronic diseases increase the risk of developing dental diseases.

Author	Year	Chronic Conditions Considered	Conditions Impacting health	Types of QOL survey used	Age Group
Deyo et al.	1982	Rheumatoid Arthritis (RA)	RA	Self-Admnistered	Adults
Mason et al.	1983	RA, hypertension, cancer, diabetes, cardiac disease and pulmonary disease	RA, pulmonary disease	Self-Admnistered	Adults
Cassileth et al.	1984	Arthritis, cancer, diabetes, renal disease, dermatological disorders and depression	All	Self-Admnistered	Adults
Kempen et al.	1997	Asthma/chronic bronchitis, heart condition, hypertension, diabetes, back problem, RA, migraine and dermatological disorders	RA,back problem	Self-Admnistered	Elderly
Ferrer et al.	1997	Chronic Obstrucutive Pulmonary disease (COPD)	COPD	Self-Admnistered	Adults
Schlenk et al.	1998	Urinary incontinence, prostate cancer, AIDS, fibromyalgia, hyperlipidaemia and COPD	prostate cancer, hyperlipidaemia, AIDS	Self-Admnistered	Adults
Sieberer et al.	1998	Asthma and diabetes	None	KINDL	Children
Lam et al.	1999	Hypertension, diabetes, heart disease, osteoarthritis, asthma, COPD, stroke, depression	Depression, osteoarthritis	Self-Admnistered	Adults
Sprangers et al.	2000	Cancer, cardiovascular disease (CVD), cerebrovascular, endocrinologic, gastrointestinal, musculoskeletol conditions and psychiatric disorders	Cerebrovascular, renal and muskuloskeletol conditions	SF-36	Adults
Sturm et al.	2002	Obesity, smoking and drinking	Obesity, smoking	SF-12	Adults
Alonso et al.	2004	allergies, arthritis, chronic lung disease, hypertension, ischemic heart disease, congestive heart failure, and diabetes	Arthritis, Ischemic heart disease and diabetes	SF-36	Adults
Lubetkin et al.	2005	Diabetes, asthma, high blood pressure, heart disease, stroke, emphysema	-	EQ-5D	Adults
Saarni et al.	2005	29 chronic conditions	Parkinsons disease, anxiety, depression, arthritis	EQ-5D	Adults
Griffin et al.	2009	Arthritis, RA, asthma, obesity, bronchitis, cancer, CVD, diabetes, uncontrolled diabetes, emphysema, HCV,HIV, liver condition, stroke and thyroid condition	RA, diabetes and liver condition	NHANES	Adults

Table 2-1: Summary of section 2.1 literature survey

2.2 Measure of disease burden

2.2.1 Quality Adjusted Life Year

A quality adjusted life year (QALY) is a measure of disease burden taking into accounts both the quality and quantity of life. It was originally used to measure the effectiveness of a health care intervention and also for cost-effectiveness analysis. It was created with an intention to aid decision-makers for resource allocation.[17-19] Both the US Panel on Cost-Effectiveness in Health and Medicine and Britain's National Institute of Health and Clinical Excellence (NICE) has approved the QALY concept. A perfect health is quantified as 1 and death is quantified as 0.[20]Therefore, when some medical intervention extends a person life by 2 years, and the person has perfect health for those two years, then we say the person has obtained two additional QALYs due to the intervention. If say, his life was extended by two years with average quality of life, then the QALY associated with the intervention could be estimated as (2*0.5) =1.

Many argue that there are some conditions worse than death and so QALYs should have a negative range as well. Notwithstanding such arguments, QALYs are still commonly used in cost utility analysis to calculate the ratio of cost to QALYs saved for a particular health care intervention.[21] The ratio is also made use for health care resource allocation.

2.2.2 Disability-Adjusted Life Year (DALY)

Disability-Adjusted Life Year or DALYs were initially developed by the World Health Organization (WHO) in order to represent the global burden of disease.[23-24]Ata very high level, one could understand one DALY as one lost year of health life. This quantity of measure is rapidly becoming popular in the field of public health and health impact assessment.

DALY is a measure of the overall disease burden, expressed as the number of years lost due to ill-health, disability or early death. The overall burden of disease is assessed using the disability-adjusted life year (DALY), a time-based measure that combines years of life lost due to premature mortality and years of life lost due to time lived in states of less than full health.

DALYs for a disease or health condition are calculated as the sum of the Years of Life Lost (YLL) due to premature mortality in the population and the Years Lost due to Disability (YLD) for incident cases of the health condition.[28]

2.3 Weighting factor for Chronic Diseases

Limited research has been done towards finding a weighting factor for each chronic disease which could add more perspective to the chronic condition in terms of both health care policy decisions and medical resource allocation. Mossey and Roos [1987] were one of the first who came up with a scoring scale for illness severity.[29] It was based on the use of insurance claims data over a 1-year period. The Illness Scale score increased with ‘age’ and was associated with ‘probability of dying in the following year’,

'self-rated health', 'number of chronic conditions', 'activities of daily living', and 'days in bed' in the prior year.

Von Korff et al. [1992] developed the well-known 'Chronic Disease Score' (CDS) whose modifications and extensions are still in use today.[30] They utilized population-based automated pharmacy data and patterns of use of selected prescription medications during a 1 year time period to construct a measure of chronic disease status known as the Chronic Disease Score. A multidisciplinary expert panel applied predefined scoring rules for various medication use patterns to 1 year of dispensing records, creating a summary measure of an individual's burden of chronic disease. Johnson et al. [1994] replicated the CDS for validation purposed, with a different set of data and recommended that CDS could be used as a readily accessible low cost measure for health status.[31]

Clark et al. [1995] developed a revised chronic disease score to predict health care utilization, costs, hospitalization, and mortality and compared it to the original CDS that was derived through clinical judgments of disease severity.[32] The revised CDS weighting scheme introduced three sets of scoring weights, one for each of the following outcomes: total health care costs, outpatient care costs, and primary care visits. Empirical weights were derived from linear regression models of age, gender, and medication use on each of these outcomes. The resulting scores were more predictive of utilization outcomes and of following year hospitalizations than the original CDS.

Fishman et al. [2003] modified the CDS in such a way that it could be used in different health care settings.[33] To differentiate from CDS they called their model RxRisk. It is an all-ages and market segment pharmacy-based risk assessment model that can be easily replicated in multiple health care settings. It produces estimates of future

health care cost based on an individual's age, sex, and chronic condition profile measured by pharmacy dispenses linked to chronic conditions or clinically homogenous groups. Kathleen Putnam et al. [2002] compared the original CDS, revised CDS and RxRisk models and commented that all models performed similarly in predicting health care costs with the 'revised CDS' slightly better than the others.[34]

2.4 Contribution of this Thesis

The impact of liver condition and poor vision along with the regular chronic conditions has not been examined in most of the previous research. Although both these conditions have been extensively researched at an individual level by medical practitioners and researchers, their impact along with all the other chronic diseases on general health subject to various risk factors is yet to be seen. Also, poor hearing, Hepatitis-C (HCV) and emphysema have not been commonly considered. This thesis will include 20 chronic conditions viz., arthritis, asthma, cancer, chronic bronchitis, obesity, kidney disease, congestive heart failure, coronary heart disease, angina pectoris, heart attack, diabetes, emphysema, HCV, liver condition, stroke, thyroid condition, poor vision, poor hearing, anxiety and poor oral health.

It is very intuitive that when a disease is quite prevalent and its impact on health is severe, there has to be more importance given to that disease while making health-care policy decisions or allocating medical resources. This calls for a weighting factor that takes into consideration both prevalence and impact of the chronic condition. Based on the above literature survey (Section 2.2), it is evident that there is no work which

provides us with such a weighting factor combining both ‘prevalence’ and ‘impact’ of a chronic condition. This thesis will help to address this need.

Chapter 3 PROBLEM DESCRIPTION AND METHODOLOGY

3.1 Problem Description

This thesis attempts to achieve two important goals. First, we investigate the influences of chronic conditions and socio-demographic factors on self-reported general health among general American Adults 18 years and older. Data from National Health and Nutrition Examination Survey (NHANES) is used to report the impact of 20 chronic conditions controlled for age, gender, social status, and race/ethnicity on self-reported general health. Second, we develop a weighting factor which represents both impact and prevalence of a chronic condition. This weighting factor is developed keeping in mind the needs of health care policy makers for medical resource allocation.

NHANES uses a weighted sampling scheme, namely oversampling of minority populations, in order to get full representation. NHANES assigns a sample weight to each sample person. It is a measure of the number of people in the population represented by that sample person reflecting the unequal probability of selection, non-response adjustment, and adjustment to independent population controls. By "unweighting" the provided data, unbiased national estimates may be obtained.

The chronic diseases considered are Diabetes, Kidney Problem, Asthma, Overweight, Arthritis, Stroke, Thyroid Disease, Chronic Bronchitis, Liver Condition, Cancer, Congestive Heart Failure, Coronary Heart Disease, Angina Pectoris, Heart Attack, Emphysema, Hepatitis C, Poor Vision, Poor Oral Health, Poor Hearing, and Anxiety. The criteria used for selecting these chronic conditions was based on their

overall prevalence being greater than 1% for the sample size considered. This is justified because prevalence greater than 1% means that a good number people have the disease and the effects of it are worth analyzing.

The race/ethnicity groups considered here are Hispanic, Non-Hispanic White, Non-Hispanic Black, and Others. The poverty income ratio (PIR) is the ratio of income to the family's appropriate poverty threshold (US Census Bureau, 2003a).The official poverty definition counts money income before taxes and excludes capital gains and noncash benefits (such as public housing, Medicaid, and food stamps). PIR values below 1 are below the official poverty threshold while PIR values of 1 or greater indicate income above the poverty level (US Census Bureau, 2003b). For this thesis work, a person is considered to be"poor" only if PIR is less than 2. The age levels considered are 'Adults' (between age 18 and 65) and 'Retired' (above the age of 65).

3.2 Data Set

NHANES is a survey research program conducted by the National Center for Health Statistics (NCHS) to assess the health and nutritional status of adults and children in the United States. It conducts a combination of examination, laboratory, and questionnaire for each person across a large and representative population group. Questionnaires are administered to NHANES participants both at home and in the trailers after an initial screening. The examination component consists of medical, dental, and physiological measurements, as well as laboratory tests administered by highly trained

medical personnel. To produce reliable statistics, NHANES over-samples persons 60 and older, African Americans, and Hispanics.

This thesis utilizes a 10-year NHANES dataset (from 1999 to 2008) with a total sample size of 51,623 representing 303.8 million (US population as per July 2008 estimate) Americans. This represents people from all ages and race/ethnicities. As only adults are considered, the sample set reduces to 28,852 out of which 22,159 are between the age of 18 and 65 while 6,659 are over 65.

3.3 Case Definitions for Chronic Conditions

Table 3.1shows each chronic condition and how it is defined. The source of this data is from NHANES through a combination of examinations, laboratory tests, and questionnaires. But, this information is not used directly in this research. The rationale behind each case definition is presented below. In most cases if the condition is self-reported, a “Yes” is sufficient to decide upon the presence of the condition. For Obesity we choose that the subject is obese if his/her BMI is greater than 30 kg/m^2as per The World Health Organization (WHO) which defines "overweight" as a BMI equal to or more than 25, and "obesity" as a BMI equal to or more than 30. The nine forms of cancer that were considered were, Breast , Colon and Rectal (Combined), Endometrial, Kidney (Renal Cell) Cancer, Leukemia, Lung (Including Bronchus), Melanoma, Non-Hodgkin Lymphoma, Pancreatic, Prostate and Thyroid cancer. The reason behind considering only these cancer types were because they were the most prevalent cancer forms as indicated by the American cancer society. The specimen is considered to be Hepatitis C positive if

he tested positive for the Hepatitis C antibody lab test. Oral health is defined as poor if the reported General Condition of mouth and teeth was fair or poor.

Chronic Condition	**Case Definition***
Obesity	Body Mass Index (kg/m^2) Obese if BMI $\geq$ 30
Diabetes	Answered 'Yes' to Doctor told you have diabetes by a doctor or health care professional
Kidney Problem	Answered 'Yes' to Ever told you had weak/failing kidneys by a doctor or health care professional
Asthma	Answered 'Yes' to both Ever been told you have asthma and Had asthma attack in past year by a doctor or health care professional
Arthritis	Answered 'Yes' to Doctor ever said you had arthritis by a doctor or health care professional
Stroke	Answered 'Yes' to Ever told you had a stroke by a doctor or health care professional
Thyroid Disease	Answered 'Yes' to Ever told you had thyroid disease by a doctor or health care professional
Chronic Bronchitis	Answered 'Yes' to Ever told you had chronic bronchitis by a doctor or health care professional
Liver condition	Answered 'Yes' to both Ever told you had any liver condition and Do you still have a liver condition by a doctor or health care professional
Cancer ¥	Answered 'Yes' to Ever told you had cancer or malignancy and having one of the nine cancer conditions¥ from response to What kind of cancer by a doctor or health care professional
Congestive heart failure	Answered 'Yes' to Ever told had congestive heart failure by a doctor or health care professional
Coronary heart disease	Answered 'Yes' to Ever told you had coronary heart disease by a doctor or health care professional

Angina Pectoris	Answered 'Yes' to Ever told you had angina/angina pectoris by a doctor or health care professional
Heart Attack	Answered 'Yes' to Ever told you had heart attack by a doctor or health care professional
Emphysema	Answered 'Yes' to Ever told you had emphysema by a doctor or health care professional
Hepatitis C	Hepatitis C antibody (confirmed) 'Positive' in medical examination conducted by a doctor or health care professional
Poor Vision	Answered 'Yes' to Trouble seeing even with glass/contacts by a doctor or health care professional
Poor hearing	Answered 'Yes' to General condition of hearing by a doctor or health care professional
Anxiety	Answered 'Yes' to Seen mental health professional /past yr by a doctor or health care professional
Oral health	Reported General Condition of mouth and teeth as fair or poor versus good or very good

* 'Yes' answer indicates that the condition was self reported
¥The nine cancers considered were Bladder, Breast, Colon, Kidney, Leukemia, Lung, Melanoma, Prostate and Thyroid Cancer

Table 3-1: Case definitions for chronic conditions

Self-reported general health was coded into two response categories namely good health (if the participant described his health in general was either Excellent, very good or good) and bad health (if the participant described his health in general was either fair or poor).

Gender was coded into male and female and Age was coded into two levels namely 'Adults' (if participant's age is between 18 and 65) and 'Retired' (if participant's

age is above 65). Race was coded into four response levels namely Hispanic (If the participant responded to his race/ethnicity as either Mexican American or other Hispanics), Non-Hispanic White (If the participant responded to his race/ethnicity as Non-Hispanic White), Non-Hispanic Black (If the participant responded to his race/ethnicity as Non-Hispanic Black) and Others (If the participant responded to his race/ethnicity as Other Race). Poverty was coded into two response levels namely below poverty (if participant's Family PIR was ≤ 2) and Above Poverty (if participant's Family PIR was > 2).

The primary reason behind reclassifying multiple levels into two levels is because there would be sufficient data for all the groupings. In addition to that, it is also simpler to interpret the results obtained from the logistics regression model. For example, if the number of levels from NHANES were to be used directly, Health would have 5 levels (Excellent, very good, good, fair and poor) and information gets dispersed into multiple levels.

3.4 Calculation of Prevalence

Prevalence is ratio of the number of people who had the condition to the total number of people examined. In NHANES, some respondents may not submit their response for certain questions, some may refuse to answer, and some may not know the answer to the question. So, many responses may be classified as missing, don't know or refused. In the calculation of prevalence, missing data is not considered.

3.5 Logistic Regression Model

Logistic Regression is used to assess the likelihood of a disease or health condition as a function of a risk factor. Logistic regression assesses the association between independent variable(s) (Xi) - sometimes called exposure or predictor variables and a dichotomous dependent variable (Y) - sometimes called the outcome or response variable. It tells you how much an increment in a given exposure variable affects the odds of the outcome.

Simple logistic regression is used to obtain the associations between one (dichotomous) outcome and one (continuous, ordinal, or categorical) exposure variable while multiple logistic regression is used to explore associations between one (dichotomous) outcome variable and two or more exposure variables.

The main reason behind using multiple logistic regression in this thesis is that it can provide us with the association between the exposure variable and the outcome variable after isolating it from the effects of one or more other variables (i.e., covariates). The process of accounting for covariates is called adjustment. This isolated association or relationship between the exposure variable and outcome variable is expressed in terms of an odds ratio.

The odds ratio is a measure of effect size, describing the strength of association or non-independence between two binary data values. It is the ratio of the odds of an event occurring in one group to the odds of it occurring in another group. The odds ratio was used to see how much association some of the chronic diseases had, controlling for risk factors.

A logistic regression model has been built in order to find the impact of chronic diseases on general health in American Adults (age >=18). The variable, 'General health', in NHANES has different levels of response viz., excellent, very good, good, fair, poor. These levels are grouped into simply two discrete levels namely good and bad. So, the model was built with general health as the dependent variable and the various chronic diseases and risk factors as independent variables.

$$E\{Y\} = [1 + \exp(-X^I * \beta)]^{-1} \quad \text{.....3.1}$$

A first order multiple regression model with 24 predictor variables was considered a priori to be reasonable:

where,

$$\beta = \begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \\ \vdots \\ \beta_{24} \end{bmatrix} \quad and \quad X = \begin{bmatrix} 1 \\ X_1 \\ X_2 \\ \vdots \\ X_{24} \end{bmatrix}$$

this can be looked at as,

$$(X^I * \beta) = \beta_0 + \sum_{j=1}^{24} (\beta_j * X_j) \quad \text{.....3.2}$$

The multiple logistic regression model can therefore be stated as follows:-

Y_i are the independent random variable with expected value, E {Yi} and,

$$E\{Y_i\} = [1 + \exp(-X_i^I * \beta)]^{-1} \quad \text{.....3.3}$$

where,

Y_i is the dependent/outcome variable representing self-reported general health

$X_{1i}$is the independent/predictor variable representing Obesity

$X_{2i}$is the independent/predictor variable representing Diabetes

$X_{3i}$is the independent/predictor variable representing Kidney Problem

$X_{4i}$is the independent/predictor variable representing Asthma

$X_{5i}$is the independent/predictor variable representing Arthritis

$X_{6i}$is the independent/predictor variable representing Stroke

$X_{7i}$is the independent/predictor variable representing Thyroid Disease

$X_{8i}$is the independent/predictor variable representing Chronic Bronchitis

$X_{9i}$is the independent/predictor variable representing Liver Condition

$X_{10i}$is the independent/predictor variable representing Cancer

$X_{11i}$is the independent/predictor variable representing Congestive Heart Failure

$X_{12i}$is the independent/predictor variable representing Coronary Heart Disease

$X_{13i}$is the independent/predictor variable representing Angina Pectoris

$X_{14i}$is the independent/predictor variable representing Heart Attack

$X_{15i}$is the independent/predictor variable representing Emphysema

$X_{16i}$is the independent/predictor variable representing Hepatitis C

$X_{17i}$is the independent/predictor variable representing Poor Vision

$X_{18i}$is the independent/predictor variable representing Poor Oral Health

$X_{19i}$is the independent/predictor variable representing Poor Hearing

$X_{20i}$is the independent/predictor variable representing Anxiety

$X_{21i}$is the independent/predictor variable representing risk factor gender

$X_{22i}$is the independent/predictor variable representing risk factor age

$X_{23i}$is the independent/predictor variable representing risk factor poverty

$X_{24i}$is the independent/predictor variable representing risk factor race/ethnicity

β_{ji} represents the intercepts of the respective independent variables from j = 1 to 24.

The odds ratio is found out by simply taking the exponent of the estimated regression co-efficient ($\beta_1 \ldots \beta_{24}$) in the fitted logistic response function (3.1).

With input data of the dependent and independent variables, the logistic model is built and solved using SAS which gives estimated regression coefficients and odds ratios in the output window.

3.6 Process of choosing the methodology for *Weighting Factor*

While coming up with a weighting factor combining multiple criteria, there are several methods to choose from depending on whether a decision maker(s) is/are available or not. There are two basic approaches towards forming a weighting factor, one is the additive scheme and the second is the multiplicative scheme (See Fig 3.1 to view the various methods considered).

In a multiplicative scheme, there is no concept of scaling because when we scale each of the criteria and then normalize each criterion to a fraction of 1, the scaling factor gets annulled. This is evident by the following mathematical proof.

Let WF_i represents the weighting factor of chronic disease i

or_i represent the odds ratio of chronic disease i

p_i represent the prevalence of chronic disease i

SF_{1i} represent the scaling factor of odds ratio of chronic disease i

SF_{2i} represent the scaling factor of prevalence of chronic disease i

OR_i represent the scaled odds ratio of chronic disease i

⇨ $OR_i = (or_i / SF_{1i})$.....3.4

P_i represent the scaled prevalence of chronic disease i

⇨ $P_i = (p_i / SF2_i)$.....3.5

Weighting factor is defined as the product of OR_i and P_i.

⇨ $WF_i = (OR_i * P_i)$.....3.6

Now,

$$WF_i = \frac{(OR_i * P_i)}{\sum_i (OR_i * P_i)} \quad \text{.....3.7}$$

$$= \frac{\frac{or_i}{SF_{1i}} * \frac{p_i}{SF_{2i}}}{\sum_i (\frac{or_i}{SF_{1i}} * \frac{p_i}{SF_{2i}})} = \frac{(or_i * p_i)}{\sum_i (or_i * p_i)} \quad \text{.....3.8}$$

As seen from equation 3.8, weighting factor (WF_i) is independent of the scaling factor.

The advantage of using a multiplicative scheme is that there is no requirement for scaling. But, there is an outweighing disadvantage to it as well. The multiplicative scheme allocates a latent bias to criteria that has large standard deviation. For example if one criterion has a standard deviation from mean significantly larger than the other criteria, then there will be more weightage to that criterion. Thus, a multiplicative scheme, although considered, has to be overlooked.

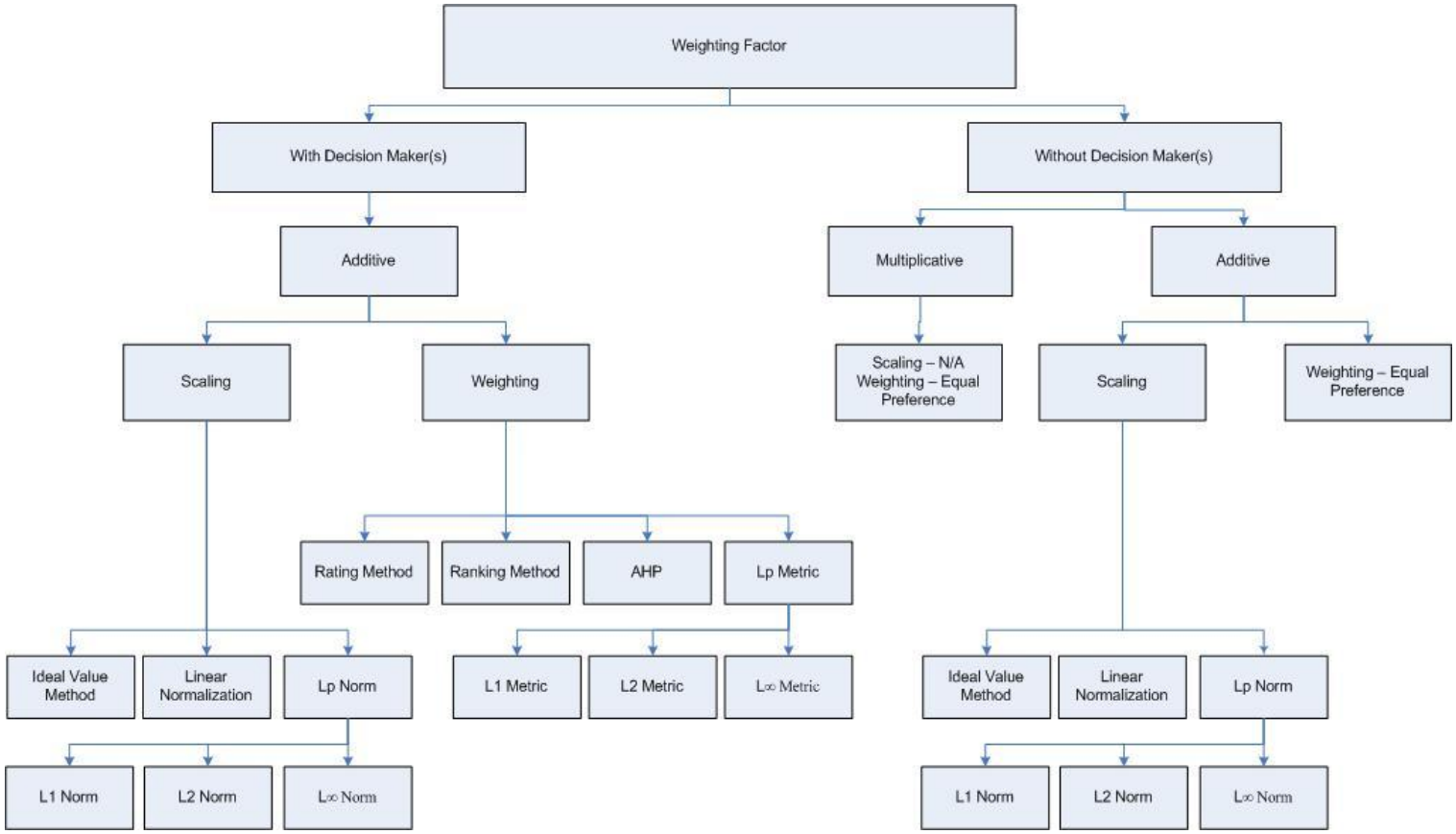

Figure 3-1: Different scaling and weighting methods considered for the determination of weighting factor

That leaves us with an additive scheme based approach. In an additive scheme, there are several steps that have to be followed. First, each criteria has to be scaled by a particular scaling method and consequently a weighting factor is allocated to each criteria based on the various weighting methods. So, now the probing question is which scaling method works best with which weighting method. Velazquez et al. [2010] thoroughly analyzed what is the best combination of weighting–scaling methods for single and multiple decision makers using the weighted sum decision making model.[35] The result of the research states, "Overall, considering both single and group decision making, the best method was vector scaling L_∞ Norm with ranking which outperformed all other combinations of methods. The worst method was the combination of vector scaling L_∞ Norm with L_∞ Metric". So, In the event of having several decision makers trying to do a medical budgeting or any policy making, a vector scaling 'L_∞ Norm' with a 'ranking' weighting methodology is the best option.

Step 1: Scaling the elements

In vector normalization, each criterion is divided by the Lp norm[36] and is defined below:

Let or_i represent the odds ratio of chronic disease i

p_i represent the prevalence of chronic disease i

OR_i represent the scaled odds ratio of chronic disease i

⇨ $OR_i = (or_i / L_{p1})$.....3.9

P_i represent the scaled prevalence of chronic disease i

⇨ $P_i = (p_i / L_{p2})$.....3.10

Since, L_∞ Norm is chosen; p takes on the value ∞ and L_∞ is defined as[36]

⇨ $L_{\infty 1} = \text{Max} \{ | or_i |, i = 1,2,3,\ldots 24\}$ 3.11

⇨ $L_{\infty 2} = \text{Max} \{ | p_i |, i = 1,2,3,\ldots 24\}$ 3.12

Thus, the L_∞ scaled criteria are:-

⇨ $OR_i = (or_i / L_{\infty 1}) = (or_i / \text{Max } |or_i|)$ 3.13

⇨ $P_i = (p_i / L_{\infty 2}) = (p_i / \text{Max } |p_i|)$ 3.14

Step 2: Ranking to determine weights

The Decision maker ranks all the criteria in order of increasing relative importance and the highest criterion gets the rank of one.[37]

Let r_i represent the rank of the i^{th} criterion,

λ_i represent the weight of the i^{th} criterion

k represent the number of alternatives

⇨ $\lambda_i = (k - r_i + 1) / \{ (\sum_j (k - r_j + 1) \text{ where } j = 1 \text{ to } k \}$ 3.15

Step 3: Arriving at the Score

Utilizing the weight of the criterion and the scaled values of every element, we can come up with the score for each alternative.

⇨ $S_i = \sum_j \{ (\lambda_i * OR_i) \text{ where } i = 1 \text{ to } 24 \}$ 3.16

Step 4: Normalizing the Score – Weighting Factor (WF)

In order to represent each score as a fraction of 1, we need to normalize the final score.

⇨ $WF_i = Si / \{ \sum_i S_i \text{ where } i = 1 \text{ to } 24 \}$ 3.17

As far as this thesis work is concerned, there are two criteria which need to be accounted for while forming the weighting factor. Since there are no decision makers, it is assumed that both prevalence and impact have equal importance. That rules out the scope for any weighting methods and of course L_∞ Norm is selected as the scaling method.

Thus, $\lambda_1 = \lambda_2 = 0.5$, which reduces $S_i = 0.5\ (OR_i + P_i)$.....3.18

Since, 0.5 in equation 3.18 is just a plain constant and will not contribute towards the weighting factor, we could drop it off and we would have a weighting factor which is the L_∞ scaled sum of the two criteria. This of course is consequently converted to a fraction of 1.

Chapter 4 RESULTS

The aim of the model discussed in chapter 3 was to come up with a single weighting factor that could quantify the importance of the various chronic conditions considered. In this section, all the actual results after running the model at each level are shown and the results are relevantly discussed.

4.1 Discussion of prevalence results

Prevalence as discussed in chapter 3 is calculated as the ratio of the number of people who had the condition to the total number of people examined. Table 4.1 shows the prevalence percentages along with the standard errors for the various chronic conditions categorized by the sociodemographic characteristics. Most of the prevalence results were in alignment with the national prevalence percentages. The most prevalent health conditions among American adults are Poor Oral health, obesity, arthritis, poor vision and thyroid diseases. This has been touched upon by several of the prior research.[1-16] It is quite evident that participants from the "retired" (greater than 65 years) age group, quite understandably so, had significantly higher prevalence percentages in many of the chronic conditions. Some of the percentages that were significantly higher when compared to the "adults" (between 18 and 65 years) age group were for the chronic conditions Arthritis, Thyroid, Cancer and Cardiovascular diseases. But, one condition that was significantly lower among the retired age group when compared to other age groups was anxiety.

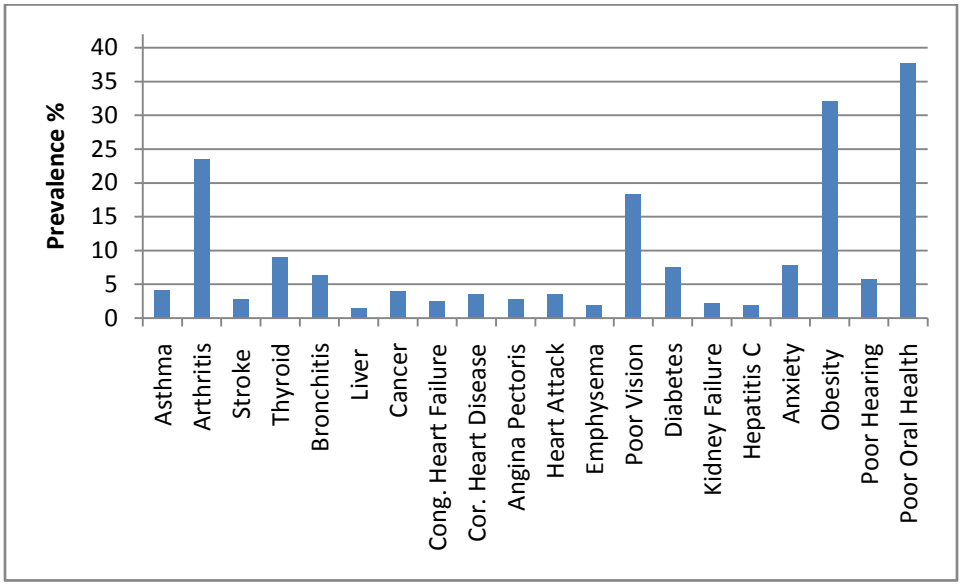

Figure 4-1: Prevalence of various health conditions

The prevalence of arthritis in women is significantly higher than that in men. Asthma and bronchitis were significantly higher in women while men were more likely to encounter poor hearing health conditions.

As far as race/ethnicity is concerned diabetes is significantly higher in Non-Hispanic Blacks when compared to the other races while poor oral health was significantly higher amongst Hispanics. Clearly, poor hearing conditions were more common among Non-Hispanic whites.

Participants who were less than 200 % of the federal poverty guideline were more likely to be associated with chronic health conditions. Some of the noticeable ones were poor oral health and poor vision followed by arthritis and emphysema. In all, it will be safe to generalize those participants who were old and below poverty guidelines are more likely to be affected by chronic conditions. These results are somewhat in alignment with Lubetkin et al. [2005] in the sense that socioeconomic factors influence health related quality of life.

PREVALENCE (%)																						
Conditions	All Participants		Sociodemographic Characteristics																			
			Age (years)				Sex				Race/Ethnicity								Income			
	> 18	S.E	Adults (18 - 65)	S.E	Retired (> 65)	S.E	Male	S.E	Female	S.E	Hispanic	S.E	Non-Hispanic White	S.E	Non-Hispanic Black	S.E	Others	S.E	≤ 200 % FPG	S.E	> 200 % FPG	S.E
Asthma	4.16	0.1	4.44	0.2	2.67	0.2	3.85	0.1	5.36	0.2	2.46	0.1	4.75	0.2	5.46	0.2	4.26	0.5	5.29	0.1	4.14	0.1
Arthritis	23.51	0.3	17.53	0.3	53.14	0.6	19.19	0.4	27.5	0.4	10.59	0.4	26.25	0.4	20.94	0.6	18.19	1.2	26.15	0.4	21.82	0.4
Stroke	2.78	0.1	1.4	0.1	9.67	0.4	2.4	0.1	3.13	0.2	1.31	0.2	2.92	0.2	3.62	0.3	2.54	0.5	3.86	0.2	2.09	0.1
Thyroid	8.98	0.2	7.13	0.2	18.35	0.5	3.21	0.2	14.31	0.3	4.48	0.3	10.5	0.3	4.47	0.3	7.71	0.8	8.28	0.2	9.43	0.3
Bronchitis	6.4	0.2	5.86	0.2	8.95	0.4	4.23	0.2	8.4	0.2	2.64	0.2	7.16	0.2	5.15	0.3	5.68	0.7	7.8	0.2	5.5	0.2
Liver	1.47	0.1	1.52	0.1	1.18	0.1	1.82	0.1	1.15	0.1	1.46	0.2	1.41	0.1	1.17	0.2	2.61	0.5	1.91	0.1	1.19	0.1
Cancer	3.98	0.1	1.94	0.1	15.39	0.5	3.51	0.2	4.41	0.2	0.82	0.1	4.9	0.2	2.7	0.2	1.67	0.4	3.87	0.2	4.05	0.2
Cong. Heart Failure	2.42	0.1	1.13	0.1	8.91	0.4	2.65	0.1	2.22	0.1	1.07	0.1	2.54	0.1	3.02	0.2	2.09	0.4	3.52	0.2	1.72	0.1
Cor. Heart Disease	3.46	0.1	1.75	0.1	12.1	0.4	4.67	0.2	2.33	0.1	1.53	0.2	4.07	0.2	1.92	0.2	3.25	0.6	3.8	0.2	3.24	0.2
Angina Pectoris	2.74	0.1	1.5	0.1	8.91	0.4	2.98	0.2	2.52	0.1	1.27	0.2	3.17	0.2	1.6	0.2	2.32	0.5	3.58	0.2	2.21	0.1
Heart Attack	3.52	0.1	1.85	0.1	11.93	0.4	4.54	0.2	2.58	0.1	1.23	0.2	4.01	0.2	3	0.2	3.01	0.5	4.72	0.2	2.75	0.1
Emphysema	1.82	0.1	1.02	0.1	5.8	0.3	1.93	0.1	1.71	0.1	0.26	0.1	2.19	0.1	0.92	0.1	1.91	0.4	2.7	0.1	1.25	0.1
Poor Vision	18.38	0.2	17	0.3	25.69	0.5	13.65	0.2	17.47	0.2	16.44	0.3	15.19	0.3	17.42	0.4	13.74	0.8	19.18	0.2	13.01	0.2
Diabetes	7.42	0.2	5.4	0.2	17.5	0.5	5.41	0.2	5.72	0.2	4.66	0.2	5.18	0.2	8	0.3	6.09	0.5	6.65	0.1	4.77	0.2
Kidney Failure	2.19	0.1	1.63	0.1	4.79	0.3	1.88	0.1	2.48	0.1	2.02	0.2	2.02	0.1	3.31	0.3	1.98	0.4	3.19	0.2	1.56	0.1
Hepatitis C	1.82	0.1	2.05	0.1	0.61	0.1	1.87	0.1	1.11	0.1	1.08	0.1	1.41	0.1	2.63	0.2	0.89	0.2	2.22	0.1	0.98	0.1
Anxiety	7.86	0.2	8.62	0.2	4.02	0.2	7.39	0.2	9.03	0.2	4.18	0.2	9	0.2	6.97	0.2	6.9	0.6	9.23	0.2	7.52	0.2
Obesity	31.98	0.3	32.31	0.3	29.4	0.6	23.43	0.3	27.23	0.3	24.3	0.4	25.23	0.3	31.62	0.4	16.5	0.9	25.17	0.3	25.52	0.3
Poor Hearing	5.67	0.1	3.62	0.1	16.45	0.5	5.33	0.2	3.48	0.1	2.4	0.1	5.37	0.2	2.01	0.1	2.87	0.4	4.79	0.1	4.09	0.1
Poor Oral Health	37.65	0.3	37.95	0.3	36.27	0.6	37.23	0.4	36.71	0.3	46.43	0.5	34.52	0.4	41.77	0.5	39.2	1.2	42.08	0.3	33.31	0.4

Table 4-1: Prevalence percentages of chronic diseases among adults for various sociodemographic factors

4.2 Odds Ratio along with 95% Confidence Interval

As described in detail in chapter 3, a logistic regression model is utilized to explore the impact of chronic diseases on general health in American Adults (age >=18) after controlling for common risk factors (i.e., age, sex, race or ethnicity and income levels). The variable, 'General health', in NHANES has different levels of response viz., excellent, very good, good, fair, poor. These levels are grouped into simply two discrete levels namely good and bad. So, the model was built with general health as the dependent variable and the various chronic diseases and risk factors as independent variables.

Some of the very noticeable chronic conditions that have a severe impact on health are emphysema, diabetes, stroke and poor oral health. These results when compared to what was found in earlier research have both similarities and differences too. It has been clearly established[3, 13] that diabetes influences quality of life and what is found here only complements that fact. But, the findings which are related to emphysema is quite different from what is found in literature. In an isolated study in COPD, it has been shown that patients with COPD have a substantial compromise on quality of life.[6] Although emphysema has been considered in many research efforts [6-7, 9, 14-15], not many have reported emphysema as a condition that affects the quality of life by much. But, the top finding (through the odds ratio) is that emphysema has a significant impact on general health. Stroke and more so poor oral health, historically, have never been highlighted as chronic conditions which can influence health. Fig 4.2 shows the impact of various chronic conditions on general health adjusted for risk factors.

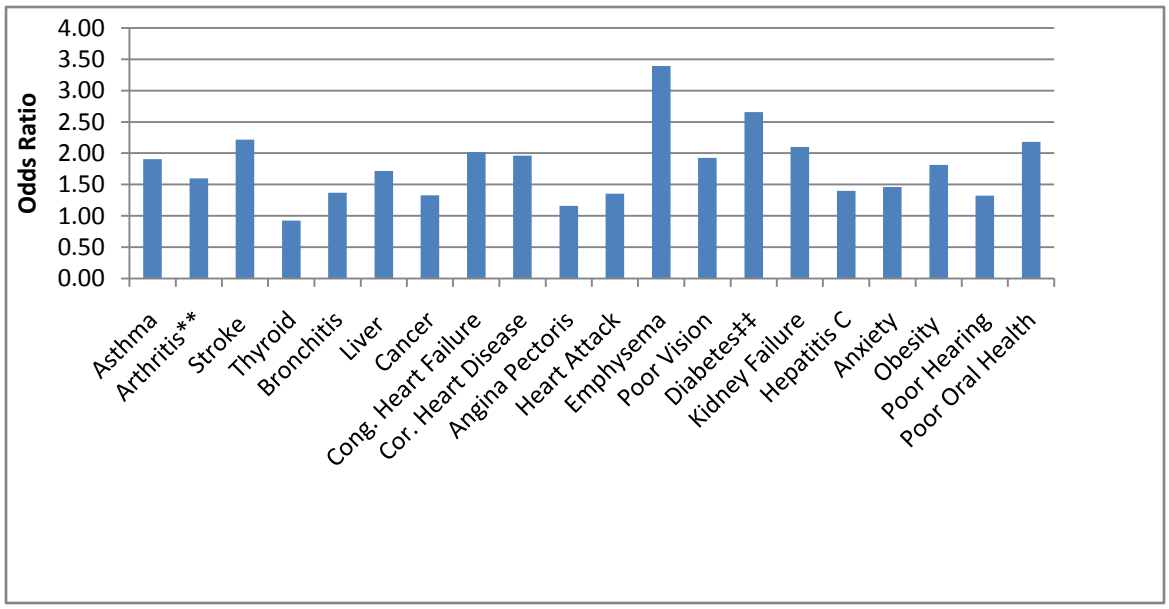

Figure 4-2: Odds Ratio of the various health conditions

Participants with kidney conditions or congestive heart disease were also more likely to have a significant impact on general heath.

It is evident from the results (Table 4.2) that participants from the lower income groups were more likely to likely to be impacted while the gender you come from does not seem to matter.

Explanatory Variable	Dependent Variable in Logistics Regression* Model‡	
	General Health	
	Odds Ratio	95% Confidence Interval
Male	0.97	0.964 0.967
Age§	0.99	0.990 0.999
Income#	2.63	2.622 2.628
Asthma	1.90	1.899 1.909
Arthritis**	1.60	1.598 1.603
Stroke	2.22	2.209 2.222
Thyroid	0.93	0.925 0.929
Bronchitis	1.37	1.365 1.371
Liver	1.72	1.709 1.723
Cancer	1.33	1.323 1.330
Cong. Heart Failure	2.02	2.009 2.023
Cor. Heart Disease	1.96	1.956 1.968
Angina Pectoris	1.16	1.156 1.165
Heart Attack	1.35	1.348 1.357
Emphysema	3.39	3.379 3.403
Poor Vision	1.93	1.923 1.928
Diabetes‡‡	2.66	2.651 2.660
Kidney Failure	2.10	2.094 2.109
Hepatitis C	1.40	1.397 1.407
Anxiety	1.46	1.459 1.464
Obesity	1.81	1.810 1.814
Poor Hearing	1.32	1.318 1.324
Poor Oral Health	2.18	2.179 2.184

* Used cumulative logistic regression model for all dependent variables with more than two response categories.

‡ Since $P < 0.001$ for all chronic conditions considered, none of the explanatory variables corresponding to the chronic conditions were dropped.

§ Continuous variable.

FPG: Federal poverty guideline.

** Includes rheumatoid arthritis, osteoarthritis and other.

‡‡ Includes controlled and uncontrolled diabetes.

Table 4-2: Odds Ratio from logistics regression model

4.3 Correlation Analysis

Correlation Analysis between chronic conditions was done to gain insight into the interaction between the chronic conditions. Correlation effects were observed (Table 4.3) between Hepatitis C and Liver condition and between Chronic Bronchitis and Asthma. Also, there were strong correlation effects internally between the cardiovascular diseases. The logistic regression model including the aforementioned interactions was run. However, the interaction terms were not significant and did not change the results. Therefore, they were dropped from the model.

	Gender	Poverty	Diabetes	Kidney F	Asthma	Obesity	Arthritis	Stroke	Thyroid	Bronchiti	Liver Con	Cancer	*Cong.he*	*Cor. hea*	*Angina*	*Heart a*	Emphys	Hep C	Poor Vision	Poor Heari	Anxiety	Poor Oral
Gender	1	-0.0627	-0.004	-0.02	-0.063	-0.046	-0.0979	-0.022	-0.194	-0.0851	0.0275	-0.023	0.0141	0.064	0.014	0.053	0.008	0.0372	-0.05399	0.05844	-0.0455	0.00603
Poverty		1	0.0635	0.0544	0.0318	0.022	0.04978	0.052	-0.0197	0.04581	0.02906	-0.004	0.0572	0.015	0.0409	0.052	0.053	0.0621	**0.10735**	0.02804	0.0214	**0.11023**
Diabetes			1	**0.1232**	0.0164	**0.1478**	**0.16465**	**0.125**	0.0716	0.04224	0.03253	0.0524	**0.1622**	**0.1416**	**0.122**	**0.132**	0.045	**0.1324**	**0.10723**	0.06181	0.0062	0.0369
Kidney Failure				1	0.027	0.0351	0.06924	0.091	0.0393	0.05889	0.06148	0.0485	**0.13**	0.0903	0.0847	0.098	0.053	0.0266	0.08414	0.04509	0.0251	0.02151
Asthma					1	0.0702	0.06305	0.039	0.0253	**0.23845**	0.01282	0.002	0.0565	0.0217	0.0399	0.031	0.094	0.015	0.04806	0.01728	0.0587	0.00961
Obesity						1	**0.12054**	0.031	0.0491	0.06295	0.02569	-0.006	0.0406	0.0294	0.0405	0.036	-0.004	-0.025	0.04058	0.02058	0.0078	0.03653
Arthritis							1	**0.138**	**0.1581**	**0.13041**	0.04795	**0.1247**	**0.1386**	**0.1348**	**0.1509**	**0.14**	**0.107**	0.0346	**0.1464**	**0.13005**	0.0351	0.05597
Stroke								1	0.0575	0.05221	0.03312	0.0678	**0.1626**	**0.1435**	**0.1388**	**0.154**	0.075	0.0221	0.0934	0.07278	0.0298	0.02811
Thyroid Disease									1	0.07659	0.02316	0.0807	0.0539	0.0579	0.0729	0.046	0.031	-0.008	0.06942	0.05077	0.0372	0.01801
Bronchitis										1	0.0537	0.0429	**0.1015**	0.0655	0.0752	0.062	**0.181**	0.0402	0.09229	0.04843	0.062	0.03825
Liver Condition											1	0.0142	0.0405	0.0181	0.0279	0.029	0.016	**0.3003**	0.05784	0.01172	0.0495	0.02888
Cancer												1	0.0699	0.0718	0.0652	0.079	0.076	-0.011	0.03303	0.07494	-0.0051	0.00399
Cong. Heart Failure													1	**0.328**	**0.2618**	**0.368**	**0.151**	0.0192	0.08497	0.09554	0.017	0.03519
Cor. Heart Disease														1	**0.4454**	**0.512**	**0.1**	-0.014	0.05647	0.07883	-0.0018	0.01918
Angina Pectoris															1	**0.428**	0.087	-0.014	0.08229	0.07392	0.0163	0.01849
Heart Attack																1	**0.115**	0.0011	0.07168	0.08333	0.0122	0.02373
Emphysema																	1	0.0163	0.05586	0.06219	0.0171	0.03206
Hepatitis C																		1	0.05267	0.00286	0.0448	0.06585
Poor Vision																			1	0.0997	0.0616	0.09905
Poor Hearing																				1	0.0281	0.02035
Anxiety																					1	0.03083
Poor Oral																						1

Table 4-3 : Correlation between various chronic conditions

4.4 Weighting factor

Calculation of the weighting factor, as discussed in chapter 3, follows a four step methodology. L_∞ scaling is used to scale both prevalence and odds ratio. The assumption here is that both the criteria are equally important which rules out the possibility of any independent weights for the criteria. An additive scheme is used to come up with the score and is finally normalized to a fraction of 1. These steps are illustrated below:-

Step 1: Scaling the elements

Chronic Condition	Prevalence	Odds Ratio	Prevalence (Scaled)	Odds Ratio (Scaled)
Asthma	0.04	1.90	0.11	0.56
Arthritis	0.24	1.60	0.62	0.47
Stroke	0.03	2.22	0.07	0.65
Thyroid	0.09	0.93	0.24	0.27
Bronchitis	0.06	1.37	0.17	0.40
Liver	0.01	1.72	0.04	0.51
Cancer	0.04	1.33	0.11	0.39
Cong. Heart Failure	0.02	2.02	0.06	0.59
Cor. Heart Disease	0.03	1.96	0.09	0.58
Angina Pectoris	0.03	1.16	0.07	0.34
Heart Attack	0.04	1.35	0.09	0.40
Emphysema	0.02	3.39	0.05	1.00
Poor Vision	0.18	1.93	0.49	0.57
Diabetes	0.07	2.66	0.20	0.78
Kidney Failure	0.02	2.10	0.06	0.62
Hepatitis C	0.02	1.40	0.05	0.41
Anxiety	0.08	1.46	0.21	0.43
Obesity	0.32	1.81	0.85	0.53
Poor Hearing	0.06	1.32	0.15	0.39
Poor Oral Health	0.38	2.18	1.00	0.64

Table 4-4 : L infinity scaled values of odds ratio and prevalence

Step 2: Ranking to determine weights of the criteria

Since, we assume that both impact and prevalence are of equal importance, both of them have equal preference.

Step 3: Arriving at the Score

Chronic Condition	Score
Asthma	0.6720
Arthritis	1.0963
Stroke	0.7270
Thyroid	0.5119
Bronchitis	0.5734
Liver	0.5451
Cancer	0.4970
Cong. Heart Failure	0.6588
Cor. Heart Disease	0.6705
Angina Pectoris	0.4149
Heart Attack	0.4925
Emphysema	1.0483
Poor Vision	1.0559
Diabetes	0.9800
Kidney Failure	0.6780
Hepatitis C	0.4618
Anxiety	0.6399
Obesity	1.3838
Poor Hearing	0.5402
Poor Oral Health	1.6435

Table 4-5 : Scores of various chronic conditions

Step 4: Normalizing the Score – Weighting Factor (WF)

Chronic Condition	Normalized Weighting Factor
Asthma	0.0439
Arthritis	0.0717
Stroke	0.0475
Thyroid	0.0335
Bronchitis	0.0375
Liver	0.0356
Cancer	0.0325
Cong. Heart Failure	0.0431
Cor. Heart Disease	0.0438
Angina Pectoris	0.0271
Heart Attack	0.0322
Emphysema	0.0686
Poor Vision	0.0691
Diabetes	0.0641
Kidney Failure	0.0443
Hepatitis C	0.0302
Anxiety	0.0418
Obesity	0.0905
Poor Hearing	0.0353
Poor Oral Health	0.1075

Table 4-6 : Normalized weighting factors for chronic conditions

As discussed in Chapter 1, the motivation behind doing this research is to come up with a single factor that could quantify the importance of these health conditions. This single factor is the Normalized weighting factor or simply ‘weighting factor’. It should also be kept in mind that this weighting factor is a combination of prevalence and impact with equal preference. This factor could be different if there were single/multiple decision makers who came up with different level of importance between the criteria. Fig 4.3 shows the various chronic conditions and their corresponding weighting factor.

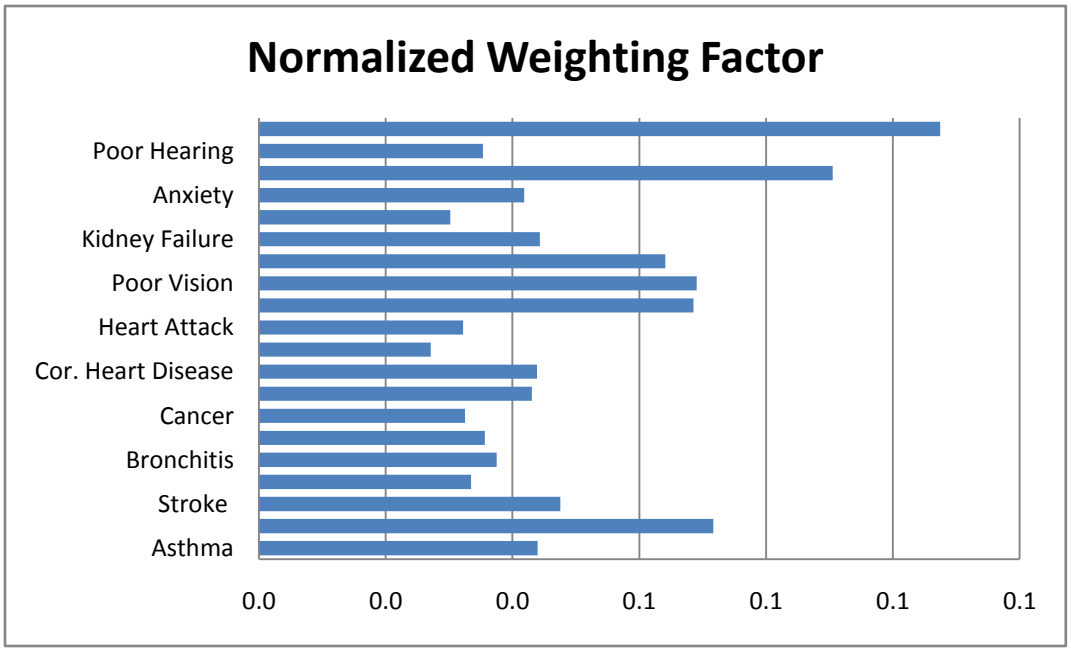

Figure 4-3 : Weighting factor for chronic conditions

4.5 Health conditions ranked in order of 'Weighting Factor'

Fig 4.4 shows the various health conditions sorted in descending order of their weighting factors. It could be generalized that the health condition with the highest weighting factor is the most important health condition in the sense that it is the one which should draw more attention. This is because, when we say oral health has a weighting factor of 0.1075, it almost means that it needs to be given 10.75% of the pie where the pie could be anything from resources to research time. Fig 4.5 shows clearly, according to the results of this research as to how the pie should be shared among the various health conditions.

The condition that was found to be of top importance (Table 4.6) is poor oral health. The reason this result is glaring is because many participants have indicated that when they have oral health conditions, it seems to affect their lifestyle significantly. This when coupled with the fact that it so prevalent amongst all sections of the population, makes poor oral health the number 1

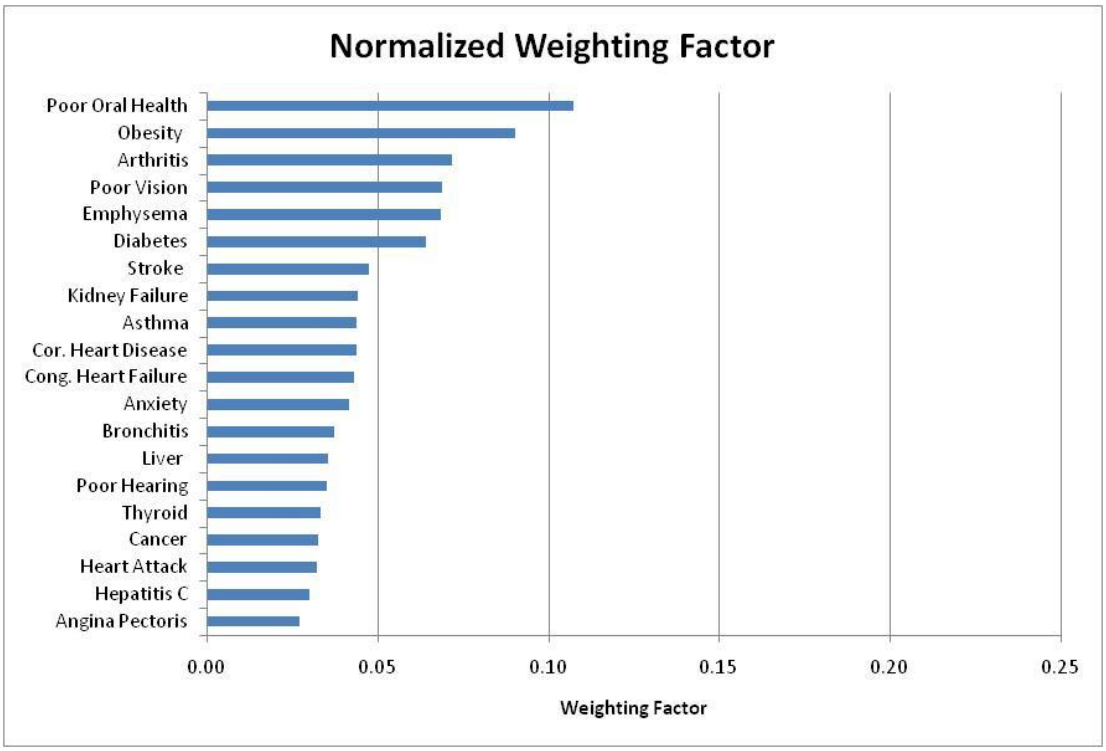

Figure 4-4 : Weighting factor ranked in order of importance

important health condition. It should rightfully be given a sizeable share of the pie as it would benefit a lot of people.

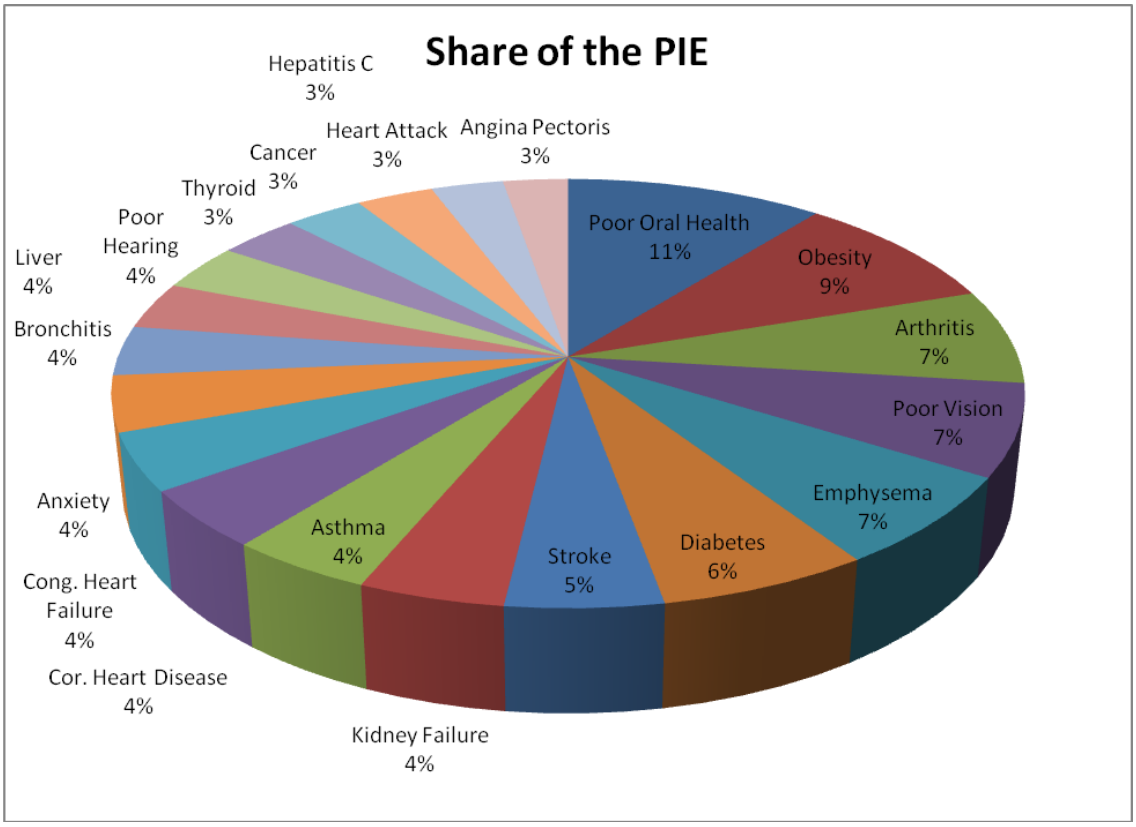

Figure 4-5 : Share of the PIE

It has been shown that chronic conditions like rheumatoid arthritis, liver condition and diabetes have a significant impact on oral health[16], but it has been rarely ever shown that poor oral health has a significant impact on general health.

The other important health conditions are obesity, arthritis, poor vision, emphysema and diabetes. The reason obesity is in the top of the list is because of its prevalence in the American population. On the contrary, emphysema features in the top due to its sheer impact on day-to-day life. As per the results from the logistics regression model, emphysema had the most impact on general health of all the health conditions considered. So, although its prevalence is only mid-level, it needs to be given its due share of the pie due to its sheer impact on normal life. As indicated in chapter 2, arthritis is one of the conditions that has both high prevalence and high

impact on general health. Poor vision and diabetes are the other two health conditions which call for a good share of the pie.

Chronic Condition	Prevalence	Odds Ratio	Prevalence (Scaled)	Odds Ratio (Scaled)	Score	Normalized Weighting Factor
Poor Oral Health	0.38	2.18	1.00	0.64	1.6435	0.1075
Obesity	0.32	1.81	0.85	0.53	1.3838	0.0905
Arthritis	0.24	1.60	0.62	0.47	1.0963	0.0717
Poor Vision	0.18	1.93	0.49	0.57	1.0559	0.0691
Emphysema	0.02	3.39	0.05	1.00	1.0483	0.0686
Diabetes	0.07	2.66	0.20	0.78	0.9800	0.0641
Stroke	0.03	2.22	0.07	0.65	0.7270	0.0475
Kidney Failure	0.02	2.10	0.06	0.62	0.6780	0.0443
Asthma	0.04	1.90	0.11	0.56	0.6720	0.0439
Cor. Heart Disease	0.03	1.96	0.09	0.58	0.6705	0.0438
Cong. Heart Failure	0.02	2.02	0.06	0.59	0.6588	0.0431
Anxiety	0.08	1.46	0.21	0.43	0.6399	0.0418
Bronchitis	0.06	1.37	0.17	0.40	0.5734	0.0375
Liver	0.01	1.72	0.04	0.51	0.5451	0.0356
Poor Hearing	0.06	1.32	0.15	0.39	0.5402	0.0353
Thyroid	0.09	0.93	0.24	0.27	0.5119	0.0335
Cancer	0.04	1.33	0.11	0.39	0.4970	0.0325
Heart Attack	0.04	1.35	0.09	0.40	0.4925	0.0322
Hepatitis C	0.02	1.40	0.05	0.41	0.4618	0.0302
Angina Pectoris	0.03	1.16	0.07	0.34	0.4149	0.0271

Table 4-7 : Weighting factors of chronic conditions ranked in order of importance

Chapter 5 CONCLUSION

The impact of chronic health conditions on general health is an important topic due to the indecision surrounding, which health conditions should draw more attention by decision makers who influence health care needs, public policy making, and research priorities. This thesis focused on analyzing the individual impact of chronic diseases along with their prevalence and more importantly developing a single factor that quantified the importance of the various health conditions.

In this thesis, we investigated the influences of chronic conditions subject to different socio-demographic factors on self-reported general health among general American Adults 18 years and older. Data from NHANES was used for the analysis to report the impact of 20 chronic conditions controlled for age, gender, social status and race/ethnicity on self-reported general health. A weighting factor was developed to represent both impact and prevalence as a single factor that could quantify the importance, or in a sense, the severity of the different health conditions.

A multivariate statistical analyses was performed to determine the association of several chronic conditions with self reported general health after controlling for common risk factors. Towards this, a multivariate logistics regression model was used to come up with the odds ratio that represented the impact of chronic diseases on general health. A four step bi-criteria additive scheme was used to come up with the weighting factor.

It was found that the most prevalent health conditions among American adults are Poor Oral health, Obesity, Arthritis, Poor Vision and Thyroid diseases. It was evident that age groups that were classified as retired (i.e. older than 65 years) and those with low income levels are more likely to be affected by chronic conditions. Also, the prevalence of arthritis in women was found to be significantly higher than that in men. Asthma and Bronchitis were found to be significantly

higher in women while poor hearing health conditions were more prevalent in men. Some of the very noticeable chronic conditions that had severe impact on health were emphysema, diabetes, stroke and poor oral health.

From the final weighting factor, the condition that was found to be of top importance (Table 4.6) or in other words the health condition that should receive top share of the pie was poor oral health. It was also found that obesity had high importance. This result in coordination with the fact that there was 77% increase in medication intake by obese people[11] should help illustrate the greater danger obese people are in compared to others. The other important health conditions were arthritis, poor vision, emphysema and diabetes.

Some of the limitations of this research were that we combined all the types of arthritis, diabetes and cancer into individual variables due to insufficient data to represent all of them separately. It might be interesting to see what will happen if these conditions are separated. Also, it was assumed that the two criteria, prevalence and impact had equal weightage which may not be the case in an actual setting.

For future research, one could consider analyzing the effects other critical health conditions which are not considered here. This research has assumed equal preference of the two decision making criteria while quantifying the weighting factor. There are many possible extensions to this model that could be considered. One could extend the number of decision making criteria to greater than two and also incorporate decision makers to come up with the weights for each of those criteria.

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