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Exploring Chronic Disease Trends among Adults in the USA: A Statistical Analysis with Visual Insights

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Abstract

Chronic diseases are some of the most widespread and expensive health conditions in the United States. This study evaluates the prevalence of chronic diseases in the U.S. from 2011 to 2021, using data from the U.S. CDC, along with visualization and descriptive statistical analysis techniques. Despite increased awareness and advancements in prevention, diagnostics, and treatment, the prevalence of certain chronic diseases, such as obesity, diabetes, and asthma, continues to rise each year. Other conditions, such as kidney disease and heavy alcohol consumption, have shown little to no improvement. Notably, the prevalence of these diseases in each state is not directly correlated with population size but is instead influenced by various factors, including living conditions, unhealthy lifestyle habits, socioeconomic status, and access to healthcare services. For instance, Mississippi has an average obesity rate of 37.6% and an average diabetes rate of 12.8%, both of which are partially influenced by an average tobacco use rate of 23%. In comparison, the U.S. averages for obesity, diabetes, and tobacco use are 30.4%, 9.5%, and 18.3%, respectively.

Keywords

chronic kidney disease, diabetes, obesity, asthma, alcohol consumption, U.S. states

1. Introduction

Chronic diseases like obesity, stroke, kidney disease and diabetes. Many of them can be prevented by addressing four key risk behaviours: heavy alcohol consumption, tobacco use, physical inactivity and poor nutrition. These risk behaviours, and associated chronic conditions, lead to reduced quality of life, premature death, and increased health service use. Effective management of chronic disease requires focusing on lifestyle changes and addressing social determinants of health that impact well-being [1]

Chronic illnesses encompass a wide range of conditions persisting for a year or longer, necessitating continual medical care and often restricting daily activities [2]. They play a significant role in driving US's annual healthcare expenditure of $4.1 trillion. The global economic impact of chronic diseases is projected to reach $47 trillion by 2030.[3]. In U.S. approximately 45% of population lives with at least one chronic disease, and this number continues to rise. Furthermore, one in four adults has two or more chronic conditions, while more than half have at least one. [4] [5].

To address the questions posed, our paper employs a comprehensive approach combining statistical methods [6], [7] and visualization techniques [8], [9]. We analyzed trends in chronic diseases and conditions among adults in the US by examining data over time. This includes a variety of conditions such as alcohol consumption, asthma, diabetes, lung diseases, and kidney conditions. By applying time-series analysis from 2011 to 2021, we identified patterns and shifts in the prevalence of these conditions, providing insights into how their impact has evolved.

To determine regional variations, we employed geographical mapping and state-level comparisons. This analysis enabled us to pinpoint which states exhibit the highest and lowest prevalence of chronic

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diseases and conditions. Through the use of heat maps and bar graphs, we visually represented these disparities, facilitating a clearer understanding of geographic trends and variations. Overall, our solution integrates rigorous statistical analysis with effective visualization techniques to offer a detailed and insightful view of chronic disease trends, regional disparities, and the impact of alcohol consumption on health outcomes.

The remainder of this paper is organized as follows. In Section 2, we review the related work. Section 3 provides an overview of the dataset and the methods used to extract and present information related to chronic diseases. In Section 4, we present and discuss statistical information and visualizations on alcohol consumption, asthma, diabetes, kidney disease, and obstructive pulmonary conditions. Finally, in Section 5, we conclude the paper and offer insights for future research directions.

2. Related Work

Chronic diseases place a significant burden on Ireland's healthcare system, as well as those of other countries, requiring well-coordinated, long-term management strategies [10]. The studies [11], [12] focus on current research into chronic disease management within Ireland. In [11], algorithms are being developed to accurately and securely link patient records across multiple systems by utilizing available data points such as medical history, demographic details and other relevant attributes. This HL7-FHIR-based approach tackles the challenge of integrating data from diverse sources, while ensuring compliance with protecting patient information and privacy regulations. In [12], the authors present a practical method for integrating four different HSE databases in Ireland into a unified system. Specifically, they employed a Global Schema Layer dependent on a Local Schema Layer. These layers can be shared and applied across multiple use cases (subject to governance) or used for individual case studies. The paper demonstrates how 20 queries can extract new insights from the unified dataset—something not achievable with the separate systems. However, neither paper provides clear information about the relationship between chronic diseases over time, especially in a time series context.

Several studies have applied statistical methods to extract information about chronic diseases, such as [13], [14] and [15]. Beasley et al. [13] used statistical methods to address the risk factors and primary prevention strategies for childhood asthma, including: (1) demographic, developmental, and lifestyle factors (family history, genetics, urbanization, and stress); (2) infection-related factors (pertussis); (3) medication use (antibiotics); (4) diet (salt intake); and (5) inhaled exposures (paternal smoking and outdoor air pollution). O'Neill et al. [14] conducted a cross-sectional analysis of The Irish Longitudinal Study on Ageing Wave 1, examining patients with type 2 diabetes. They identified financial barriers in primary care for individuals with uncomplicated diabetes and noted that those ineligible for the Cycle of Care program were more likely to manage their condition without medication. Baral et al. [15] analyzed mortality trends related to chronic lower respiratory diseases, focusing on gender, race, and geographic disparities in the U.S. It highlighted a decline in mortality, especially among men and non-Hispanic White populations, from 1999 to 2020. This paper can help you understand the trends in respiratory-related chronic diseases and their demographic variations. However, each study addresses only a specific chronic disease: Beasley et al. [13] on asthma, O'Neill et al. [14] on diabetes, and Baral et al. [15] on lower respiratory diseases.

In studying chronic diseases, the authors in [16] analyzed four critical conditions prevalent among the elderly: heart disease, diabetes, chronic kidney disease, and hypertension. Unlike our approach, their primary focus was on developing an advanced prediction system. This system utilized neural network models to forecast disease outcomes and was designed for integration into mobile platforms, enhancing accessibility for both patients and healthcare providers. The papers by Bauer et al. [17] and Boersma et al. [5] both investigate chronic disease in the U.S. However, [17] is a survey paper that presents strategies to reduce the burden of chronic diseases, whereas [5] is a statistical report showing that, in 2018, 51.8% of U.S. adults had at least one chronic condition, and 27.2% had multiple chronic conditions

Similar to our study, Raghupathi et al. [18] analyzed the current state of various chronic diseases

across U.S. and its individual states, utilizing data from the Centers for Disease Control and Prevention (CDC) and employing visualization and analytics techniques. Their study provides an in-depth analysis of multiple categories of chronic diseases at the state level. By leveraging visual and descriptive analytics, it sheds light on the relationships between behavioral habits, preventive health measures and chronic conditions. However, unlike our study, their focus was on mental health, gender, ethnicity, and insurance coverage. Additionally, their analysis only covered the years 2012 to 2014.

3. Materials and Methods

3.1. Dataset

The CDC's National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP) plays a crucial role in supporting states in the collection of data on chronic diseases and key health indicators through a variety of surveillance systems. This data is fundamental to the CDC's ability to fully understand the impact of chronic diseases on individuals and communities across the United States. Additionally, it allows for the evaluation of the effectiveness of public health interventions aimed at addressing these significant health challenges. In 2023, the NCCDPHP released the 'U.S. Chronic Disease Indicators (CDI)' dataset, comprising 1,185,676 records [19].

Table 1
Categories and their element examples in chronic diseases

Category	Description
Year	15 years of collection from 2007 to 2021
States	50 states, including Alabama, Alaska, California, Guam, Hawaii, Iowa, Oklahoma, Texas, Virginia, Washington
Topics	17 chronic diseases and indicators, such as Alcohol Consumption, Arthritis, Asthma, Cancer, Cardiovascular Disease, Diabetes, Kidney Disease, Mental Health, Nutrition, Physical Activity, Weight Status, Tobacco
Questions	Each topic includes several questions, such as: number of hospitalizations, hospitalizations among Medicare-eligible persons aged 65 or older, mortality rate (percentage), and the prevalence of the topic among adults aged 18 and above (percentage)
Gender	Includes Overall, Male, Female
Race	Includes 8 categories: Hispanic, White, Black, Asian or Pacific Islander, American Indian or Alaska Native, Asian Multiracial, non-Hispanic, Other
Datasource	Data collected from 18 sources, including American Community Survey, Behavioral Risk Factor Surveillance System, National Vital Statistics System, the U.S. Renal Data System, the State Tobacco Activities Tracking and Evaluation System, and the Youth Risk Behavior Surveillance System.

Table 1 provides an overview of the key categories, and their descriptions and elements related to chronic disease data collection in the United States. It outlines the scope of data gathered over a 15-year period, covering all 50 U.S. states. The table identifies 17 chronic diseases and indicators, such as asthma, diabetes and alcohol consumption, along with specific questions used to collect relevant data. It also accounts for demographic factors, including gender and race. Furthermore, the table highlights the wide range of data sources, from national surveys to state-specific registries, offering a comprehensive view of the multifaceted approach to chronic disease surveillance in the country

3.2. Statistics and visualisation

This study delves into chronic disease characteristics in the U.S., examining how population, behaviors, and other health factors relate to these conditions at the state level and by years. Using visual analytics, primarily descriptive, we analyze data sourced from CDC. Visual analytics merges computer analytics with human insight, enabling real-time analysis and uncovering hidden insights [20, 21]. It transforms data overload into opportunity and fosters transparent processing for analytical discussions. This

interdisciplinary research encompasses data mining, statistics, visualization, and more, highlighting the scientific discipline of integrating diverse areas into visual analytics .

Historically, automatic analysis techniques such as and data mining and statistics developed separately from interaction and visualization methods. A significant advancement in visual analytics was the shift from confirmatory data analysis—where charts were primarily used to present results—to exploratory data analysis, which involves actively interacting with the data [22]. This transition underscored the importance of interactive methods for data exploration and understanding.

Combining statistical methods with visualization techniques offers numerous benefits. Statistical methods are instrumental in extracting and combining information from complex datasets, providing a solid foundation for analysis. They enable the identification of patterns, relationships, and trends that might not be immediately apparent. Visualization techniques then enhance this process by translating these statistical insights into clear, intuitive graphical representations. This synergy allows for a more comprehensive understanding of the data, as visualizations can reveal underlying structures and anomalies that statistics alone might miss.

Moreover, visualization facilitates the exploration of data by allowing users to interact with it dynamically. This interaction enables iterative refinement of hypotheses and models, leading to deeper insights and more informed decision-making. By visualizing statistical results, users can better grasp the implications of their findings and communicate them more effectively to others

4. Extracted Information and Discussion

4.1. Heavy Alcohol Consumption

Heavy alcohol consumption is a risk factor for many chronic diseases and conditions, including diabetes, stroke, and cancer [23]. It is also ranked as the seventh global leading risk factor for death and disability [24]. Figure 1 depicts the prevalence of heavy alcohol consumption among adults (aged ≥ 18) in the United States over an 11-year period from 2011 to 2021. Additionally, it highlight the states with the highest and lowest percentages of heavy alcohol consumption during this time frame. The National Institute on Alcohol Abuse and Alcoholism defines heavy drinking as consuming five or more drinks per day (male) or four or more drinks per day (female) [25].

In Figure 1, states having high alcohol consumption are Montana, Alaska, South Carolina, Maine, Hawaii, Oregon, South Dakota, Illinois, Iowa and Massachusetts. These states share several common factors that may influence high alcohol consumption. Many, such as Montana, Alaska, Maine, and South Dakota, have rural, outdoor-focused lifestyles, where social gatherings often center around activities like hunting, fishing, and community events where alcohol is prevalent. Harsh winters in places like Alaska, Maine, and South Dakota lead to more indoor socializing, often with alcohol. Tourism-heavy states like Hawaii and Oregon see increased alcohol consumption due to visitor indulgence. Urban centers in Illinois and Massachusetts have vibrant nightlife and hospitality industries that contribute to higher alcohol use in these regions.

4.2. Asthma

Asthma is a chronic lung condition that affects individuals of all ages. It is characterized by inflammation and constriction of the muscles around the airways, which makes breathing more difficult for those affected [26]. It is associated with reduced quality of life, increased hospitalisation, and premature death[13]. Asthma onset is multi-factorial, with risk factors including smoking, air pollution, and other airborne pollutants. In adults, obesity has been identified as a risk factor for late onset asthma [27].

As shown in Figure 2, asthma prevalence in the United States increased between 2011 and 2021, mirroring global trends. High asthma diagnosis rates in states such as New Hampshire, Maine, Rhode Island, West Virginia, Vermont, Massachusetts, and Kentucky are driven by multiple factors. Poor air quality due to industrial pollution and coal mining, particularly in West Virginia and Kentucky, exacerbates respiratory conditions. In New England, cold climates increase indoor allergen exposure,

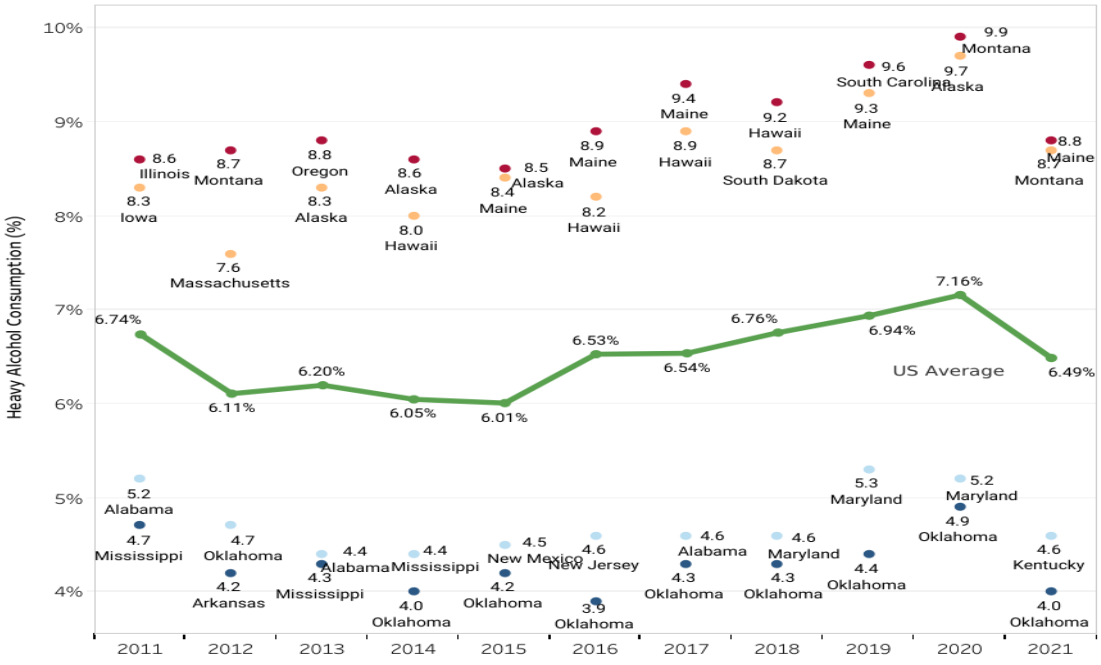


Figure 1: Heavy alcohol consumption over the years

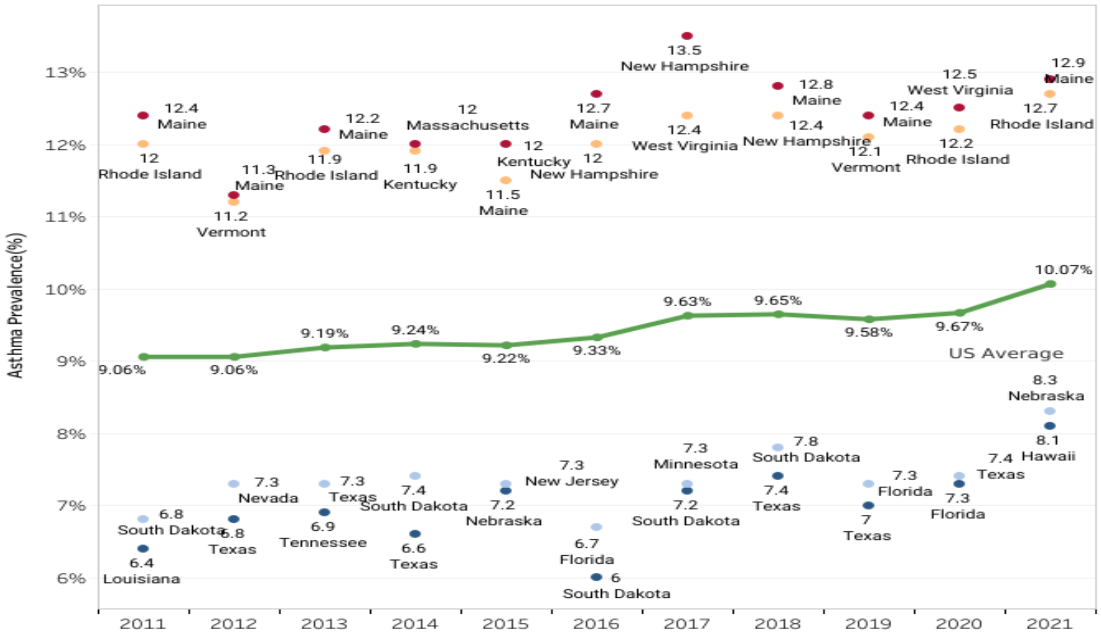


Figure 2: Asthma over the years

such as dust and mold, which can trigger asthma. Additionally, Kentucky and West Virginia's high smoking rates contribute to increased secondhand smoke exposure, while socioeconomic challenges, including limited healthcare access, further elevate asthma prevalence, especially in rural and low-income communities.

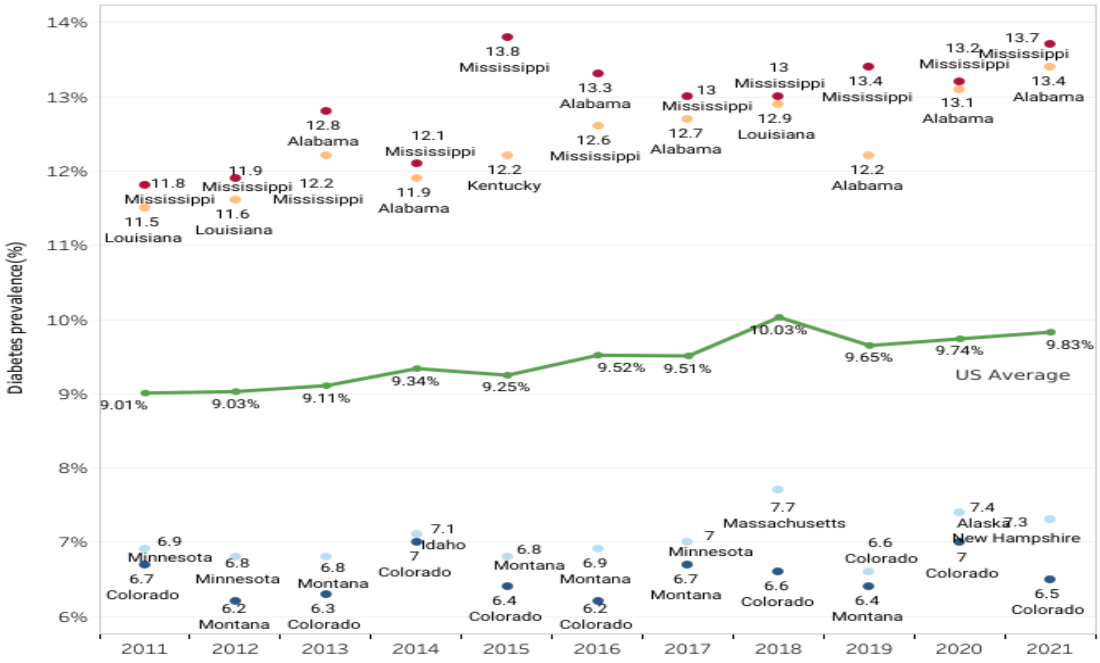


Figure 3: Diabetes over the years

4.3. Diabetes

Diabetes is a chronic metabolic disease characterised by elevated blood glucose levels [28]. There are three main types: type 1, type 2 and gestational. Type 1 typically presents in childhood or adolescence, and it occurs when the body is unable to produce insulin. Type 2 typically presents in adults, accounting for 90% of all diabetes cases globally [29]. Elevated glucose level in people with diabetes leads to microvascular and macrovascular complications, damaging the heart, blood vessels, eyes, kidneys, and nerves [28]. As a result, diabetes is a leading cause of cardiovascular disease, blindness, kidney failure and lower-limb amputation in almost all high-income countries [30].

As shown in Figure 3, prevalence rates of diabetes have risen from 2011 to 2021, with Mississippi consistently exhibiting the highest prevalence. This upward trend aligns with global patterns [31]. The high diabetes rates in states such as Mississippi, Alabama, Louisiana, and Kentucky can be attributed to several interrelated factors. These states often have high obesity rates—a major risk factor for diabetes—due to poor dietary habits and limited access to healthy food options. Socioeconomic challenges, including lower income levels and reduced access to healthcare, further exacerbate the issue by restricting opportunities for preventive care and early diagnosis. Additionally, socioeconomic factors and lifestyle patterns in these states contribute to high levels of physical inactivity. Public health disparities and lower levels of health education also play a role, as individuals may lack access to resources necessary for effective disease management and prevention.

4.4. Chronic Kidney Disease

Chronic Kidney disease (CKD) occurs due to disease pathways that irreversibly alter the function and structure of the kidney. It is typically diagnosed when signs of damage are seen over an at least 3-month duration [32]. Risk factors for onset include diabetes and hypertension. Socio-economic factors also play a role, with those within the lowest socioeconomic quarterly having a 60% higher risk of progressive CKD than do those in the highest quarterly.

Figure 4 illustrates the prevalence of CKD among adults in the US and its states over an 11-year period, from 2011 to 2021. The high CKD rates in states such as Hawaii, North Carolina, Kentucky, Georgia, Mississippi, Oklahoma, Louisiana, West Virginia, Texas, Delaware, Arizona, Nevada, Alabama,

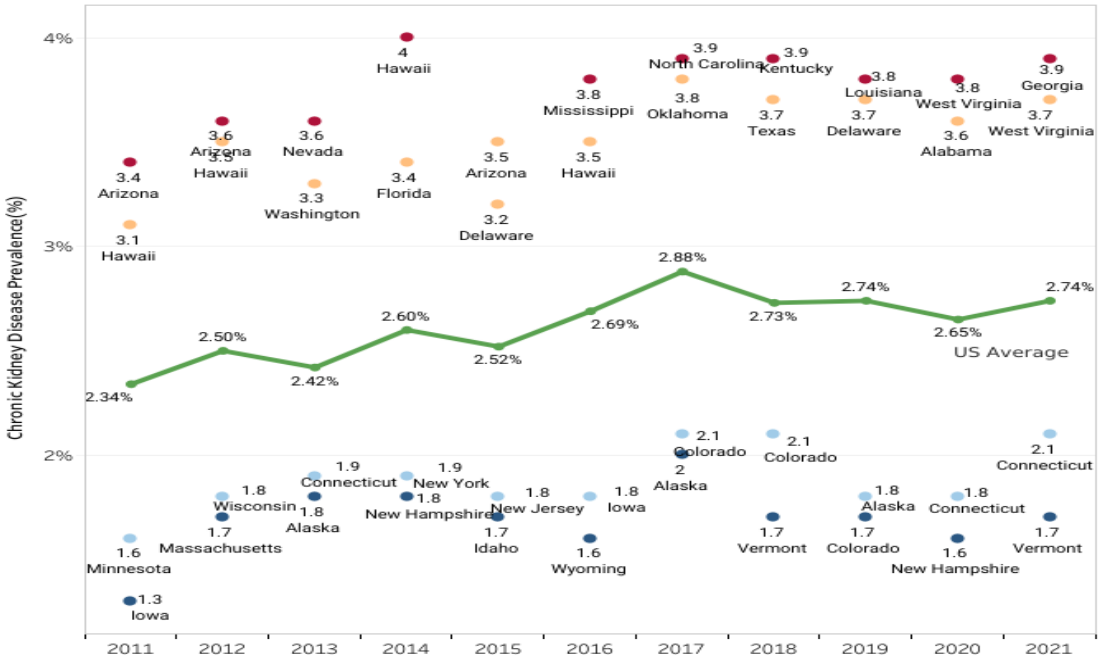


Figure 4: Chronic kidney disease over the years

Florida, and Washington. Many of these states experience high rates of diabetes and hypertension, two leading risk factors for CKD. In particular, Mississippi, Alabama and West Virginia face high levels of diabetes and obesity, exacerbating CKD prevalence. Additionally, states with high temperatures and frequent droughts, such as Arizona and Nevada, can lead to dehydration, further stressing kidney function. Socioeconomic factors, including limited access to healthcare in rural areas like Kentucky and West Virginia, contribute to delayed diagnosis and treatment of CKD. High rates of obesity and poor dietary habits in states like Louisiana and Georgia also increase the risk of developing CKD.

4.5. Chronic Obstructive Pulmonary

Chronic obstructive pulmonary disease (COPD) includes chronic bronchitis and emphysema and is a long-term lung disease preventing airflow to the lungs, resulting in breathing problems [33]. Globally, it is the fourth leading cause of death. The primary risk factor for onset is smoking, however, second-hand smoke during pregnancy or early childhood and air pollution have been identified as risk factors. In addition, those with COPD are also more likely to have other chronic diseases including asthma, heart disease and diabetes.

Figure 5 illustrates that Kentucky consistently has the highest prevalence of COPD, while Hawaii has the lowest. High COPD rates in states like Kentucky, Alabama, Arkansas, and Louisiana are linked to several key factors. These states often have elevated smoking rates, the primary risk factor for COPD, with regions like Kentucky having strong tobacco industries that promote widespread smoking. Additionally, high levels of industrial pollution and poor air quality in some areas contribute to worsening respiratory conditions. Socioeconomic factors, such as lower income and limited access to healthcare in rural areas, can lead to delays in diagnosing and treating COPD. Moreover, regions with high poverty rates may have increased exposure to indoor pollutants, such as secondhand smoke or poor housing conditions, which further deteriorates respiratory health.

4.6. Correlation between Diseases

Figure 6 shows the average percentages of populations in all states affected by chronic diseases or health indicators, such as heavy alcohol consumption, diabetes, kidney disease, and obesity. It also

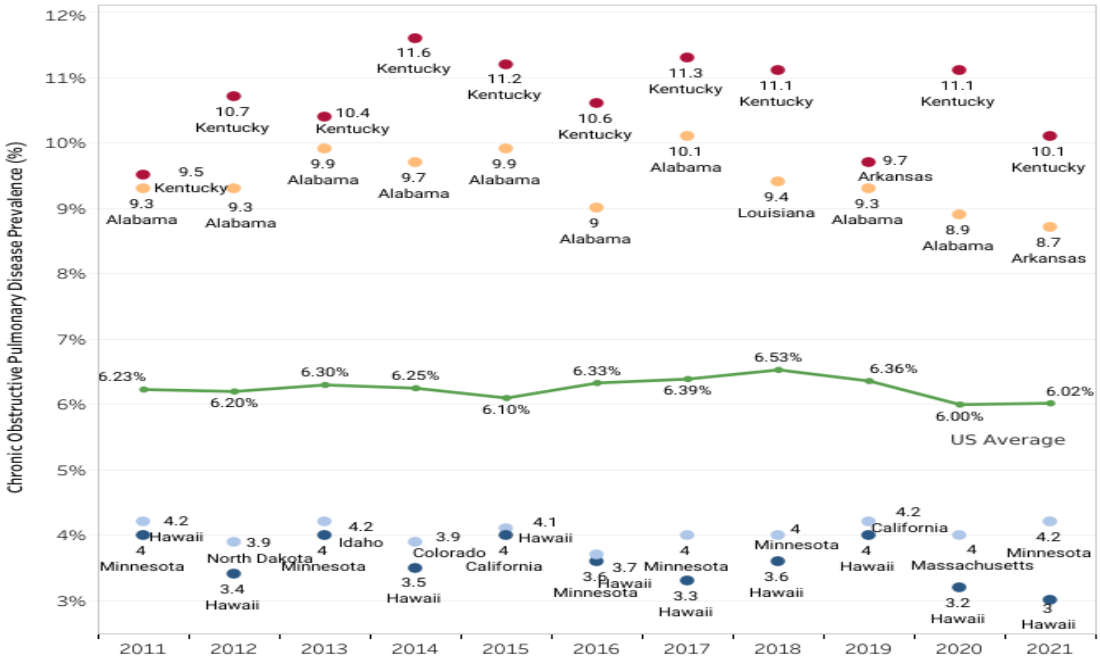


Figure 5: Chronic obstructive pulmonary over the years

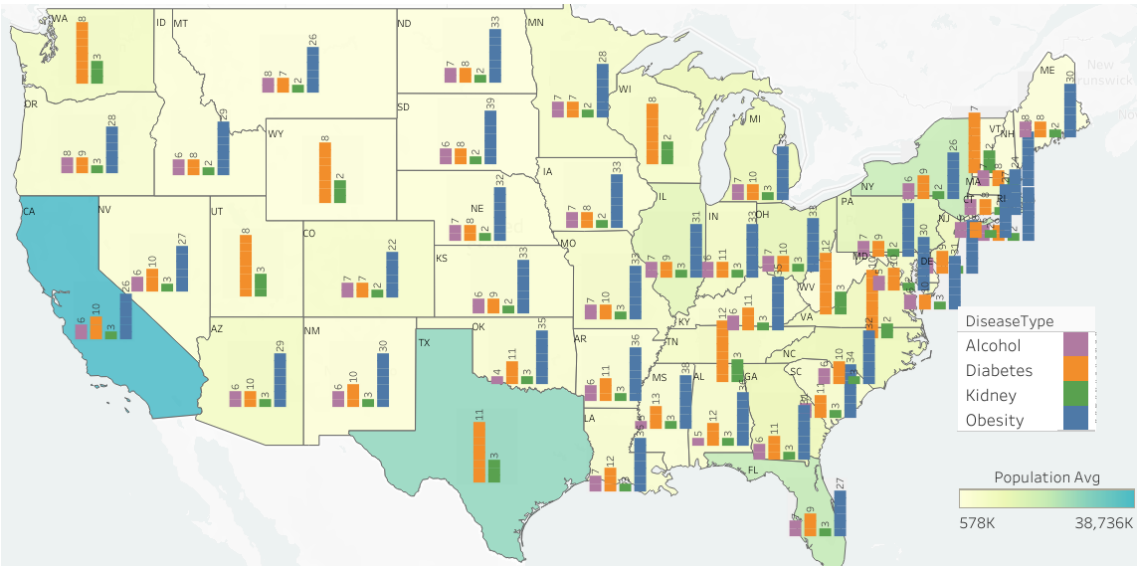


Figure 6: Average percentages of alcohol consumption, diabetes, kidney disease, and obesity across U.S. states

displays the population sizes of each state. Mississippi (MS) has the highest percentage of diabetes at 12.8% and the second-highest obesity rate at 37.6%, with a population of approximately 37 million people. South Carolina (SC) has high percentages of alcohol consumption and diabetes, both at 6.9% and 11.4%, respectively, with a population of around 41.6 million. Arkansas (AR) and Alabama (AL) show elevated rates of kidney disease and obesity, both at 3.1% and 36%, respectively.

Figure 7 highlights trends in various chronic diseases and health behaviors between 2011 and 2021 in U.S. Alcohol consumption fluctuated slightly, peaking at 7.2% in 2020 before decreasing to 6.5% in 2021. Asthma rates saw a gradual increase, from 9.1% in 2011 to 10.1% in 2021. COPD prevalence remained relatively stable, ranging from 6.2% to 6.4% between 2011 and 2020, with a slight decrease to 6.0% in 2021.

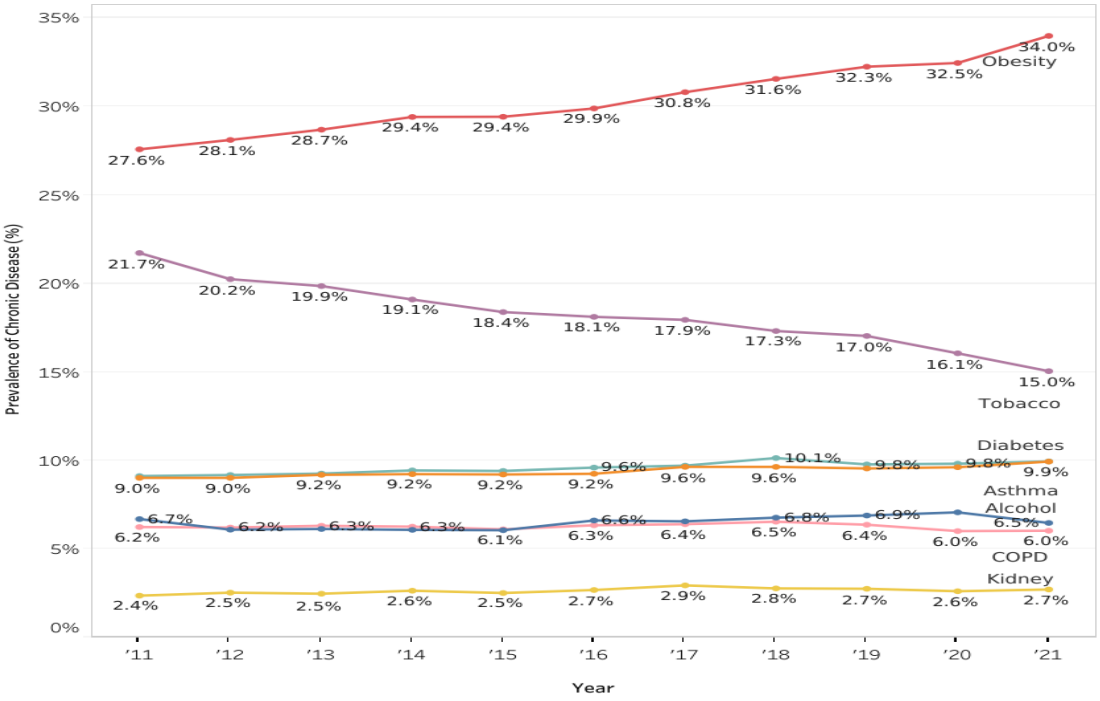


Figure 7: Prevalence of chronic diseases in the US over the years

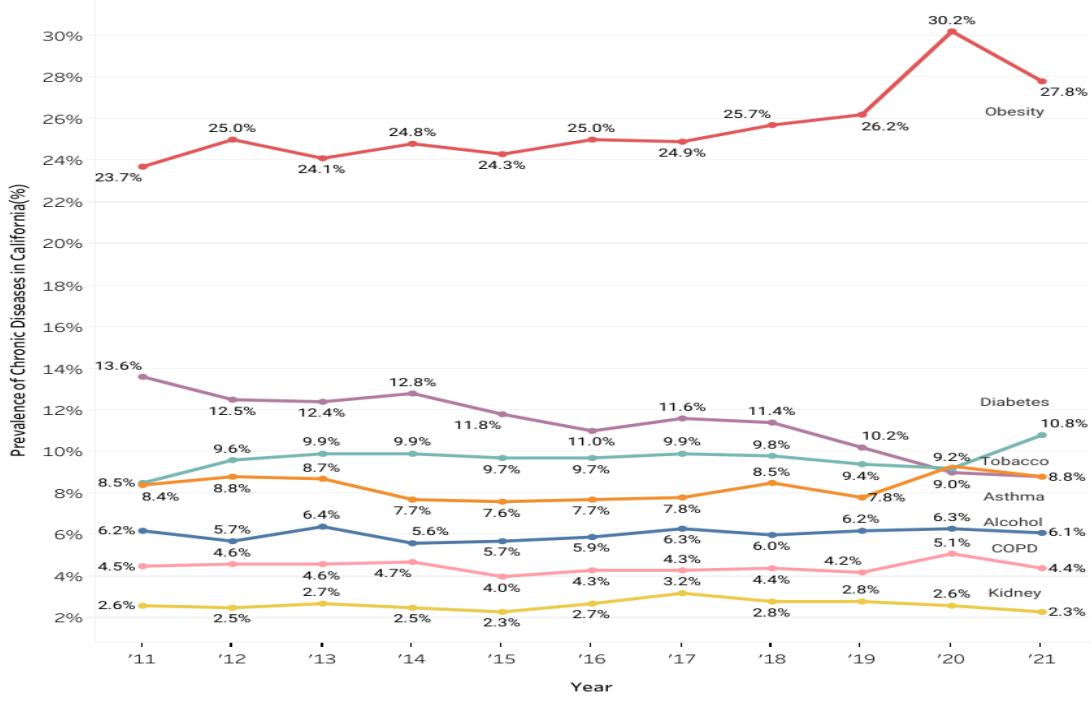


Figure 8: Prevalence of chronic diseases in California over the years

Diabetes rates steadily increased from 9.0% in 2011 to 9.8% in 2021, with a peak of 10.0% in 2018. Kidney disease prevalence remained relatively stable, rising slightly from 2.3% in 2011 to 2.7% in 2021. Obesity, however, showed a dramatic rise, starting from 27.6% in 2011 and reaching 34% in 2021, signifying a critical public health concern. In contrast, tobacco use consistently declined, falling from 21.7% in 2011 to 15.0% in 2021.

Figure 8 presents trends in several health indicators and diseases in California, with an average population of 57.5 million, over the period from 2011 to 2021. Alcohol consumption showed fluctuations, starting at 6.2% in 2011 and peaking at 6.4% in 2013, with variations throughout the years. By 2021, the rate stood at 6.1%, indicating stable but moderate changes over time. Asthma rates remained relatively steady with minor fluctuations, rising from 8.4% in 2011 to a peak of 9.3% in 2020 before slightly decreasing to 8.8% in 2021. COPD prevalence stayed fairly stable, ranging between 4.0% and 5.1%, with the highest rate recorded in 2020 at 5.1%, followed by a slight drop to 4.4% in 2021.

Diabetes rates showed a steady and concerning upward trend, increasing from 8.5% in 2011 to 10.8% in 2021. Kidney disease rates fluctuated between 2.3% and 3.2%, with the highest rate observed in 2017 (3.2%), followed by a decline to 2.3% in 2021. Tobacco use saw a significant decline, decreasing from 13.6% in 2011 to 8.8% in 2021, reflecting a positive public health trend in reducing smoking rates. Obesity showed a notable rise from 23.7% in 2011 to 30.2% in 2020, with a slight decrease to 27.8% in 2021, highlighting concerns over increasing inactivity throughout the decade.

5. Conclusion and Future Work

We utilized the U.S. CDC dataset on chronic diseases covering the years 2011 to 2021 for information extraction and visualization. This dataset enabled us to analyze and present detailed trends for seven major chronic diseases and health indicators: alcohol consumption, asthma, COPD, diabetes, CKD, obesity, and tobacco use. Each indicator was visualized both independently and collectively, providing clear insights into their prevalence across the U.S. and within individual states.

Notably, the prevalence of these diseases in each state is not directly correlated with population size. Instead, the rates are shaped by various factors, including living conditions, unhealthy lifestyle habits, socio-economic status, and access to healthcare services. These factors contribute to the disparities in chronic disease rates observed across different regions of the U.S. Our analysis underscores the need to address not only individual health behaviors but also the broader socio-economic and environmental factors to effectively mitigate the rise of these chronic conditions.

In the future, we plan to use AI algorithms [34] to classify states based on features like economic factors, disease rates, racial demographics, healthcare infrastructure, and lifestyle habits. This will help identify patterns and group states with similar characteristics, offering insights into the factors driving chronic disease rates. We will also apply predictive algorithms to forecast the prevalence of specific chronic diseases in individual states, using historical data and trends to anticipate future public health challenges.

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