Social Determinants of Health: A Retrospective Cohort & Epidemiological Study on Treatment of Hypertension at the Epworth Clinic: April 2010 – September 2020

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Chapter 1: Overview of Social Determinants of Health

The social determinants of health describe the economic, cultural, and environmental conditions that influence a community's health risks and medical outcomes (Social Determinants of Health, 2020). Studies addressing the social determinants of health examine and often attempt to influence the social and behavioral factors that influence health and mortality. Although the United States invests more money, per capita, in healthcare than any other developed country, research and programs focused on social and behavioral factors of health have long remained marginal to healthcare spending. As a result, the United States has large and avoidable differences in health access, status, outcomes, and costs across populations. For example, life expectancy of 40-year-old men in the poorest 1% of the U.S. income distribution is 14.6 years shorter than for men in the richest 1%. For women, this difference is 10.1 years (Adler, 2016).

Health disparities research in American populations has investigated associations between illness and adverse environmental exposures including air, water, and soil quality; crime, violence, and bullying; and access to exercise, green spaces, and nutritious foods. This research has shown how such factors are implicated in medical problems like anxiety, chronic stress, and behavioral health issues (Schmidt, 2007). Social inequity has been found to influence how the body responds to chronic stress (Palmer, 2019). However, it has been widely debated whether these physiologic processes are a result of daily stress, social inequity, or a combination of these factors. Although exposed to adverse social determinants of health, not all individuals experience worse health outcomes (Palmer, 2019). Protective social factors including social support, education, mentoring, and family structures, have been suggested as preventative and resilience mechanisms which allow individuals to adapt their functioning in the face of adverse exposures (Palmer, 2019).

Geography and Built Environments

A second theme of research has examined the important role neighborhoods play in the social determinants of health and the convergence between the built and social environment where people live (Palmer, 2019). Neighborhoods have been shown to contribute to both morbidity and mortality and minority and low socioeconomic status populations are more likely to be living in resource poor communities. However, there is variability among these communities with life expectancies varying tremendously between these different populations (Palmer, 2019). Studies examining the social determinants of health aim to observe the structure and context of the communities that contribute to health disparities. As with studies of individuals, these neighborhood-based projects investigate exposure to environmental toxins, availability of social support, high social stressors like violence, constrained lifestyles with high density of tobacco and alcohol stores, and psychosocial mechanisms that influence health behaviors (Palmer, 2019).

Lifestyle Drift & Concentration of Medical Care

Two particular health determinants have gained particular attention: lifestyle drift and the overconcentration of health care in affluent areas (Marmot, 2014). Lifestyle drift is the tendency for health care to fixate on individual behaviors (diet, alcohol, drugs, etc.) and ignore the drivers of such behaviors. The overconcentration of health care, especially in urban areas, is directly related to access to medical services and the associated health of individuals and populations. Disparate socioeconomic conditions have been the cause of numerous health inequalities (Marmot, 2014). With a lack of knowledge behind the drivers of individual behaviors and a lack of proper health care, difficulties are present regarding proper medical services in lower income communities.

Other researchers have proposed that examining the provision of disproportionate services for similar conditions can reveal systemic problems in health systems. Equitable care for each

person's individual circumstance which is irrespective of geography, gender, race/ethnicity, age, culture, or sexual orientation is assured by the Office of Health Equity (Marmot, 2014). However, in a comprehensive study of Veteran's Administration Hospitals, the risk of hospitalization of white veterans compared to non-white veterans showed that white veterans had a 15% decreased odds of hospitalization when compared with non-white veterans. The differences suggest variations in the hospitalization rates across the Veteran's Health Administration primary care clinics across the country and invite future research to determine why such variations might exist (Hatef, 2019). For example, equation models that can contrast access, service provision, and outcomes by various social determinants of health assessments can aid in designing health interventions in the population to improve inequity in health care.

Policy Interventions: Toward a Value-Based Health System

To reduce social disadvantage in different populations, policies can be put in place to minimize health inequalities. For example, health gaps between blacks and whites narrowed in the years after civil rights legislation was passed (Adler, 2016). Research focused on the upstream effects of social as well as economic policies can reduce the health disparities between different populations. However, upstream factors including governance and legislation typically create structural challenges that impose downstream barriers that lead to health inequalities (Palmer, 2019). Furthermore, racism and discrimination continue to be both overt and systemic issues that must be considered when researching health inequalities.

Researchers agree that two structural changes in the way the US health care system incentivizes care need to be addressed to alleviate health disparities. First, medical systems need to recognize each patient's social circumstances and build medical care plans that address and take into account these circumstances (Garg, 2019). Second, the U.S. must transform from fee-for-service reimbursement to a value-based model in which payment would be based on quality measures and health outcomes rather than the amount of care provided (Garg, 2019). A

value-based system that incentivizes outcomes over amount of care has recently been extended into Medicaid. As shown below, value-based healthcare, which gives incentives to health providers to improve their care and hold down costs, could broaden the ability for more Americans to be insured and covered for medical fees. However, there are challenges associated with implementing these Medicaid value-based systems.

A value-based system relies on equitable access to adequate supportive networks and community-based medical services. While some Americans have sufficient medical services, others lack the resources to have these networks. Current financial incentives for health care providers that emphasize recruiting well-insured and higher-paying populations presents further challenges (Garg, 2019). Often, health care providers prioritize referrals of low-income, uninsured, and underinsured populations to community-based medical services that lack the proper resources in their respective areas. A value-based approach with incentives for greater inclusion in extensive health systems would allow for patients needs to be met, especially in underserved, low-income, and racial minority populations.

A third policy challenge includes the Medicaid program diverting resources from one at-risk population to another. For example, the Massachusetts Medicaid ACO program uses an adjusted risk-scoring system that weighs the social determinants of health to determine where resources should be pooled. When the system screens for a specific disease which is found in one at-risk population, resources are often moved from a different at-risk population which has confounding factors that lead to lack of medical care in that community (Garg, 2019).

To address these issues, a value-based health care system could engage multiple sectors to address the adverse effects of health and implement real changes to improve of the quality of health care. Through better partnerships between state agencies and the health care system, initiatives aimed at addressing the social determinants of health can be supported. Additionally,

a more substantial Medicaid-supported social determinants of health care model can be created to bring health care sector and community agencies together (Garg, 2019). Medicaid, which serves 74 million Americans that are affected by adverse social circumstances (Garg, 2019), can assist in blending administrative and financial resources to enable families' access to health care and social services. This would create proper job-search assistance, resources that could be allocated to assist the community, and social services to help families living in difficult social circumstances.

Chapter 2: Epidemiological Studies in Medicine

Epidemiology is the study of the distribution and determinants of health-related states or events in specified populations and the application of this study to the control of health problems in the general population (Dicker, 2012). Epidemiology is data-driven and relies on a systematic and unbiased approach to the collection, analysis, and interpretation of data. Epidemiology observes changes taking place in a studied community and the emergence of new diseases or conditions within that community (Frérot, 2018). Methodologically, epidemiology consists of describing health status, identifying risk factors, and analyzing relationships between health and different hazardous agents (Gulis, 2015). Epidemiology has traditionally focused on the emergence of infectious diseases. However, epidemiology has emerged to study non-communicable infectious diseases, trauma, chronic diseases, as well as environmental and behavioral health. Through the use of ratios, probabilities, and other statistical calculations, the factors regarding disease emergence and spread, and the health outcomes in a population can be determined.

Epidemiologists work with other health professionals to study patterns, means of transmission, and determinants of different health events within a population (Hernandez, 2020). Epidemiology relies on the frequency and pattern of these health events. Frequency is the

number of health events (ex: number of cases of a disease) and the relationship of that number to the size of the population (Dicker, 2012). A pattern of health events is the occurrence of health-related events by time, place (geographic) and person (demographics) (Dicker, 2012). These health-related events are what epidemiologists analyze to assess the determinants of different diseases.

Epidemiology examines the 'where', 'why', and 'how' of health-related events. Epidemiology is used to search for determinants, which are the causes and other factors that influence the occurrence of a disease (Dicker, 2012). It is assumed that an illness does not occur randomly in a population but develops when risk factors accrue in an individual. As a discipline of public health, epidemiology promotes health and prevents disease in society. Through epidemiology, continuous public health surveillance can occur which allows for patterns and health outcomes to be monitored for the benefit of faster disease recognition, prevention, and improved population health. One of the main goals of epidemiology is to be proactive in learning about diseases: learning about the disease's risk factors, means of transmission, and reservoirs to provide knowledge for responses to health-related events (Hernandez, 2020).

Epidemiological studies aim to understand disease transmission and increase disease prevention. Public health surveillance, one of the main functions of epidemiology, is the systematic collection, analysis, and dissemination of health data to assist in public health decisions (Dicker, 2012). Epidemiology also consists of field investigations at times to identify the cause of a particular disease. Analytic studies and evaluation aim to look at the causes and modes of transmission, and determine the effectiveness, efficiency, and impact of the study (Dicker, 2012).

The epidemiologic approach counts the cases of disease by time, geographical place, and person. The number of disease cases are divided by an appropriate denominator to calculate a

specific rate, which is then compared over time. Other studies can be specific to specific populations. A disease case is a set of standard criteria to determine if an individual has a certain disease or health condition (Dicker, 2012).

A disease cause is a focal point of epidemiological studies. Causation is best represented by the epidemiologic triad or triangle as shown below in Figure 1. The disease starts with an external agent, which is an infectious microorganism or pathogen (Dicker, 2012). A susceptible host, which is the human who gets the disease, is then infected through an environment, which is comprised of extrinsic factors that affect the agent and provide an opportunity for exposure to the disease.

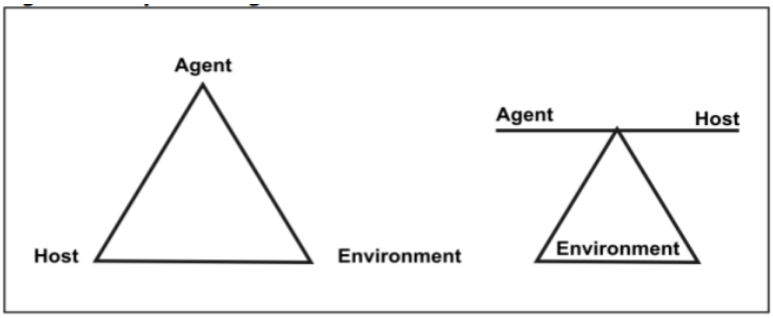


Figure 1. Epidemiological Triangle. The epidemiological triangle depicts the susceptible host, the environment, and the agent (Dicker, 2012).

The environment brings the host and agent together allowing for infection to occur. This process is called the chain of infection: transmission occurs when the agent leaves its reservoir (host) through a portal of exit, is transferred by a mode of transmission, and infects a susceptible host when it enters a portal of entry (Gulis, 2015). This chain of infection is depicted in Figure 2.

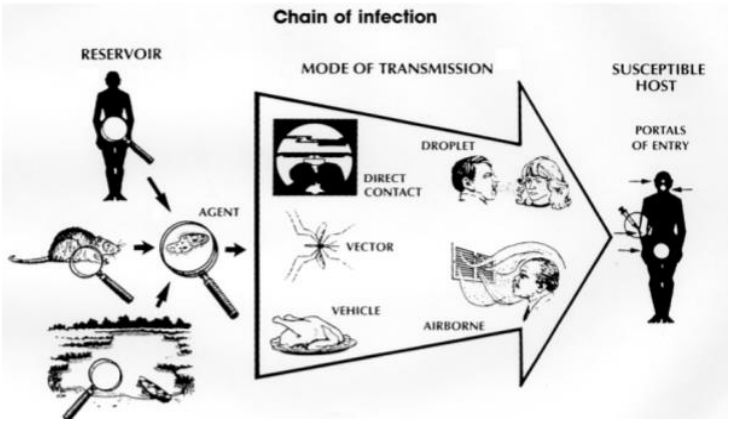


Figure 2. Chain of Infection. The chain of infection consists of the reservoir (agent), the mode of transmission (how the disease spreads), and the susceptible host which is infected through a portal of entry (Dicker, 2012).

In epidemiology, each disease has a natural history and spectrum of disease. The natural history is the progression of a disease in an individual over a period of time without treatment. The spectrum of disease consists of the disease that progress to an illness that ranges from mild to severe to fatal (Dicker, 2012). As shown in Figure 3, the spectrum of a disease results in either recovery, disability, or death.

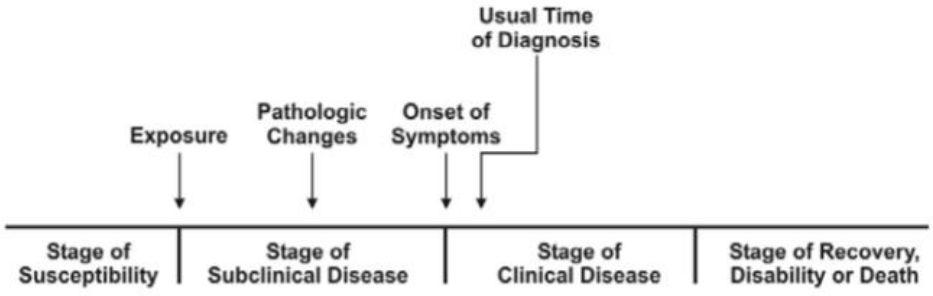


Figure 3. Spectrum of a Disease. The spectrum of a disease is the timeline that a disease follows starting with the stage of susceptibility, infection, and ultimately results in recovery, disability, or death (Dicker, 2012).

Disease incidence and prevalence are commonly used to express the health status of a population. Prevalence describes how widespread a disease is throughout a population and does not take into account disease exposure. Incidence refers to new disease cases in a population over a specified period of time and conveys information about the exposure and risk of contracting a disease (Dicker, 2012). Commonly used, the incidence rate is the speed (frequency) of new disease occurrences in a population (Spronk, 2019). When analyzing data using the incidence rate, it implies that this pattern has occurred and will continue to occur in the foreseeable future.

Morbidity and mortality rates describe disease progression and severity. Morbidity refers to an individual's state of being symptomatic or unhealthy from a disease (Hernandez, 2020). Morbidity is typically expressed using prevalence or incidence. Mortality represents the number of deaths caused by a health event in a defined population during a specified time interval (Hernandez, 2020). Mortality is usually delineated as a rate per 1000 individuals, otherwise called the death rate. Morbidity and mortality rates allow for continuous evaluation of disease efficacy or the ability to plan interventions against the disease.

Measures of association quantify the relationship between exposure and disease among two groups (Dicker, 2012). The relative risk, also called the risk ratio, compares the risk of a health event among one group with the risk among another group. Figure 4 depicts a two-by-two table which calculates the odds ratio and quantifies the relationship between an exposure with two categories and health outcomes (Dicker, 2012).

	Disease	No Disease	Total	Risk
Exposed	a = 100	b = 1,900	2,000	5.0%
Not Exposed	c = 80	d = 7,920	8,000	1.0%
Total	180	9,820	10,000	

Figure 4. Exposure and Disease in a Hypothetical Population of 10,000 People. A two-by-two table calculates the risk of both exposure and disease for 10,000 people. These tables can be used to determine relative risk among different groups of individuals (Dicker, 2012).

Public health impact, specifically the attributable risk percent, places the association between an exposure and an outcome into a meaningful public health context (Dicker, 2012). For example, the attributable risk percent evaluates the amount of disease in an exposed group that is attributable to an exposure. Accurate assessment of these measures is crucial to understanding and evaluating their impact on society (Hernandez, 2020). These metrics allow policy makers, in collaboration with health care professionals, to effectively prioritize which health events to take on first and proactively manage the health event in real time.

Chapter 3: What is Hypertension?

Overview

Hypertension is associated with increased risk of cardiovascular diseases (Oparil, 2018). As one of the most common chronic medical conditions, hypertension affects more than one billion adults worldwide (Iqbal, 2020). Hypertension has been defined as having a systolic blood pressure value of 130 mmHg or more and/or diastolic blood pressure over 80 mmHg. Numerous risk factors include alcohol consumption, physical inactivity, and unhealthy diet (Mills, 2020), as well as major depression and anxiety (Grimsrud, 2009).

Epidemiology

Hypertension affects over one billion adults worldwide with a prevalence among adults of 31.1% (1.39 billion) (Mills, 2020). Hypertension affects US men and women almost equally with approximately 41 million men and 45 million women having this condition (Alexander, 2021). Hypertension predominantly affects individuals between the ages 45 to 64 years with the percentages nearly equal between men and women (Alexander, 2021). There is an increasing trend of hypertension in adults. This is expected to significantly increase by 2025 which is predicted to be driven by increased in hypertension cases in economically developing nations (Alexander, 2021).

Anatomy & Pathophysiology

Blood pressure is modulated by numerous factors including humoral mediators, vascular reactivity, circulating blood volume, vascular caliber, blood viscosity, cardiac output, blood vessel elasticity, and neural stimulation (Yang, 2021). Although not certain, it is suggested that hypertension is caused by multiple factors interacting such as genetics, excess salt intake, and adrenergic tone.

Before hypertension becomes hypertension, there is a progression from prehypertension and early hypertension which then can result in established hypertension. A common hypothesis is that prehypertension results in the oxidation of lipids which causes formation of isoketals or isolevuglandins—these are presented to T-cells which activate and infiltrate critical organs such as the kidneys, which impairs the response of the renin-angiotensin-aldosterone system (Yang, 2021; Iqbal, 2020). Additionally, activation of the sympathetic nervous system and noradrenergic stimuli have shown similar activation of T cells which could also contribute to hypertension occurring (Alexander, 2021).

Younger individuals typically present hypertension as elevated cardiac output which is a result of sodium retention by the kidneys and leads to cardiac stimulation by adrenergic hyperactivity (Yang, 2021). Increased sodium retention leads to more volume of blood which increases blood pressure. However, when hypertension is sustained, vascular remodeling occurs—vasoconstriction and vascular rarefaction (Yang, 2021). Cortisol has also been associated with hypertension. Cortisol reactivity caused by psychosocial stress, which points at the hypothalamic-pituitary-adrenal functionality, has been shown in cases of hypertension as well (Alexander, 2021).

Etiology & Pathology

Noticeable trends are shown with Diabetes Mellitus Type II as one of the most prevalent comorbidities. Atherosclerosis, a common result of diabetes, increases blood pressure and results in hypertension. Diabetes can also cause vascular inflammation, which thickens the walls of blood vessels and reduces the width of passageway for blood, and leads to high blood pressure (Petrie, 2018). Another comorbidity with hypertension was obesity which plays a major role of increasing sodium reabsorption in the kidneys, resulting in increased arterial (blood) pressure (Aronow, 2017). Studies have shown that obesity also impair renal pressure natriuresis by activating the renin-angiotensin and sympathetic nervous system, leading to increased blood pressure (Aronow, 2017). Hypertension was also comorbid with asthma, which has been recognized as a pro-inflammatory disorder and leads to vascular wall stiffness (Ferguson, 2014). Systemic inflammation and vascular wall stiffness often result in hypertension for individuals with asthma.

Hypertension is also commonly comorbid with obesity. Among low-income men, it has been found that men with obesity were two times more likely to have high blood pressure compared to men with normal weight (Bruce, 2011). Ewald, assessing the prevalence of obesity and hypertension in adolescent patients from a clinic serving low-income patients showed that that

obese men were more likely to be diagnosed with hypertension (Ewald, 2017). The study also indicated that excessive sodium intake is a risk factor for higher blood pressure and is strongly corelated with the development of excess weight (Ewald, 2017).

Differential Diagnosis Treatment

Various conditions play critical roles in the development of hypertension. Some of these conditions include primary pulmonary hypertension, coronary atherosclerosis, peripheral vascular disease, and kidney disease. Primary pulmonary hypertension is high blood pressure in the lungs which causes blood vessels in the lungs to constrict (Oldroyd, 2020). This disease is classified by increased vascular resistance and narrowing of blood vessels, which significantly increases blood pressure. Coronary atherosclerosis is the damaging of artery walls and the buildup of fat and calcium inside them (Nakanishi et al., 2017). The buildup of this plaque results in the narrowing of the arteries and the increased pressure of blood flowing through the arteries causes more damage. This leads to hypertension and damage to the arteries over time. Peripheral vascular disease is a chronic progressive atherosclerotic disease that leads to partial or total peripheral vascular blockage (Gul, 2020). The narrowing of the vascular tracts results in increased blood pressure and essential hypertension. Kidney disease is when the arteries around the kidney narrow, weaken, or harden, and cannot deliver enough blood to kidney tissue, resulting in a lack of filtration (Wadei, 2012). The kidney's play a large role in maintaining blood pressure—the renal artery perfusion pressure directly regulates sodium excretion, which in turn affects the amount of water the body retains. Known as pressure natriuresis, the kidney influences how much volume of water is excreted and retained—influenced upstream by sodium consumption (Wadei, 2012). The kidneys directly regulate how much blood volume there is in arteries and the arterial blood pressure.

Treatment

A healthy diet and increased physical activity have been effective in lowering blood pressure and preventing hypertension (Oparil, 2018). Lifestyle changes reduce risk factors and favorably affect blood pressure levels—these are essential for the prevention of high blood pressure.

Systolic blood pressure levels rise slowly but continuously as people age. Treatment for hypertension is preventative rather than palliative with most clinicians offering medication such as diuretics, Angiotensin-converting enzyme (ACE) inhibitors, and beta-adrenergic blockers to alleviate high blood pressure. Diuretics affect the body by decreasing the amount of sodium and water retained in the kidneys—this decreases blood volume and thus, blood pressure. ACE inhibitors relax arteries and veins by preventing the production of angiotensin II, which narrows blood vessels (Herman, 2020). Narrower blood vessels lead to higher blood pressure. Beta-adrenergic blockers work by blocking the hormone epinephrine, which results in a slower heartbeat with slower conduction velocity—this reduces cardiac output and decreases blood pressure (Farzam, 2021). If left untreated, hypertension can lead to renal disease, myocardial infarction, and cerebrovascular accidents (Ashley, 2004).

Hypertension and Socioeconomic Status

Hypertension and hypertension control have been associated with income inequality. One observational study found that hypertension is more common and more poorly controlled in lower socioeconomic groups (Anstey, 2019). Social connectedness (psychological), stress factors, and the availability of appropriate food options were reported to be factors associated with an increased risk of developing high blood pressure in New York public housing (Al-Bayan, 2016). Study participants attributed their stress to personal issues including unemployment and inferred that their health was impacted by lack of healthy food options (Al-Bayan, 2016).

Hypertension has remained one of the largest public health problems in low-and middle-income countries with 1 in 3 people affected by the disease (Sarki, 2015). Hypertension

prevalence is higher in the elderly and lower educational status is also associated with a higher prevalence of hypertension (Sarki, 2015). Estimates show that in low-and middle-income countries, the prevalence of hypertension was also higher in urban communities (Sarki, 2015).

Chapter 4: Epworth Clinic

The Epworth Methodist Free Medical Clinic has operated for 21 years on Salisbury Street in Worcester, MA, and is home to the Worcester Free Medical Service Program which operates in association with the University of Massachusetts Medical School (Epworth Methodist Free Medical Program, 2020). With a mission to extend medical outreach and services to the greater Worcester community, the Epworth clinic provides free medical services through a walk-in program for patients who are uninsured, underinsured, or who are unable to afford insurance co-payments. The Epworth Medical Service provides checkups, work and school physicals, sick visits, lab testing, TB testing, and dental services including screening and exams. The service operates every Monday evening and patients can receive health services free of charge. The Epworth Clinic is staffed by volunteer physicians and clinicians including students from the University of Massachusetts Medical School.

Patient data is entered by physicians or medical students into a EMR database hosted by Athena (www.athenahealth.com). The EMR organizes patient visits and helps physicians document patient encounters fast and accurately. The EMR allows clinic staff to schedule and track visits, permits the clinician to document information from the patient encounters and look up prior medical information including labs, prescriptions, and vital signs, and document societal risks and determinants that could influence patient care.

All the data that is entered into Athena is then transferred manually to another secure web application called REDCap. REDCap is a valuable piece of software that is used to collect the data that was acquired in Athena to a more suitable online database geared more towards research studies. Once the data has been inputted into REDCap, the data trends can be observed and the social determinants of health can be analyzed.

Chapter 5: Methods

Data was gathered from REDCap and analyzed using Microsoft Excel. Patients clinically diagnosed with hypertension and patients that met the criteria for hypertension but were not diagnosed (by text) were examined. The following section offers insight to the gender demographics, insurance status', incidence by age, hypertension rates, hypertension severity, location of patients attending the clinic, and amount of work physicals conducted at the Epworth Clinic overall and in the Greater Worcester Area.

The gender demographics and insurance status' of patients who was clinically diagnosed with hypertension and patients that met the criteria for hypertension but were not diagnosed (by text) at the Epworth Clinic between April 2010 and September 2020 was collected.

The prevalence of hypertension was determined by either diagnosis note within the clinical record or by the vital signs reported in the patient chart apart from a clinical diagnosis (textual diagnosis). The textual diagnosis was determined by the patient's systolic and/or diastolic blood pressure meeting the criteria of stage 1 hypertension or greater (130/80) (Iqbal, 2020).

The severity of clinically diagnosed patients at the Epworth Clinic between April 2010 and September 2020 was collected. The severity of patients that met the criteria for hypertension

but were not diagnosed (by text) at the Epworth Clinic between April 2010 and September 2020 was also gathered. The cases of hypertension (clinical and by text diagnoses) were analyzed using the sort function in Excel to determine the severity.

The comorbidity of 154 patients who were diagnosed with hypertension by a clinician at the Epworth Clinic between April 2010 and September 2020 was recorded.

From the data recorded, patients that were diagnosed with hypertension were plotted on a map of Massachusetts using zip code. The hypertension diagnoses of patients attending the Epworth Clinic were plotted on a map of the Greater Worcester Area using zip code as represented by Figure 14A.

The insurance status of each patient who completed a work physical by a clinician at the Epworth Clinic between April 2010 and September 2020 was collected. Work physicals were conducted on 434 patients at the Epworth Clinic between April 2010 and September 2020. Zip codes were on record for 402 out of the 434 patients.

The treatment of hypertension cases (clinical and by text diagnoses) was observed for patients at the Epworth Clinic between April 2010 and September 2020.

Chapter 6: Results

A total of 1418 patients attended the Epworth Free Medical Service from April 2010 to September 2020, the time for which this project was developed.

Gender and Insurance Status of Clinic Population

As Figure 5(A) shows, 55.2% of all patients using the clinic over the study period identified as female, 43.9% identified as male, 11 patients were unknown, and 1 patient identified as other. Figure 5(B) shows the insurance status of patients: 847 (59.7%) patients had no insurance, 501 (35.3%) reported insurance coverage (35.3%), and 70 (4.9%) patients' insurance status was unknown. The average age for all patients attending the clinic over the study period was 35.82 years.

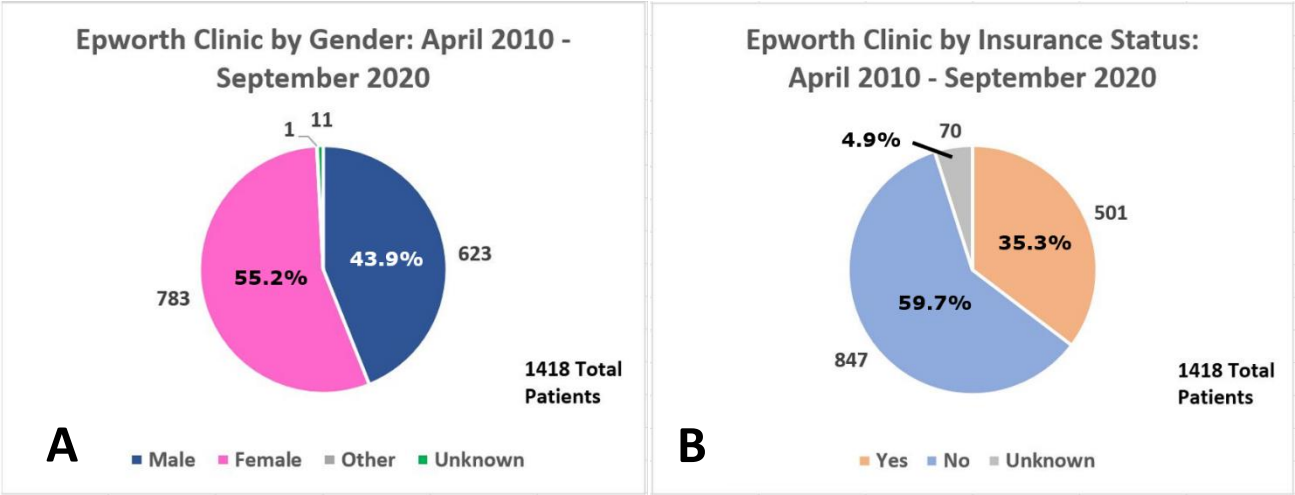
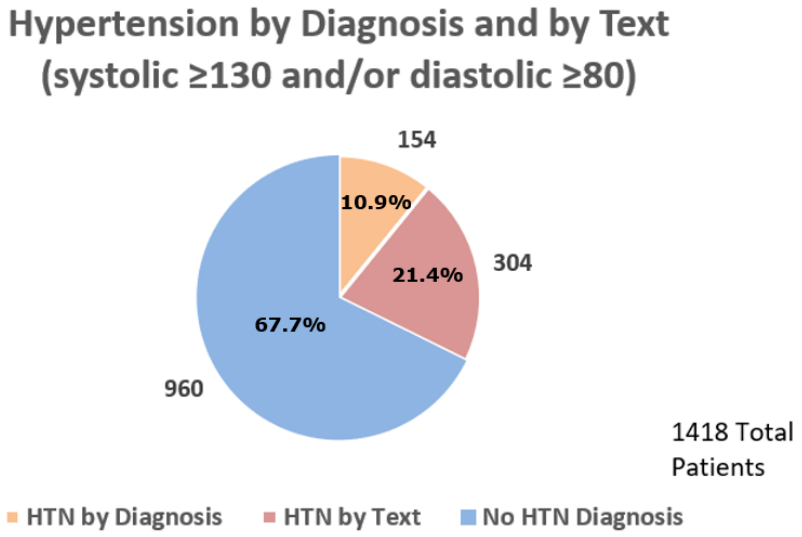


Figure 5. Epworth Clinic Gender Demographics and Insurance Status. Figure 5A depicts the Epworth Clinic by gender demographic of 1418 patients screened between April 2010 and September 2020. Figure 5B represents the insurance status of 1418 subjects attending the Epworth Clinic between April 2010 and September 2020.

Hypertension Rates: By Clinical Diagnosis & Vital Signs Recording

As Figure 6 demonstrates, 458 (32.3%) patients met hypertension criteria (clinical or textual diagnosis); 154 (10.9%) patients were clinically diagnosed with hypertension (stage 1 or stage 2) and 304 (21.4%) met the textual diagnosis criteria.



	HTN by Diagnosis	HTN by Text
Average Age (years)	50.07	44.15

Figure 6. Hypertension by Diagnosis and by Text. This figure depicts the prevalence of hypertension in the Epworth Clinic using diagnosis by clinician and diagnosis by text (met the criteria of stage 1 hypertension or greater). The average age (years) for both groups is included.

Hypertension Rates by Gender Demographics – Clinical & Textual Diagnosis

The gender demographics of 154 patients who were diagnosed with hypertension by a clinician at the Epworth Clinic between April 2010 and September 2020 were collected. As shown in Table 3, 50.0% of patients identified as female, 48.7% identified as male, and 2 patients were unknown. The gender demographics of 304 patients who were not diagnosed with hypertension but met the criteria of a hypertension diagnosis at the Epworth Clinic between April 2010 and September 2020 were collected. As shown by Table 3, 51.3% of patients identified as female, 48.0% identified as male, and 2 patients were unknown.

Table 3. Hypertension by Diagnosis and by Text: Gender Demographics.

Gender	HTN by Diagnosis	HTN by Text
Male	75 (48.7%)	146 (48.0%)
Female	77 (50.0%)	156 (51.3%)
Unknown	2 (1.3%)	2 (0.7%)
Total →	154	304

Table 3 represents the gender demographics of clinically diagnosed hypertensive patients and patients that met the criteria for hypertension (by text).

Hypertension Rates by Insurance Status – Clinical & Textual Diagnosis

The insurance status of each patient who was diagnosed with hypertension by a clinician at the Epworth Clinic between April 2010 and September 2020 was collected. Of the 154 total patients diagnosed with hypertension, 107 patients had no insurance (69.5%), 35 indicated that they did have insurance (22.7%), and 12 patients were unknown for insurance status (7.8%). The insurance status of each patient who were not diagnosed with hypertension but met the criteria of a hypertension diagnosis at the Epworth Clinic between April 2010 and September 2020 was collected. Of the 304 total patients that met the criteria of a hypertension diagnosis (by text), 188 patients had no insurance (61.8%), 96 indicated that they did have insurance (31.6%), and 20 patients were unknown for insurance status (6.6%).

Table 4. Hypertension by Diagnosis and by Text: Insurance Status.

Insurance Status	HTN by Diagnosis	HTN by Text
Yes	35 (22.7%)	96 (31.6%)
No	107 (69.5%)	188 (61.8%)
Unknown	12 (7.8%)	20 (6.6%)
Total →	154	304

Table 4 represents the insurance status' of clinically diagnosed hypertensive patients and patients that met the criteria for hypertension (by text).

Table 5. Hypertension Diagnosis: Incidence by Age.

Age Group (years)	Number of Patients
10 - 19	2
20 - 29	17
30 - 39	15
40 - 49	32
50 - 59	44
60 - 69	34
70 - 79	7
80 - 89	1
Unknown	2
Total →	154

Table 5 represents the incidence by age of patients clinically diagnosed with hypertension.

Hypertension Diagnosis – Incidence by Age

The incidence of hypertension diagnoses by age was collected for patients attending the Epworth Clinic between April 2010 and September 2020. The incidence of patients aged 10-19 was 2; the incidence of patients aged 20-29 was 17; the incidence of patients aged 30-39 was

15; the incidence of patients aged 40-49 was 32; the incidence of patients aged 50-59 was 44; the incidence of patients aged 60-69 was 34; the incidence of patients aged 70-79 was 7; the incidence of patients aged 80-89 was 1; and 2 patients were unknown for age. Additionally, as shown by Figure 5, the average age for patients clinically diagnosed with hypertension was 50 years while the average age for patients that were met the criteria for hypertension but were not diagnosed was 44 years.

Hypertension Severity – Diagnosis by Clinician

Of the 154 patients diagnosed with hypertension, 150 (97%) had measured systolic and diastolic blood pressures and 4 patients did not have measured blood pressures. Figure 7 and Figure 8 show that 133 (88.7%) patients met the criteria for stage 2 hypertension (systolic ≥140 mm Hg and/or diastolic ≥90 mmHg) and 11 (7.3%) patients met the criteria for stage 1 hypertension (systolic 130-139 mm Hg and/or diastolic 80-89 mmHg). Six patients appear to have been misdiagnosed or their status as medically-controlled hypertension was not fully documented in the chart: Two patients met the criteria for elevated blood pressure (systolic 120-129 mm Hg and/or diastolic 80-89 mmHg), three patients met the criteria for normal blood pressure (systolic <120 mm Hg and/or diastolic <80 mmHg), and one patient met the criteria for low blood pressure (systolic <90 mm Hg and/or diastolic <60 mmHg).

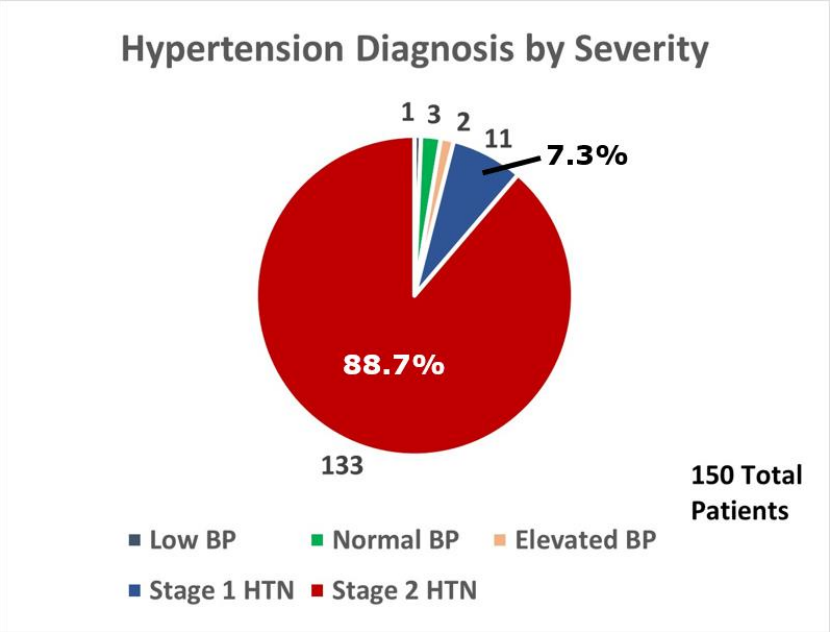


Figure 7. Hypertension Diagnosis by Severity. This figure represents the severity of 150 patient's diagnosis of hypertension (Low BP, Normal BP, Elevated BP, Stage 1 HTN, Stage 2 HTN).

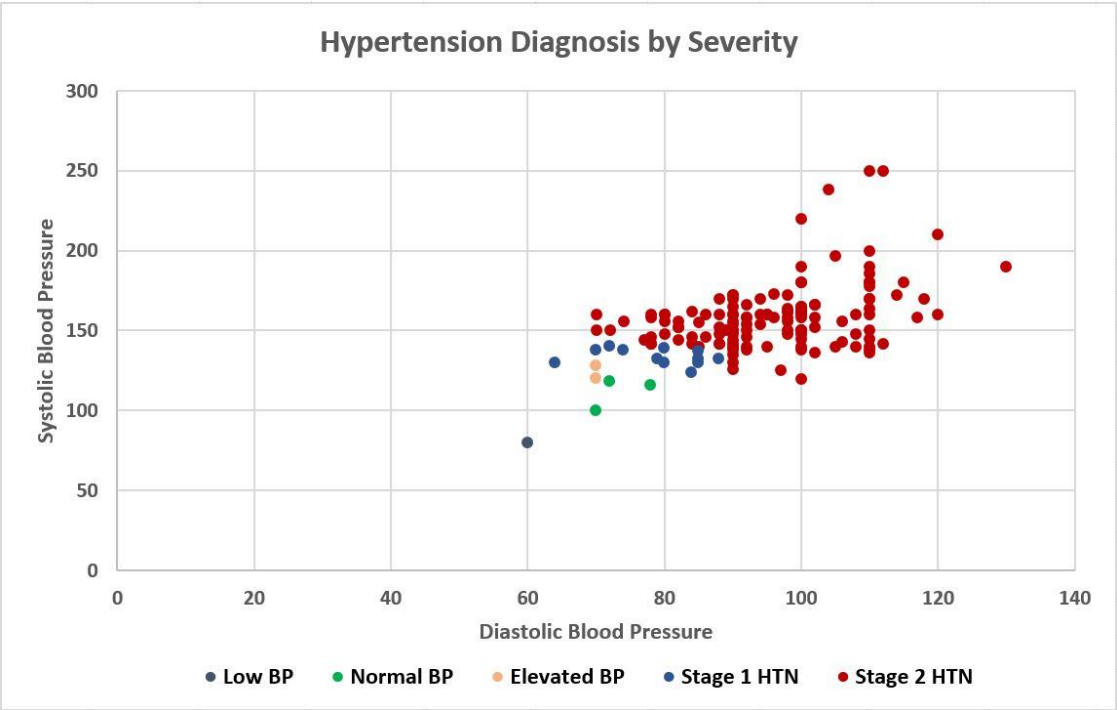


Figure 8. Hypertension Diagnosis by Severity. The severity of 150 patient's diagnosis of hypertension (Low BP, Normal BP, Elevated BP, Stage 1 HTN, Stage 2 HTN) is plotted using the systolic blood pressure measurement on the y-axis and the diastolic blood pressure measurement on the x-axis.

Hypertension Severity – Textual Diagnosis

Of the 304 patients that met the criteria for hypertension but were not diagnosed, had measured systolic and diastolic blood pressures and 4 patients did not have measured blood pressures. Figure 9 and Figure 10 show that 193 (63.5%) patients met the criteria for stage 2 hypertension (systolic ≥140 mm Hg and/or diastolic ≥90 mmHg) and 111 (36.5%) patients met the criteria for stage 1 hypertension (systolic 130-139 mm Hg and/or diastolic 80-89 mmHg).

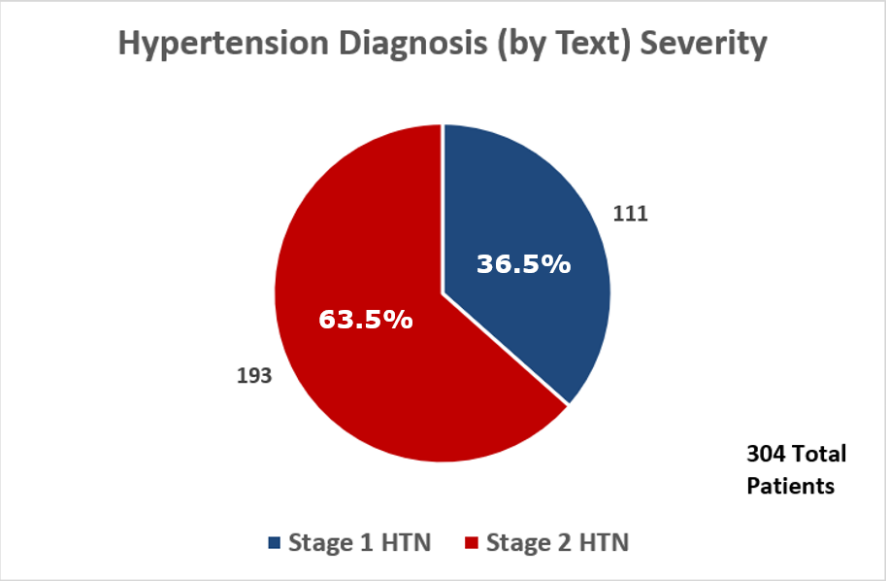


Figure 9. Hypertension Diagnosis (by text) by Severity. This figure represents the severity of 304 patient's diagnosis of hypertension by text (Stage 1 HTN, Stage 2 HTN).

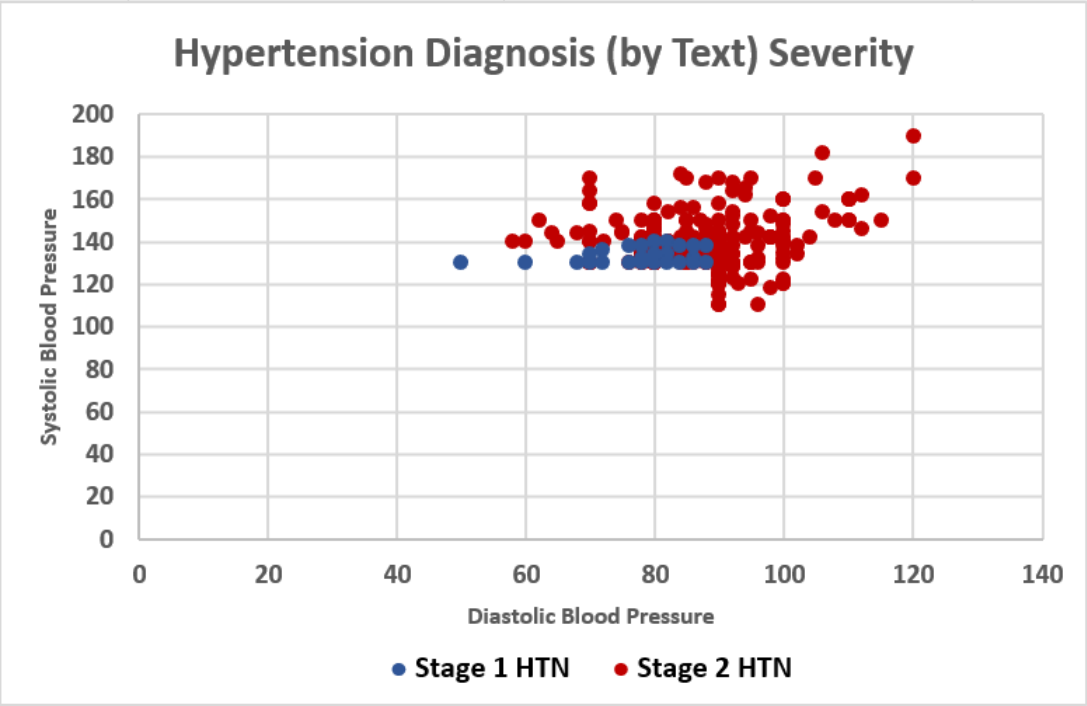


Figure 10. Hypertension Diagnosis (by text) by Severity. The severity of 304 patient's diagnosis of hypertension by text (Stage 1 HTN, Stage 2 HTN) is plotted using the systolic blood pressure measurement on the y-axis and the diastolic blood pressure measurement on the x-axis.

Hypertension Comorbidity with Additional Risk Factors

Figure 11 demonstrates that the majority of patients diagnosed with hypertension (105 patients or 68.2%) were not assigned a comorbidity. Diabetes Mellitus Type II was the most prevalent comorbidity (24 patients or 15.6%). Six patients (3.9%) were diagnosed with obesity and four patients (2.6%) were diagnosed with asthma. Additionally, patients diagnosed with hypertension were also diagnosed with high cholesterol (2 patients, 1.3%), hepatitis C (2 patients, 1.3%), hyperlipidemia (2 patients, 1.3%), hypothyroidism (2 patients, 1.3%), hyperglycemia (1 patient, 0.6%), hyperthyroidism (1 patient, 0.6%), glaucoma (1 patient, 0.6%), fibromyalgia (1 patient, 0.6%), tobacco dependence (1 patient, 0.6%), anxiety (1 patient 0.6%), and depression (1 patient, 0.6%).

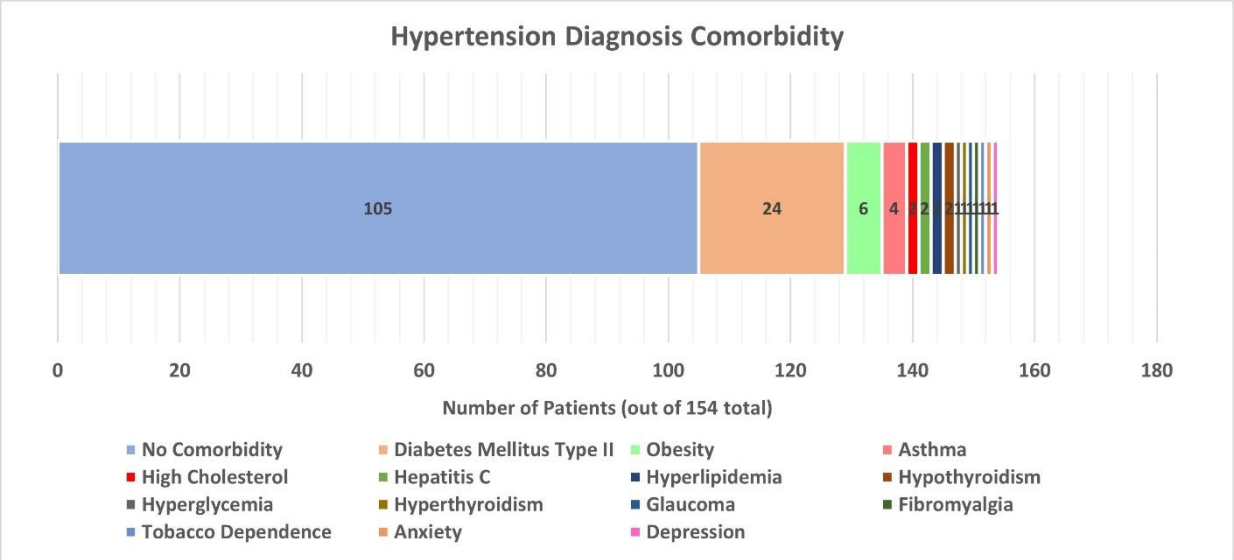


Figure 11. Hypertension Diagnosis Comorbidity. The comorbidity of hypertension diagnosis with additional risk factors was gathered in 154 patients. The most common comorbidity with hypertension was none, followed by Diabetes Mellitus Type II, obesity, and asthma.

Hypertension by Geographic Distribution

Most of the hypertension diagnoses are located in the Greater Worcester Area which is where the Epworth Clinic is located.

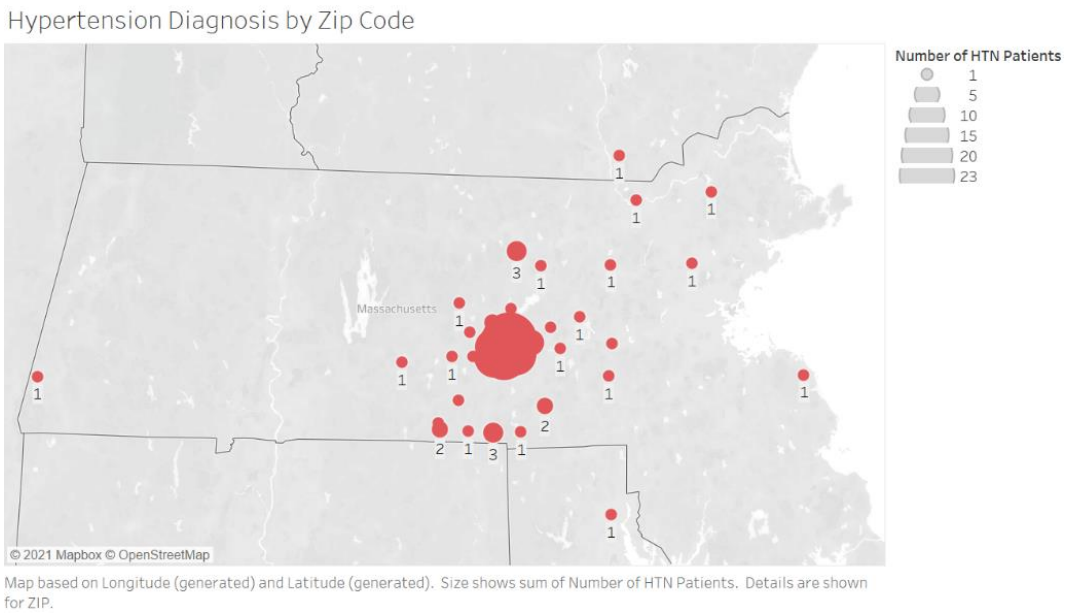


Figure 12. Hypertension Diagnosis by Zip Code – Epworth Clinic. The hypertension diagnosis of each patient is plotted on the map based on the zip code that each patient resides in. The majority of hypertension diagnoses were from the Greater Worcester Area.

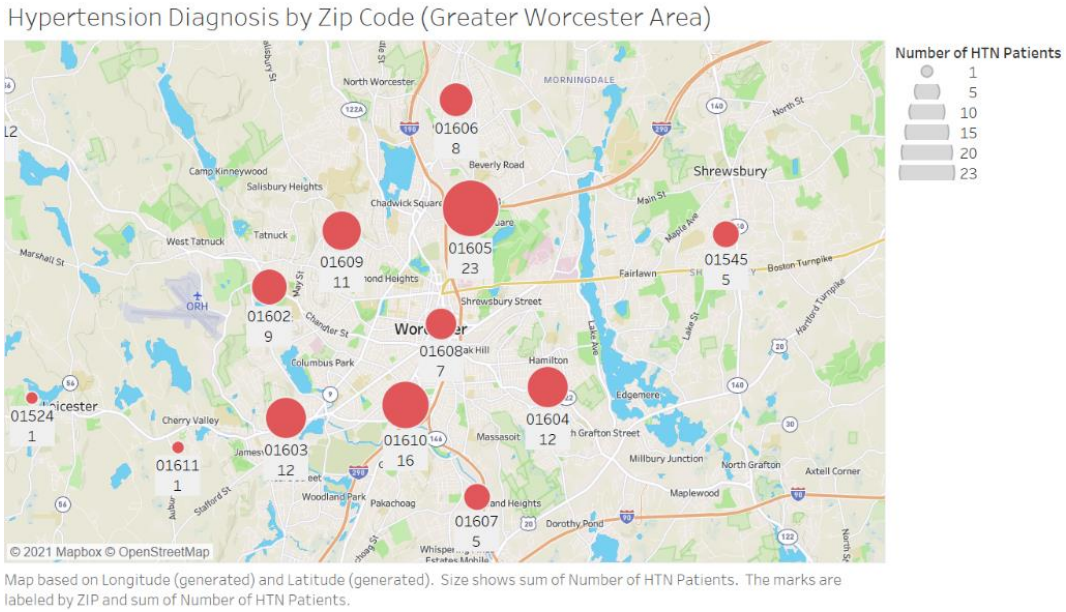


Figure 13. Hypertension Diagnosis by Zip Code (Greater Worcester Area). The hypertension diagnosis of each patient is plotted on the map of the Greater Worcester Area based on the zip code that each patient resides in.

Given the Epworth Clinic's location in Worcester, MA, 01609, the majority of the patients diagnosed with hypertension reside in the Greater Worcester Area. The highest prevalence of hypertension from patients diagnosed at the Epworth Clinic is in 01605, the Northeast side of Worcester. As shown by Figure 13, there is a trend of high hypertension prevalence in the southern areas of Worcester: 01610 (16 – South Worcester), 01604 (12 – SE Worcester), 01603 (12 – SW Worcester).

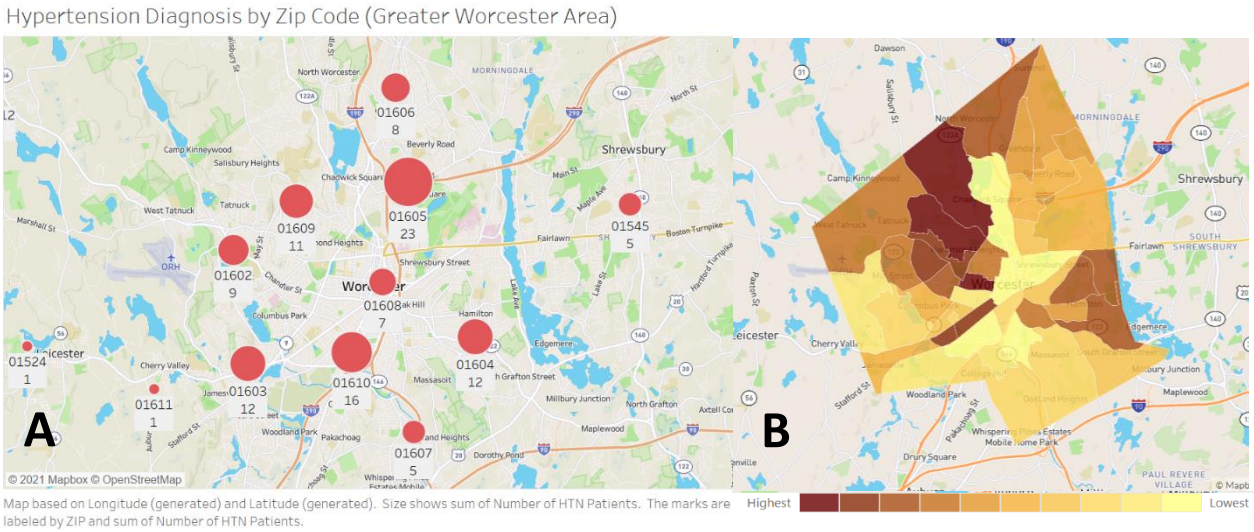


Figure 14. Hypertension Diagnosis by Zip Code (Greater Worcester Area) vs. Greater Worcester Area by Wealth Concentration. Figure 14A depicts the hypertension diagnosis of each patient is plotted on the map of the Greater Worcester Area based on the zip code that each patient resides in. Figure 14B represents the wealth concentration of different communities in the Greater Worcester Area (https://www.neighborhoodscout.com/ma/worcester, 2021).

These hypertension diagnoses are concentrated mainly in the south of Worcester as well as the Northeast side of Worcester. The wealth concentration of different communities in the Greater Worcester Area is shown in Figure 14B. The lower income communities (lower wealth concentration) of the Greater Worcester Area coincide with the map of hypertension diagnoses

of patients attending the Epworth Clinic. Higher prevalence of hypertension diagnosis of patients attending the Epworth Clinic is exhibited in both South Worcester and Northeast Worcester. As illustrated by Figure 14B, the Worcester communities that are considered lower concentrations of wealth are South Worcester and Northeast Worcester, which aligns with the hypertension diagnosis results from the Epworth Clinic.

Work Physicals

Of the 402 work physicals conducted that indicated where each individual lived, 330 were from patients residing in the Greater Worcester Area. The highest prevalence of work physicals conducted are from 01609—the same zip code that the Epworth Clinic is located. The amount of work physicals completed moderately align with the hypertension diagnoses with the concentrations of both work physicals (SW – 29, S – 55, SE – 61, NE – 64) and hypertension diagnoses (SW – 12, S – 16, SE – 12, NE – 23) in south of Worcester as well as the Northeast side of Worcester. However, there is also a concentration of work physicals completed in the Northwest side of Worcester—48 work physicals completed.

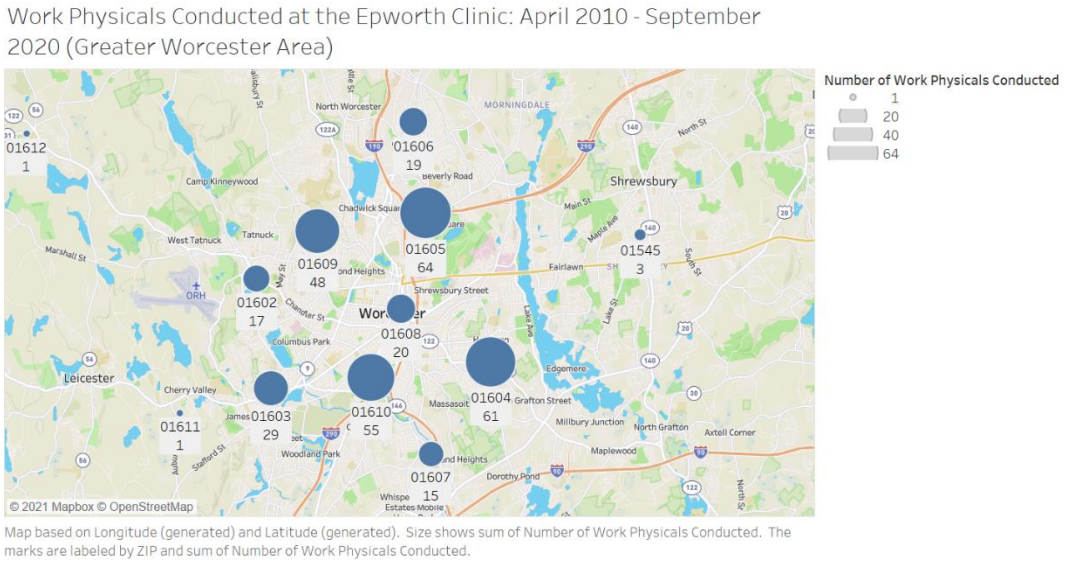


Figure 15. Work Physical's Conducted at the Epworth Clinic: April 2010 – September 2020 (Greater Worcester Area). This figure represents the number of work physicals that were

conducted at the Epworth Clinic between April 2010 and September 2020. This data can be used as a comparison to the hypertension diagnoses data for the Greater Worcester Area.

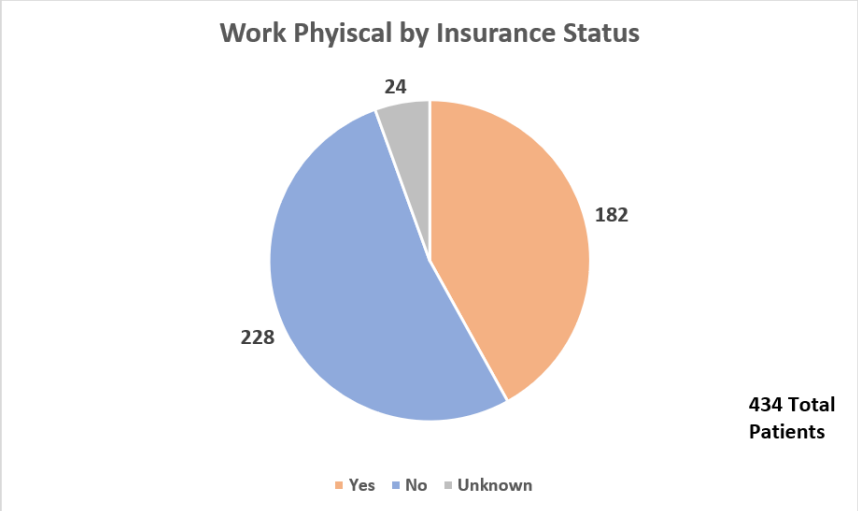


Figure 16. Work Physical by Insurance Status. Figure 14 represents the insurance status of 434 patients that completed a work physical at the Epworth Clinic between April 2010 and September 2020.

Of the 434 total patients that completed a work physical, 228 patients had no insurance (52.5%), 182 indicated that they did have insurance (~41.9%), and 24 patients were unknown for insurance status (5.5%). The prevalence of patients with insurance attending the Epworth Clinic for a work physical (41.9%) is nearly double the prevalence of patients with insurance diagnosed with hypertension. (22.7%).

Table 6. Hypertension by Diagnosis and by Text: Treatment.

Treatment	HTN by Diagnosis	HTN by Text
HTN Medication	92	11
Recommended follow up (2-4 weeks)	21	3
Counseled for ↑ exercise, ↓ salt consumption	5	0
No treatment	36	290
Total →	154	304

Table 6 represents the treatment of clinically diagnosed hypertensive patients and patients that met the criteria for hypertension (by text).

Treatment of Hypertension – Clinical Diagnosis & Textual Diagnosis

Of the 154 patients diagnosed with hypertension, 92 patients received hypertension medication, 21 patients were recommended a follow up in 2-4 weeks to check blood pressure, 5 patients were counseled to increase exercise and decrease salt consumption, and 36 patients received no treatment. Of the 304 patients that met the criteria for hypertension but were not diagnosed, 11 patients received hypertension medication, 3 patients were recommended a follow up in 2-4 weeks to check blood pressure, and 290 patients received no treatment.

Chapter 6: Discussion

In this study, the gender demographics, insurance status, hypertension rates, hypertension severity, incidence of age of hypertensive patients, where patients with hypertension diagnoses resided, where patients that completed a work physical resided, the insurance status of patients that completed a work physical, and the treatment of individuals that were clinical diagnosed and textually diagnosed with hypertension were observed.

The gender demographics results from the patients with hypertension and patients that met the criteria of hypertension but were not diagnosed are equivalent to the gender demographics of the entire Epworth Clinic during the study period. No unusual data is seen and no particular gender demographic disparities are seen between the full Epworth Clinic data and patients diagnosed with hypertension from the Epworth Clinic.

The study found a significant lack of insurance for patients diagnosed with hypertension. Sixty-nine percent (69.5%) of hypertensive patients do not have insurance compared to 59.7% for all patients attending the Epworth Clinic during the study period. This shows about a 10% increase lack of insurance for hypertensive patients. For those that met the criteria for hypertension but were not diagnosed, 61.8% did not have insurance. These results are similar to those of the entire Epworth Clinic. These findings could suggest that patients with hypertension have inadequate access to proper healthcare due to their lack of insurance. Hypertensive patients who lack insurance can be from lower income areas and cannot receive the necessary care to alleviate their hypertension without attending the Epworth Free Clinic. The average age for patients attending the Epworth Clinic during the study period was 35.82 years which was lower than patients clinically diagnosed with hypertension (50.07 years) and patients that met the criteria for hypertension but were not diagnosed with hypertension (44.15 years). This indicates that the population attending the clinic is in lower age groups compared to those that are clinically diagnosed or met the criteria for hypertension. The older groups likely should have insurance given that this group is older in age and would have an employment status and a greater chance of having insurance.

Insurance status frequently coincides with work status. Often insurance is gained through employment. It is typically speculated that these individuals have insurance through work, which leads to better healthcare. For the hypertensive patients, almost 70% do not have

insurance benefits which could indicate why these individuals have high blood pressure that had not been properly addressed previously. Given this speculation, age must be controlled for these variables. The average age for patients attending the Epworth Clinic during the study period was 35.82 years. For patients clinically diagnosed with hypertension this average was 50.07 years and for patients that met the criteria for hypertension but were not diagnosed with hypertension this average was 44.15 years. The average age of the entire Epworth Clinic population is lower compared to the hypertensive groups—the lower age groups should have less insurance compared to that of the older groups which have a greater chance of having an employment status and private insurance. These results are suggestive of hypertensive patients lacking health insurance due to potential unemployment status.

Hypertension was assessed in 1418 total patients attending the Epworth Clinic between April 2010 and September 2020. The prevalence of hypertension was associated with either diagnosis by clinician or by text, which consists of the patient's systolic and/or diastolic blood pressure meeting the criteria of stage 1 hypertension or greater. Of the 1418 total patients, 458 (32.3%) patients met hypertension criteria (clinical or textual diagnosis); 154 (10.9%) patients were clinically diagnosed with hypertension, and 960 did not receive any hypertension diagnosis (67.7%). A total of 458 patients out of 1418 can be considered to have hypertension according to criteria with a prevalence of 32.2%. These results suggest that clinicians are not adequately diagnosing hypertension in individuals attending the Epworth Clinic. With a prevalence among adults of 31.1% (1.39 billion) in 2010 (Mills, 2020), the Epworth Clinic's rate of clinical diagnosis of hypertension is only ~10.9%. When the amount of patients that met the criteria for hypertension but were not diagnosed is added, this prevalence is 32.2% This prevalence of hypertension at the Epworth Clinic aligns well with the prevalence among adults around the world at 31.1%. The apparent lack of diagnosis for patients that met the criteria for hypertension could be a concern for the clinic. This should be considered closely when diagnosing patients in the future.

The findings indicate a high prevalence of stage 2 hypertension. Patients with stage 2 hypertension are at a greater risk of heart attack and stroke and it can be speculated that these individuals live unhealthy lifestyles. For patients diagnosed with hypertension, 133 (88.7%) patients were stage 2. For patients that met the criteria for hypertension but were not diagnosed, 193 (63.5%) patients were stage 2. This is significant, especially for patients that were not clinically diagnosed. These individuals are at severe risks of complications due to their high blood pressure. Diet, physical activity, and other factors play a significant role in mediating blood pressure. While these factors present a crucial role in maintaining a normal blood pressure, other social determinants including stress, living conditions, unemployment, and socioeconomic status contribute to patient's condition of hypertension. Communities with low social support, high social stressors, constrained lifestyles with high levels of tobacco and alcohol use as well as psychosocial mechanisms that influence these health behaviors could also contribute to hypertension in these patients.

Observing the incidence by age of clinically diagnosed hypertension cases, it is apparent that the majority of incidence can be found between the ages of 40-69 years. These results are expected as hypertension affects individuals in this range more frequently. Additionally, the average age for patients clinically diagnosed with hypertension was 50 years while the average age for patients that were met the criteria for hypertension but were not diagnosed was 44 years. This could play a role in determining a diagnosis of hypertension by the clinician. When interviewing a younger individual that meets the criteria for hypertension, a clinician might make different judgements of whether to clinically diagnose the patient—one of these factors can be age.

From the data recorded, hypertensive patients from the Epworth Clinic resided mainly from the Greater Worcester Area. The highest concentration of patients diagnosed with hypertension at the Epworth Clinic is in 01605 (23), the Northeast side of Worcester and the community the clinic is located. There is a trend of high hypertension prevalence in the southern areas of

Worcester: 01610 (16 – South Worcester), 01604 (12 – SE Worcester), 01603 (12 – SW Worcester). When comparing the concentration of hypertensive patients from the Epworth Clinic to the wealth concentration of the areas of Worcester, the results coincide with the areas of lower socioeconomic status including the Northeast (01605), South (01610), Southeast (01604), and Southwest (01603). These four Worcester communities that are considered to have lower wealth concentrations align well and can be associated with the higher hypertension rates seen in these areas from the Epworth Clinic. It must be acknowledged that due to the Epworth Clinic only obtaining data from a specific group of people, the correlation between wealth concentration and hypertension rate is moderate and should be considered more of a trend.

The amount of work physicals completed align with the hypertension diagnoses found in the Southern and Northeast communities of Worcester. Work physicals completed include 29 (7.2%) from the Southwest, 55 (13.7%) from the South, 61 (15.2%) from the Southeast, and 64 (15.9%) from the Northeast. For hypertension diagnoses, 12 (7.8%) were from the Southwest, 16 (10.4%) were from the South, 12 (7.8%) were from the Southeast, and 23 (14.9%) were from the Northeast. This comparison enables a more equitably approach to the analysis of the hypertension data. No specific outliers were found between the number of hypertensive patients and number of patients that completed a work physical in these areas of Worcester.

After investigating the treatment of patients diagnosed with hypertension and patients that met the criteria for hypertension but were not diagnosed, there are discrepancies that are present. For patients clinically diagnosed, the Epworth Clinic did a good job by providing 92 patients with hypertension medication to lower their blood pressure. However, only 21 patients out of 154 were recommended a follow up appointment at the clinic in 2-4 weeks to check blood pressure. Follow up appointments can determine whether the medication or changes to diet or exercise are working to lower the patient's blood pressure. Also, 36 patients received no treatment for their hypertension—although up to the clinician, it should be suggested that

these individuals follow up with the clinic to check blood pressure. For patients that met the criteria for hypertension but were not diagnosed, only 11 patients received hypertension medication and 3 patients were recommended a follow up in 2-4 weeks to check blood pressure. These numbers are significantly low, but expected, as these patients were not clinically diagnosed with hypertension. However, there are 290 patients that received no treatment and met the criteria for hypertension. Clinicians would be suggested to be more mindful in diagnosing patients that meet the criteria for hypertension. It would also be recommended that clinicians suggest follow up appointments for these patients much more frequently. Given that Epworth is a free clinic, patients do not always return for treatment. This adds more emphasis on clinicians advocating heavily for patients that meet the criteria for hypertension to return and get their blood pressure checked.

Chapter 7: Limitations

Limitations to the study include some lack of data, measurements taken from the patients, and the analysis of the data when looking at social determinants of health were shown.

The data gathered from the Epworth consists of a limited number of patients and a moderate sample size of 1418 patients. In terms of hypertension diagnoses, the sample size is 154 patients which is quite low. Individuals that come to the clinic are predominantly from the middle-to-lower socioeconomic classes. The Epworth Clinic only obtains data from individuals attending the clinic which means that this study does not get the full scope of hypertension prevalence in the Greater Worcester Area—it obtains a narrower scope of individuals who go to the Epworth Clinic.

In terms of diagnosing conditions, clinicians diagnose individuals based on their discretion. Although a patient may meet the criteria of hypertension, clinicians use the full picture to understand the patient's condition and make a decision based on that. While some clinicians may feel a diagnosis is necessary, others may focus on the patient's ailment first--the reason they visited the clinic.

White coat syndrome, which is where a patient's blood pressure rises when they see a doctor, can also be considered when patients visit the Epworth Clinic. Individuals who do not go to the doctors often for appointments or attend the clinic to see a doctor frequently may find themselves slightly stressed and out of place. White coat syndrome suggests the possibility that some patients may have higher than normal systolic and diastolic blood pressures due to the effect that seeing a doctor has on some individuals. Clinicians try their best to understand the full picture of a patient's lifestyle. However, it is challenging for some and the full scope of a patient's lifestyle may be unknown. This could include what kind of stressors they encounter, what diet and exercise they participate in, and what substances they take. These factors make it difficult to diagnose hypertension.

Because Epworth is a free clinic, there can be inconsistent or only one data point with regards to blood pressure, making it extremely difficult to diagnose individuals in this population. Follow-up appointments are optional and patients may have other care givers. As such, a particular medical condition may not be treated at a free clinic. Additionally, some patients may not care about their treatment for hypertension. This could include medication adherence, changes to a healthier lifestyle, and going to appointments at the clinic to check up on their hypertension. These factors may not be pertinent to their own lives and result in worse cases of hypertension. Furthermore, it is apparent that many patients attending the clinic come for another reason with a diagnosis of hypertension sometimes being a surprise for some. With this in mind, hypertension control and modification of daily habits may or may not be on the forefront of their mind to alleviate their high blood pressure.

With regards to comorbidity, it is apparent for when a patient is diagnosed with Diabetes Mellitus Type II, focus is put on controlling diabetes first, then hypertension. Numerous other factors come into play include insulin levels, diet, and exercise, which all play pivotal roles in maintaining a healthy lifestyle with diabetes. Hypertension is often subsequent to these other conditions and may result in higher systolic and diastolic blood pressures as well as more difficulty when treating hypertensive cases.

Epworth Clinic does not collect data of the employment status and occupation of individuals, making it hard to discern between patients who are employed and attend the clinic and those who are not. It is often assumed that when an individual does not have insurance, they are unemployed; however, it would be beneficial to gather this data for more thorough analysis of patients with hypertension and patients completing a work physical. Additionally, ethnicities of patients attending the clinic are not collected. For a more comprehensive analysis of hypertension rates, ethnicities could be gathered to see if any trends of hypertensive cases in specific ethnicities were present. It would also be recommended that the Epworth Clinic collect data on the ethnicity of patients. This would help to analyze trends of hypertension and other conditions in terms of ethnicity. Lastly, it would be advocated that diet and exercise data be recorded for patients attending the Epworth Clinic. Diet and exercise data would help understand the lifestyle these patients live and how these factors influence the development of hypertension or other conditions.

Chapter 8: Conclusion

In this study, the prevalence of hypertension and the amount of work physicals completed for patients at the Epworth Clinic between April 2010 and September 2020 was analyzed. The results presented findings of hypertension rates, hypertension severity, and where patients

with clinical hypertension diagnoses, patients that met the criteria for hypertension but were not diagnosed, or patients that completed work physicals resided in the Greater Worcester Area.

The gender demographics of patients with hypertension were similar to that of the entire Epworth Clinic with approximately 50% female, 50% male data. during that time frame. In terms of insurance status, there was a clear lack of insurance for hypertensive patients. These findings presented could suggest that individuals who have insurance through work can lead to better healthcare and healthy living.

It was evident that individuals attending the Epworth Clinic lacked insurance and most were at risk for severe heart attack and stroke with the majority of patients having stage 2 hypertension (clinically and diagnosed by text). Most patients with hypertension resided from the Northeast and Southern parts of Worcester, Massachusetts and these results coincided with the lower socioeconomic status of these areas. While diet, physical activity, lifestyle play a significant role in mediating blood pressure, social determinants including living conditions, stress, unemployment, and socioeconomic status can contribute to a patient's hypertension.

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