

4-25-2023

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**Comparing the Health Care Resource Utilization and Medication Adherence of
People with Epilepsy and People with Diabetes by Insurance Status**

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Author notes

The authors report no conflicts of interest.

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Abstract

Background: Epilepsy is one of the most common neurological diseases worldwide; diabetes is a chronic metabolic disease that affects how the body produces and uses insulin. Prescribed medications are vital for controlling these and other chronic diseases by minimizing severe health issues, which can be affected by insurance type and status. Consequences of non-adherence include uncontrolled blood glucose in people with diabetes and uncontrolled seizures in people with epilepsy. We aimed to compare the healthcare resource utilization and medication adherence of people with epilepsy and people with diabetes by insurance status.

Methods: Data was from the 2021 National Health Interview Survey. The sample (n=3,645) focused on adults 18 and older who self-reported having epilepsy (n=511) or diabetes (n=3,134). Covariates included sex, age, education level, and race. Descriptive and logistic regression analyses were weighted to account for the complex survey design. **Results:** When compared with public insurance and after adjusting for covariates, uninsured people with epilepsy had 5.96 times (95% CI 1.71-20.75) the odds and uninsured people with diabetes had 5.33 times (95% CI 3.11-9.12) the odds of delaying care. The uninsured with epilepsy had 9.63 (95% CI 2.24-41.43) times the odds, and those with diabetes had 3.82 (95% CI 2.16-6.73) times the odds of taking less medication. **Conclusions:** In line with previous research, being uninsured is a barrier to adherence and to healthcare utilization. Uninsured people with epilepsy and people with diabetes had higher odds of non-adherence with prescriptions; they also had higher odds of inconsistent healthcare resource utilization.

Keywords: health care access, health care utilization, medication adherence, socioeconomic status, diabetes, epilepsy, insurance status

Epilepsy is one of the most common neurological diseases worldwide, affecting an estimated 50 million people and 3 million adults in the United States (U.S.) (Centers for Disease Control and Prevention [CDC], 2019; World Health Organization [WHO] et al., 2019). Characterized by recurrent seizure activity in the brain, epilepsy can lead to a loss of consciousness or awareness. Depending on the severity, active epilepsy can lead to a loss of driving privileges, employment opportunities, increased morbidity and mortality, and increased healthcare requirements (CDC, 2019; Lekoubou et al., 2020). Causes vary significantly between age groups but may also be due to an infection, genetics, or head trauma (Epilepsy Foundation, 2013). The cause, frequency, and kind of seizures can help physicians determine the proper epilepsy diagnosis and to prescribe the best anti-seizure medications (ASMs), the primary form of seizure management and prevention for epilepsy. Lack of access to these medications due to cost or insurance status can lead to significant health consequences, such as status epilepticus (a seizure lasting longer than five minutes or seizing consecutively without regaining consciousness) or premature death (WHO et al., 2019).

Diabetes is a chronic metabolic disease affecting how the body produces and uses insulin (CDC, 2022b; WHO, 2022). With type I diabetes, the pancreas creates little or no insulin and is typically diagnosed in children, teenagers, or young adults. Type II diabetes is characterized by the body's resistance to insulin and inability to manage normal blood sugar levels. Gestational diabetes impacts pregnant women without diabetes (CDC, 2022b; WHO, 2022). As of 2014, 422 million individuals had diabetes worldwide, with 37.3 million cases in the U.S. (CDC, 2022b; WHO, 2022). While diabetes management is multi-faceted (lifestyle adjustments and regular healthcare visits), medication is a primary part of the regimen. Individuals with type I diabetes use an inhaler, syringe, pump, or pen for insulin; for those with type II, the treatment is typically oral medication, though insulin may be necessary (CDC, 2021). Unmanaged blood glucose levels can contribute to serious health complications such as eye disease, kidney disease, nerve

damage, high blood pressure, and other cardiovascular complications (National Center for Chronic Disease Prevention and Health Promotion, 2022).

Medication adherence is a critical component of managing these and other chronic diseases. However, non-adherence is common and associated with increased healthcare utilization and poor health outcomes (Zhang et al., 2022). Access to health insurance or affordable care is necessary for individuals to afford the financial cost of treatments or the time cost of appointments. In extreme cases, individuals may ration medication to ensure they are still taking part of their prescription, which is not recommended (Davis et al., 2008).

Literature Review

Expenses for specific diseases are complex; geographic location impacts pricing and availability (Szaflarski et al., 2020). Epilepsy-specific costs have been estimated to range from \$1,022-\$19,749 per person, while patients with diabetes have been estimated to spend \$1,240-\$3,734 per person (Borghs et al., 2020; Dall et al., 2019; Kang et al., 2018). Medical costs can include epilepsy-specific (detecting underlying causes of seizures, initiating ASMs, emergency room visits, electroencephalograms (EEG), and computer tomography scans (CT)) or diabetes-specific measures (insulin or oral medication, diabetes supplies, and courses focused on a healthier diet). Much like other costs, the breakdown of the cost burden to patients by insurance varies significantly by insurance type, patient characteristics (e.g., age, race, comorbidities), and disease severity.

Medication Adherence & Cost of Non-adherence

Adherence to prescribed medication is essential for disease management, but affordability can make this challenging for individuals with epilepsy. Non-adherence to prescribed medications is a vastly significant issue, with an overall economic impact near \$100 billion in the U.S. (Baghikar et al., 2019). The U.S. has the highest per capita prescription drug costs worldwide and had the third-highest annual increase in prescription expenditures in the last decade (Helmerts et al., 2010). As of 2009, ASMs ranked 12th in traditional drug spending,

costing \$25.41 per member per year from the pharmacy perspective (Cardarelli & Smith, 2010). As these costs are only from the pharmacy perspective, it does not include how much insurance may or may not impact patient costs. Research has shown that people with epilepsy are more likely to report an inability to afford their prescribed medication (12.8%), skip medication doses to save money (11.1%), delay refilling prescriptions (13.6%), and take less of their prescribed dose to save money (11.2%) (Tian et al., 2022). Low adherence and nonadherence are associated with higher costs and greater total healthcare utilization in inpatient and emergency room visits due to uncontrolled or breakthrough seizures (Davis et al., 2008; Pisu et al., 2019). Cardarelli & Smith (2010) found that those with untreated epilepsy had a risk of death three times higher than those who followed their prescribed treatment plan.

Among diabetes patients, cost is a known barrier to adherence, even among individuals with health insurance, where non-adherence rates are as high as 15% (Baghikar et al., 2019). Many with diabetes also have comorbidities requiring multiple prescriptions; these regimens often reduce adherence because of the overall cost burden (Kang et al., 2020). Non-adherence for diabetics can lead to undue glycemic burden and difficulty managing other comorbid conditions increasing diabetic complications and mortality (Asche et al., 2011; Kang et al., 2020). Overall, non-adherent rates ranged from 30% to 60% among epilepsy patients and 36% to 93% for diabetes patients of all types and ages (Baghikar et al., 2019; Cardarelli & Smith, 2010).

Health Care Resource Utilization

The subject of healthcare resource utilization in individuals with chronic disease and, more specifically, within epilepsy and diabetes populations has been widely researched. According to research completed by Ivanova et al. (2010), patients with epilepsy utilized healthcare resources at rates significantly higher than controls and had inpatient visits at proportions twice as high. People with epilepsy account for 10 million physician visits and 1 billion days of medication annually; individuals averaged ten physician visits (2 coded for

epilepsy) and more than 30 drug distributions annually (25% for ASMs) (Kurth et al., 2010). Lapses in prescription coverage or follow-up care could lead to a breakthrough seizure, decreasing an individual's quality of life and increasing the risk of injury and death (Bensken et al., 2022). Similarly, when comparing individuals diagnosed with diabetes and those without, diabetes patients had more ambulatory visits, emergency visits, and inpatient days (Dall et al., 2019). In 2017, diabetes patients represented 9.4% of the U.S. population but accounted for 24.8% of hospitalizations; the 30-day readmission rate for those with diabetes was also significantly higher (20.5%) than for the general readmission rate (13.9%) (Lee et al., 2021). People with diabetes who have low medication adherence rates (<80%) have more than double the risk for diabetes-related hospitalization; increasing adherence by only 10% decreases the mean number of visits by 3.6% (Asche et al., 2011). Continuous access to essential medications, well-informed healthcare workers, and uninterrupted insurance coverage is critical for people with epilepsy or diabetes to survive within the U.S. healthcare system.

Insurance Status and Type

Insurance status and type impact care affordability and access to proper care for those with chronic diseases; however, insurance choice is not always black and white. Per Moura et al. (2022), individuals with milder cases of epilepsy are likely overrepresented in employer-based health plan claims, as those with milder cases can continue employment, while this may not be the case for those with more severe cases. Nearly 50% of people with epilepsy with private insurance had an outpatient neurologist visit annually as opposed to only 14% of uninsured patients (Halpern et al., 2011). Comparatively, Mahoney et al. (2020) found that private health insurance was associated with an 18% decrease in the odds of type 2 diabetes. These results suggest that those with no or limited access to healthcare may be unaware of their condition, showing the critical role that health insurance plays in diagnosing diabetes in American adults. Private insurance can be the best option for some; however, high deductible plans with steep out-of-pocket costs can be detrimental to individuals with chronic diseases. Patients in high-

deductible plans risk high out-of-pocket costs, typically facing charges twice as high as those in traditional plans (Callaghan et al., 2019).

Public insurance is widely utilized among those with chronic conditions. Individuals with epilepsy are three times more likely to have Medicaid and less likely to have private insurance (Kobau et al., 2019). Moura et al. (2022) examined similar data and found the numbers were much less distinct, with 37.2% of epilepsy patients having public-funded insurance and 21.4% having private insurance. Among diabetes patients, Lee et al. (2021) found that those with Medicare were less likely to have been prescribed newer medications to lower their glucose levels than those on private plans. Individuals with Medicaid who had a gap in their coverage were more likely to have delays in preventative care and higher hospitalization rates; they were also less likely to have specialist visits (Halpern et al., 2011; Bensken et al., 2022). Overall, people with epilepsy or diabetes who have publicly funded plans are less likely to have the same level of care as those with epilepsy who have private insurance; however, this could be partly because of those who also have a coverage gap and have increased healthcare needs and costs.

Project Rationale and Purpose

The purpose of this project was to determine if the utilization of healthcare resources and medication adherence varies between individuals with epilepsy and individuals with diabetes by insurance status, using data from the 2021 National Health Interview Survey (NHIS). Specifically, we examined the association of insurance status with medication adherence among individuals with epilepsy and individuals with diabetes separately. We also examined the association of insurance status with healthcare utilization among individuals with epilepsy and individuals with diabetes separately. This research aimed to determine if there was a difference in healthcare resource utilization and medication adherence by insurance types, but also between two chronic diseases where a lack of medication adherence can lead to various consequences, from direct health issues to increased costs or increased healthcare resource consumption.

Materials and Methods

Data Source

The publicly accessible 2021 NHIS was utilized for analysis. Data for this project was deidentified by the National Center for Health Statistics (NCHS) before being provided for use. The NHIS is a significant data collection program part of the NCHS. The NCHS is part of the CDC. The National Health Survey Act of 1956 provided a continuous survey and special studies to compile current statistical information on the amount, distribution, and effects of illness and disability in the U.S. and any services for these conditions (National Center for Health Statistics, 2022). The survey began in 1957 and monitors the health of the U.S. population through the collection and analysis of data on various health topics in a cross-sectional household interview format, focusing on residents of households and non-institutional group quarters (National Center for Health Statistics, 2022). Interviews are conducted face-to-face, though follow-ups and additional contact are via phone (National Center for Health Statistics, 2022). Traditional survey methods were used for the 2021 collection period, but 62.8% of surveys were completed via phone (National Center for Health Statistics, 2022). Data collection is completed via clustered sampling and is continuous from January to December. In 2021, the response rate was 50.9% for the adult survey.

Study Design and Study Population

This cross-sectional epidemiological research study focused on the health of individuals living with epilepsy and diabetes (type I and II) in the U.S. in 2021. Inclusion criteria included: adults 18 years or older, self-reported epilepsy or diabetes (type I or II) on the NHIS, individuals who responded that they are on private or public insurance or are uninsured, and those who responded to survey questions on medical adherence and health care utilization. Exclusion criteria included individuals who did not respond to insurance questions, those who did not have epilepsy or diabetes, or individuals with gestational diabetes. The resulting sample size was 3,645 total people with (n=511) epilepsy and (n=3,134) people with diabetes.

Epilepsy and Diabetes Status

Individuals who self-reported having epilepsy responded yes to the question, ‘Have you ever been told by a doctor or other health professional that you have a seizure disorder or epilepsy?’. In contrast, individuals who self-reported having diabetes responded yes to the question, ‘Has a doctor or other health professional ever told you that you had diabetes?’ (National Center for Health Statistics, 2021).

Study Predictor: Insurance Status

We also looked at insurance status, which was the independent variable, by utilizing a variable that compiled multiple insurance-type questions into one health insurance hierarchy question, including private, Medicaid or other public, other coverage, and uninsured options for those under 65 and expanding the public options to include dual eligible, Medicare Advantage, and Medicare only for those over 65. This insurance variable was then recoded into one single variable for insurance that combined all ages, with categories for private, public (Medicaid, Medicare Advantage, Medicare only, and dual eligible), other coverage, or uninsured.

Study Outcomes: Health Care Utilization and Medication Adherence

We looked at several self-reported responses regarding healthcare resource utilization and medication adherence as these were the dependent variables. The questions were ‘About how long has it been since you last saw a doctor or other health professional about your health?’ (recoded to within the past year or 2+ years), ‘During the past 12 months, how many times have you gone to a hospital emergency room about your health?’ (responses were recoded to 0 times, 1 time, 2+ times), ‘During the past 12 months, how many times have you needed medical care but did not get it due to cost?’, ‘During the past 12 months, you took less medication to save money?’ and ‘During the past 12 months, did you need a prescription but not get it?’. Each question regarding the past 12 months had binary yes/no responses.

Covariates

Covariates included sex (female/male), age (18+), education level (high school graduate or less, some college, associate degree, bachelor's degree or higher), and race (Hispanic; non-Hispanic Black; combined category due to small sample sizes (non-Hispanic Asian, American Indian, Alaskan Native, and other races); non-Hispanic White).

Analysis

All analyses were conducted in Statistical Analysis Software (SAS) software, version 9.4, Cary, North Carolina. A descriptive analysis of demographic characteristics, medication adherence, healthcare resource utilization, insurance status, and the number of people who self-reported having epilepsy and diabetes was completed. The survey data were weighted to represent the U.S. population, and thus, the weights included with the NHIS dataset were utilized in all analysis procedures. Both unweighted and weighted descriptive frequencies are reported for overall sample characteristics. Further descriptive analyses include only percentages and 95% confidence intervals (CIs); these stratify the variables by epilepsy and diabetes patients and, further, by insurance status. The NHIS weights were also used in SAS to run both adjusted and unadjusted logistic regression models. Logistic regression models estimated the odds of insurance status (private, other, uninsured) on medication adherence and healthcare resource utilization compared to public insurance. Models were run separately with epilepsy or diabetes as the domain. Models were then adjusted for age, sex, education level, and race. Ninety-five percent CIs that did not contain 1.0 were considered statistically significant.

Results

Epilepsy and Diabetes Descriptives

For the 2021 NHIS sample before stratification by any variables, descriptives can be found in Table 1. Table 2 included descriptive results by those with epilepsy and those with diabetes; 56.6% (95% CI 51.2-61.9) of the epilepsy patients were female, 70.6% (95% CI 66.0-75.2) were non-Hispanic White, and 52.5% (95% CI 47.3-57.7) had a high school education or less. The mean age was 49.5 (95% CI 47.7-51.3). With regard to insurance status, 43.4% (95% CI

38.2-48.6) had private insurance, and 39.8% (95% CI 34.8-44.8) had public insurance; only 5.2% were uninsured (95% CI 2.7-7.6). Comparatively, diabetes patients were more equally divided along gender lines; 51.4% (95% CI 49.2-53.6) were males, and 48.7 (95% CI 46.4-50.8) were females. The mean age was 61.8 (95% CI 61.2-62.5). Most diabetes patients were non-Hispanic White 56.1% (95% CI 53.5-58.8) and 50.6% (95% CI 48.6-52.7) were educated at or less than a high school graduate level. Most individuals held private insurance (47.4%, 95% CI 45.3-49.4) or public insurance (37.0%, 95% CI 35.0-39.0); just 5.8% (95% CI 4.7-6.9) of those with diabetes were uninsured. These results can also be seen in Table 2.

When looking at medication adherence and healthcare resource utilization, 90.4% (95% CI 87.3-93.5) of epilepsy patients and 96.2% (95% CI 95.3-97.1) of diabetes patients saw a doctor within the last year; 64% (95% CI 59.3-69.4) of epilepsy patients and 71.9% (95% CI 69.9-73.8) of diabetes patients did not visit an emergency room (ER) within the last year, while 19.4% (95% CI 15.6-23.2) of epilepsy patients and 11.6% (95% CI 10.2-13.0) of diabetes patients had two or more visits. Additionally, less than 10% of epilepsy (9.9%, 95% CI 7.0-13.0) and diabetes (8.1%, 95% CI 6.9-9.2) patients delayed needed medical care within the last 12 months. For those epilepsy patients who took medication during the previous 12 months, 9.9% (95% CI 6.6-13.3) took less than was prescribed, and 11.8% (95% CI 8.5-15.1) did not fill a prescribed medication at all. Similarly, of those diabetes patients who took medication in the last 12 months, 7.6% (95% CI 6.4-8.7) took less than prescribed, and 10.1% (95% CI 8.8-11.5) did not fill a needed prescription. These results are presented in Appendix I, Table 2.

Descriptives Stratified by Insurance

When stratified by insurance type, the mean age for people with epilepsy ranged from 39.5 (95% CI 35.4-43.7) for those who were uninsured to 55.1 (95% CI 51.71-58.53) for those with other insurance coverage. Females with epilepsy were most likely to have public (64.8%, 95% CI 56.4-73.1) or other insurance coverage (61.8%, 95% CI 47.6-76.0). Males with epilepsy were most likely uninsured (54.3%, 95% CI 29.4-79.3). Among race and ethnicity groups, non-

Hispanic Whites were the most represented across all four insurance types but were most significantly represented in private insurance (80.8%, 95% CI 74.9-86.8). Non-Hispanic Black individuals have the highest coverage in the other coverage insurance group (19.5%, 95% CI 7.8-31.1), and Hispanics and Non-Hispanic Asian, AI/AN, and other races have the highest coverage in the uninsured group (21.1%, 95% CI 1.6-40.6 and 6.8%, 95% CI 0.0-17.4). For those with epilepsy, individuals with a high school diploma or less were the most represented across the insurance groups, though they were most often uninsured (80.3%, 95% CI 64.7-95.9). Individuals with some college education but no degree most often had other coverage (17.9%, 95% CI 7.4-28.5), as did those with an associate's degree (17.6%, 95% CI 7.2-28.1), while those with a bachelor's degree or higher most often had private insurance (28.9% CI 22.3-35.7). These results are presented in Appendix I, Table 3.

Also presented in Appendix I, Table 3, are the descriptives for healthcare resource utilization and medication adherence among those with epilepsy when stratified by insurance. For individuals with private, public, and other coverage, there was a doctor's visit within the past year for over 90% of respondents; for uninsured individuals 48.8% (95% CI 24.2-73.3) visited a doctor in the past year while 51.3% (95% CI 26.7-75.8) had not been to the doctor in 2 or more years. For individuals who visited the ER in the past 12 months, 11.7% (95% CI 6.7-16.7) of those with private insurance visited two or more times in the past 12 months; 23.9% (95% CI 16.8-30.9) for those with public insurance, 31.6% (95% CI 18.7-44.6) for those with other coverage, and 24.0% (95% CI 5.3-42.8) for uninsured individuals. When we look at medication adherence for those with epilepsy, 8.8% (95% CI 3.9-13.8) of those with private insurance took less than the prescribed amount of medication, while 37.6% (95% CI 6.5-69.0) of those uninsured did. Similarly, 11.5% (95% CI 6.5-16.6) of those with private insurance did not get a needed prescription due to cost in the last 12 months, while 28.5% (95% CI 2.1-54.9) of those who were uninsured did the same.

The mean age of people with diabetes, when stratified by insurance, ranged from 49.7 (95% CI 47.8-51.6) for those uninsured to 66.7 (95% CI 65.7-67.9) for those with public insurance. Among diabetes patients, when stratified by insurance, private, public, and uninsured coverages have nearly equal distribution between males and females; within other coverage, 70.4% (95% CI 64.6-76.2) were males, and 29.6% (95% CI 23.8-35.7) were females. Non-Hispanic White individuals are the most prevalent group across private, public, and other coverage insurances, but Hispanic individuals are the most prevalent group among the uninsured (51.4%, 95% CI 41.2-61.5). Diabetes patients with a high school education or less are most prevalent across all four insurance categories, but most significantly in the uninsured group (72.7%, 95% CI 65.2-80.2); those with a bachelor's degree or higher were most likely to have private insurance (29.0%, 95% CI 26.3-31.7) or other coverage (21.1%, 95% CI 16.0-26.3).

Looking at healthcare resource utilization, less than 5% of those with private, public, or other coverages visited a doctor in over two years; 13.3% (95% CI 6.6-20.0) of those uninsured had two or more years between their last doctor visits. For individuals with diabetes with other coverage, 17.24% (95% CI 12.4-22.1) visited the ER 2 or more times in the previous 12 months; 13.2% (95% CI 10.9-15.4) of those with public insurance visited the ER 2 or more times in the last 12 months. 33.2% (95% CI 23.4-43.0) of those who were uninsured delayed necessary medical care, 25.3% (95% CI 15.9-34.6) took less than the prescribed medication, and 18.9% (95% CI 11.8-25.9) did not get a needed prescription at all. Less than 10% of the other insurance types delayed medical care and took less medication, and between 7-12% did not get a needed prescription. These results can be found in Appendix I, Table 4.

Logistic Regression

Epilepsy Models

Logistic regression models were run for each outcome variable, with insurance status as the predictor and public insurance as the reference. Separate models were run for those with epilepsy (Appendix II, Table 5) and those with diabetes (Appendix II, Table 6). Adjusted models

then included covariates of age, sex, race, and education level. Among those who visited the ER in the previous 12 months, individuals with private insurance had 2.47 times the odds (95% CI 1.4-4.5) of having zero visits compared to those with public insurance. Additionally, uninsured individuals had 5.82 times the odds of those with public insurance to delay needed care (95% CI 1.82-18.6). Medication adherence variables showed similar results. When compared to those with public insurance, the uninsured had 7.4 times the odds of taking less medication than prescribed in the last 12 months (95% CI 1.67-32.8) and 4.14 times the odds of needing a prescription but not getting it (95% CI 1.03-16.5).

Diabetes Models

The unadjusted diabetes model also used public insurance as the reference group. Concerning ER visits in the past 12 months, those with private insurance had 1.57 times the odds of those with public insurance to visit the ER zero times (95% CI 1.17-2.10). Uninsured individuals with diabetes had 8.06 times the odds than those with public insurance of delaying needed care over the past 12 months (95% CI 4.76-13.64). Compare this to medication adherence, where individuals without insurance had 6.17 times the odds (95% CI 3.57-10.66) of taking less medication than those with public insurance. Additionally, those without insurance had 2.89 times the odds (95% CI 1.74-4.82) of those with public insurance not getting needed medication in the past 12 months. In the adjusted model for diabetes, the uninsured had 2.40 times the odds of having one ER visit in the last 12 months compared to those with public insurance (95% CI 1.02-5.63).

Discussion

Among chronic diseases such as epilepsy and diabetes, medication adherence and its impacts on healthcare resource utilization have been well-documented. An individual's insurance status and type can further complicate that relationship. Our research indicates significant barriers to adhering to prescribed medications and regarding healthcare resource utilization for uninsured individuals with epilepsy and diabetes, similar to previously completed

research. Although previous studies have determined that the number of uninsured individuals with these chronic diseases is declining, it is clear from our results that being uninsured still plays a significant role in accessing healthcare (Moura et al., 2022).

For individuals with epilepsy, non-adherence can lead to uncontrolled seizures; for individuals with diabetes, non-adherence can lead to diabetes-related complications and a lack of glycemic control. Uninsured individuals with diabetes or epilepsy were the most likely to take less than the prescribed amount of medication and not get a needed prescription. This was true among the unadjusted and adjusted models for both diseases. Previous research has also found that those with epilepsy were likely to report an inability to afford medication, delay refilling prescriptions, or take less prescribed medication (Tian et al., 2022). Additionally, it has been found that non-adherence rates range from 30-60% among epilepsy patients and 36-93% among those with diabetes (Baghikar et al., 2019; Cardarelli & Smith, 2010).

Per Zhang et al. (2022), nonadherent individuals are associated with increased preventable utilization of healthcare resources (ER visits, for example). Our research found that uninsured individuals with diabetes or epilepsy were most likely to delay needed care. In contrast, individuals with private insurance were most likely to have zero visits to the ER, and those with other insurance were most likely to have visited the ER once within the previous 12 months. Prior research on diabetes diagnoses and insurance discussed how individuals who did not have access to insurance have undiagnosed and, therefore, untreated type II diabetes; early detection and management can help to prevent further burden on the healthcare system (Mahoney et al., 2020). Halpern et al. (2011) also found that outpatient physician visits among uninsured epilepsy patients were significantly decreased compared to those with insurance.

The data in this study was representative of the U.S. population due to weights created by the NHIS, and the sample was chosen using clustered sampling, both of which are strengths. Another strength is that the results are comparable to similar studies about medication adherence and healthcare resource utilization. Limitations of this study include both recall and

reporting bias, as this was self-reported data that had questions about the previous 12 months. Other limitations were that the sample was not particularly diverse, as most participants were non-Hispanic White individuals. Additionally, the dataset for epilepsy was considerably smaller than the dataset for diabetes. Furthermore, this is a cross-sectional study, which means that causal inferences cannot be made about the relationships between medication adherence, healthcare resource utilization, and insurance status/type, regardless of if an individual has epilepsy or diabetes. Although the original dataset is publicly available and replication is possible, recruiting a more extensive and diverse group of subjects would be worthwhile to look at sociodemographic differences more effectively. Further, given differences in insurance coverage between states and over time, future studies with longitudinal data could be informative.

Conclusion

This project aimed to compare the medication adherence and healthcare resource utilization of epilepsy and diabetes patients by insurance status, using a public-use dataset from the 2021 NHIS. As medication adherence is essential for individuals with a chronic disease, and this adherence or non-adherence can directly impact how often they utilize healthcare resources, we thought it would be valuable to compare two chronic diseases significantly affected by access to medication and affordable care.

Public Health Implications

The need for increased access to affordable medications and care in the U.S. is clear. Many barriers (a for-profit healthcare system; poverty; a lack of consistent transportation, particularly in rural areas; distrust in medical professionals and science; comorbidities that make taking medication difficult, such as depression; general forgetfulness after years of taking medications for chronic illnesses) exist that cause individuals to avoid care or not take medication, however, increasing access via affordable options is one small step that we can take as a healthcare system. Per Tian et al. (2022), another area of continuous improvement is

through ongoing efforts to modernize data systems and enhance data linkage with electronic health records; this can help to direct further and future public health action by showing where there are gaps in treatment and why (insurance, costs, a specific group, or location, etc.).

Increased healthcare resource utilization and decreased adherence lead to higher societal costs, both in time and money. If an individual has to take time off work due to a health issue exacerbated by non-adherence, other community members, their family, and their work will need to fill in for them while they recover. These issues are increased by the health inequities associated with race and ethnicity and social determinants of health (particularly health care access and quality and economic stability), which should be examined further.

Recommendations

We recommend further research on medication non-adherence for individuals with chronic diseases, such as epilepsy and diabetes, particularly concerning the impact of insurance. Although cost is a barrier to adherence, previous literature shows that other factors, such as poverty and forgetfulness for long-term patients, are also involved (Szflarski et al., 2020). Removing the impact of cost to see how it affects adherence would be beneficial to address ways to improve adherence long-term, studying both the effects of lifestyle and other social determinants of health on adherence to prescriptions.

Additionally, President Biden signed the Inflation Reduction Act in October of 2022, which aims to lower prescription drug costs for Medicare beneficiaries (The White House, 2022). It would be worthwhile to study the impact of this executive order on chronic disease medication adherence, as well as the overall burden of cost to both patients and society. How this law impacts those with public insurance over time (Medicare, specifically) would be valuable to research. Specifically, looking at how this law does or does not change adherence would also be an important metric to note, as well as how this law impacts the use of healthcare resources in general.

Furthermore, Eli Lilly, a pharmaceutical company that sells one of the top insulin drugs, has recently committed to putting a cap on the cost of insulin for uninsured and publicly insured individuals (mainly for seniors) (Mark, 2023). It would be worth researching how these cost-saving measures will impact individuals who do not have insurance and the costs of insulin and other diabetes medications in the long term. As additional pharmaceutical companies have agreed to this price cap by Eli Lilly, this would be an excellent opportunity to push for further decreases in insulin costs and overall decreases across life-saving medications for other chronic diseases for all Americans, particularly among the uninsured.

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Appendix I. Descriptives**Table 1***Unweighted and Weighted Descriptives, 2021 National Health Interview Survey*

	Unweighted	Weighted
Age, Mean (95% CI)	52.63	48.25 (47.92 – 48.59)
Education, n (%)		
High school graduate or less	9,784	95,160,150 (37.83)
Some college, no degree	4,453	38,052,838 (15.13)
Associate degree	3,692	28,821,804 (11.46)
Bachelor's degree or higher	11,401	89,535,575 (35.59)
Insurance status, n (%)		
Private	17,813	156,680,958 (62.17)
Public (Medicaid, Medicare, Dual Eligible)	7,511	57,640,019 (22.87)
Other coverage	1,741	12,615,358 (5.01)
Uninsured	2,313	25,082,913 (9.95)
Race, n (%)		
Hispanic	4,081	42,840,843 (16.92)
Non-Hispanic Asian, AI/AN, + other races	2,583	21,802,944 (8.61)
Non-Hispanic Black	3,160	29,588,702 (11.69)
Non-Hispanic White	19,658	158,925,265 (62.78)
Sex, n (%)		
Female	16,102	130,863,314 (51.70)
Male	13,378	122,278,034 (48.30)
Diabetes, n (%)		
Yes	3,134	24,351,156 (9.63)
No	26,318	228,605,746 (90.37)
Epilepsy, n (%)		
Yes	511	4,527,470 (1.79)
No	28,953	248,495,115 (98.21)
# of ER visits in last 12 months, n (%)		
0 times	23,873	205,837,300 (81.96)
1 time	3,492	29,733,578 (11.84)
2+ times	1,874	11,576,795 (6.20)
How long since last doctor visit?, n (%)		
Within past year	24,609	207,298,186 (82.63)
2+ years	4,621	43,590,815 (17.37)
Delayed medical care, n (%)		
Yes	2,010	17,919,100 (7.13)
No	27,241	233,257,082 (92.87)
Did not get needed prescription, n (%)		
Yes	1,356	11,853,220 (4.72)
No	27,858	239,075,405 (95.28)
Took less medication, n (%)		
Yes	867	7,551,468 (4.64)
No	19,377	155,053,149 (95.36)

Table 2*Weighted Descriptives Stratified by Diabetes and Epilepsy Patients, 2021 National Health Interview Survey*

	Disease			
	Epilepsy		Diabetes	
	%	(95% CI)	%	(95% CI)
Age, Mean	49.49	(47.65-51.34)	61.84	(61.18-62.51)
Education				
High school graduate or less	52.53	(47.32-57.74)	50.64	(48.57-52.72)
Some college, no degree	14.45	(10.62-18.27)	14.27	(12.97-15.57)
Associate degree	13.06	(9.66-16.46)	12.83	(11.54-14.12)
Bachelor's degree or higher	19.96	(16.04-23.89)	22.25	(20.65-23.86)
Insurance status				
Private	43.36	(38.17-48.55)	47.38	(45.34-49.43)
Public (Medicaid, Medicare, Dual Eligible)	39.81	(34.80-44.82)	37.03	(35.02-39.04)
Other coverage	11.68	(8.69-14.67)	9.79	(8.64-10.94)
Uninsured	5.15	(2.72-7.58)	5.80	(4.70-6.90)
Race				
Hispanic	12.55	(8.88-16.22)	18.65	(16.38-20.92)
Non-Hispanic Asian, AI/AN, + other races	4.49	(2.61-6.38)	8.95	(7.41-10.48)
Non-Hispanic Black	12.35	(9.05-15.65)	16.28	(14.39-18.17)
Non-Hispanic White	70.60	(66.04-75.17)	56.12	(53.47-58.77)
Sex				
Female	56.56	(51.22-61.89)	48.56	(46.36-50.76)
Male	43.44	(38.11-48.78)	51.44	(49.24-53.64)
# of ER visits in last 12 months				
0 times	64.34	(59.32-69.36)	71.87	(69.94-73.81)
1 time	16.26	(12.23-20.29)	16.54	(15.00-18.09)
2+ times	19.40	(15.58-23.23)	11.58	(10.20-12.97)
Delayed medical care				
Yes	9.98	(7.00-12.97)	8.08	(6.93-9.22)
No	90.01	(87.03-93.00)	91.92	(90.78-93.07)
How long since last doctor visit?				
Within past year	90.40	(87.28-93.53)	96.23	(95.33-97.13)
2+ years	9.60	(6.47-12.72)	3.77	(2.87-4.67)
Did not get needed prescription				
Yes	11.83	(8.52-15.14)	10.12	(8.79-11.45)
No	88.17	(84.86-91.48)	89.88	(88.55-91.21)
Took less medication				
Yes	9.95	(6.64-13.27)	7.56	(6.41-8.71)
No	90.05	(86.73-93.36)	92.44	(91.29-93.59)

Table 3*Weighted Descriptives of Epilepsy Patients by Insurance Status, 2021 National Health Interview Survey*

	Insurance Status			
	Private	Public	Other coverage	Uninsured
Age, Mean (95% CI)	48.50 (45.97-51.03)	50.22 (46.75-53.68)	55.12 (51.71-58.53)	39.54 (35.36-43.72)
Education, % (95% CI)				
High school graduate or less	41.64 (34.27-49.01)	62.74 (54.58-70.91)	45.65 (31.16-60.24)	80.28 (64.69-95.88)
Some college, no degree	13.59 (8.26-18.92)	15.52 (8.94-22.11)	17.90 (7.35-28.45)	5.87 (0.00-14.12)
Associate degree	15.80 (9.95-21.65)	9.16 (4.84-13.48)	17.61 (7.15-28.06)	10.17 (0.00-21.47)
Bachelor's degree or higher	28.97 (22.27-35.67)	12.57 (7.96-17.19)	18.84 (7.31-30.37)	3.68 (0.00-10.87)
Race, % (95% CI)				
Hispanic	7.31 (3.21-11.41)	17.85 (11.36-24.35)	10.19 (0.13-20.24)	21.10 (1.57-40.62)
Non-Hispanic Asian, AI/AN, + other races	5.27 (2.10-8.44)	3.87 (1.27-6.47)	2.71 (0.00-6.87)	6.81 (0.00-17.35)
Non-Hispanic Black	6.59 (3.09-10.09)	16.60 (10.63-22.56)	19.46 (7.81-31.11)	11.95 (0.00-27.94)
Non-Hispanic White	80.83 (74.86-86.81)	61.68 (53.74-69.62)	67.66 (53.86-81.43)	60.14 (36.86-83.41)
Sex, % (95% CI)				
Female	55.27 (47.82-62.71)	64.75 (56.40-73.11)	38.21 (24.03-52.38)	45.66 (20.74-70.58)
Male	44.73 (37.29-52.18)	35.25 (26.89-43.60)	61.79 (47.62-75.97)	54.34 (29.42-79.26)
# of ER visits in last 12 months, % (95% CI)				
0 times	70.37 (62.96-77.78)	58.23 (50.25-66.22)	61.41 (47.88-74.93)	66.95 (45.78-88.12)
1 time	17.94 (11.99-23.89)	17.91 (11.32-24.50)	6.96 (1.87-12.05)	9.02 (0.00-20.33)
2+ times	11.69 (6.72-16.66)	23.86 (16.84-30.87)	31.63 (18.67-44.59)	24.04 (5.28-42.79)
Delayed medical care, % (95% CI)				
Yes	11.08 (6.44-15.73)	6.36 (2.56-10.15)	10.06 (2.05-18.16)	28.33 (8.33-48.34)
No	88.92 (84.27-93.56)	93.64 (89.85-97.44)	89.95 (81.94-97.95)	71.67 (51.66-91.67)
How long since last doctor visit?, % (95% CI)				
Within past year	93.18 (89.24-97.11)	92.26 (88.32-96.21)	92.45 (84.77-100.00)	48.75 (24.22-73.28)
2+ years	6.82 (2.89-10.76)	7.74 (3.79-11.68)	7.55 (0.00-15.23)	51.25 (26.72-75.78)
Did not get needed prescription, % (95% CI)				
Yes	11.51 (6.45-16.58)	8.80 (4.64-12.96)	16.11 (6.35-25.88)	28.52 (2.10-54.93)
No	88.49 (83.42-93.55)	91.20 (87.04-95.36)	83.89 (74.12-93.65)	71.48 (45.07-97.90)
Took less medication, % (95% CI)				
Yes	8.83 (3.88-13.79)	7.52 (3.46-11.58)	12.41 (3.67-21.15)	37.59 (6.46-69.03)
No	91.17 (86.21-96.12)	92.48 (88.42-96.54)	87.59 (78.85-96.33)	62.41 (30.97-93.84)

Table 4*Weighted Descriptives of Diabetes Patients by Insurance Status, 2021 National Health Interview Survey*

	Insurance Status			
	Private	Public	Other coverage	Uninsured
Age, Mean (95% CI)	58.66 (57.80-59.52)	66.77 (65.65-67.90)	65.54 (63.85-67.23)	49.70 (47.81-51.58)
Education, % (95% CI)				
High school graduate or less	42.36 (39.40-45.32)	59.12 (55.88-62.37)	44.72 (37.95-51.50)	72.68 (65.19-80.16)
Some college, no degree	14.52 (12.56-16.47)	14.19 (12.07-16.32)	15.71 (10.92-20.51)	11.00 (5.69-16.31)
Associate degree	14.13 (12.20-16.06)	10.51 (8.52-12.50)	18.44 (13.68-23.20)	7.93 (3.28-12.59)
Bachelor's degree or higher	28.99 (26.28-31.70)	16.17 (13.70-18.64)	21.12 (15.95-26.29)	8.39 (3.45-13.33)
Race, % (95% CI)				
Hispanic	15.11 (12.42-17.81)	19.85 (16.58-23.13)	12.40 (7.09-17.70)	51.35 (41.17-61.53)
Non-Hispanic Asian, AIAN, + other races	8.74 (6.80-10.67)	10.01 (7.39-12.62)	6.44 (3.36-9.52)	8.61 (3.13-14.09)
Non-Hispanic Black	13.86 (11.61-16.10)	18.50 (15.51-21.50)	19.80 (14.82-24.79)	16.08 (8.90-23.26)
Non-Hispanic White	62.29 (59.01-65.57)	51.64 (47.77-55.50)	61.36 (54.64-68.08)	23.95 (15.89-32.02)
Sex, % (95% CI)				
Female	44.62 (41.65-47.59)	58.02 (54.54-61.51)	29.57 (23.78-35.36)	51.90 (42.39-61.41)
Male	55.38 (52.41-58.35)	41.98 (38.49-45.46)	70.43 (64.64-76.23)	48.10 (38.59-57.61)
# of ER visits in last 12 months, % (95% CI)				
0 times	77.33 (74.74-79.93)	68.49 (65.28-71.69)	61.16 (54.77-67.55)	67.53 (58.23-76.82)
1 time	13.17 (11.11-15.23)	18.34 (15.81-20.88)	21.60 (16.14-27.06)	24.56 (15.80-33.33)
2+ times	9.50 (7.61-11.38)	13.17 (10.90-15.44)	17.24 (12.42-22.06)	7.91 (2.89-12.93)
Delayed medical care, % (95% CI)				
Yes	6.96 (5.47-8.45)	5.81 (4.22-7.40)	7.27 (3.73-10.82)	33.19 (23.43-42.96)
No	93.04 (91.55-94.53)	94.19 (92.60-95.78)	92.73 (89.18-96.27)	66.81 (57.04-76.57)
How long since last doctor visit?, % (95% CI)				
Within past year	96.71 (95.63-97.79)	96.41 (94.85-97.97)	98.79 (97.73-99.85)	86.70 (79.97-93.43)
2+ years	3.29 (2.22-4.37)	3.59 (2.03-5.15)	1.21 (0.15-2.27)	13.30 (6.57-20.03)
Did not get needed prescription, % (95% CI)				
Yes	10.99 (8.84-13.15)	7.44 (5.84-9.03)	10.68 (6.63-14.73)	18.86 (11.79-25.93)
No	89.01 (86.85-91.16)	92.56 (90.97-94.16)	89.32 (85.27-93.37)	81.14 (74.07-88.21)
Took less medication, % (95% CI)				
Yes	7.40 (5.73-9.07)	5.19 (3.86-6.52)	8.28 (4.52-12.03)	25.26 (15.91-34.61)
No	92.60 (90.93-94.27)	94.81 (93.48-96.14)	91.72 (87.97-95.48)	74.74 (65.39-84.09)

Appendix II. Weighted Logistic Regression Results**Table 5**
Weighted Odds Ratios and 95% Confidence Intervals for the Association between Medication Adherence, Healthcare Resource Utilization, and Insurance Status in Individuals with Epilepsy

	Unadjusted						Adjusted ^a					
	Last doctor visit	# of ER visits		Delayed care	Took less medication	Did not get a needed prescription	Last doctor visit	# of ER visits		Delayed care	Took less medication	Did not get a needed prescription
		0	1					0	1			
Insurance (ref= Public)												
Private	1.12 (0.51-2.60)	2.47 (1.35-4.49)	2.04 (0.96-4.35)	1.80 (0.85-3.90)	1.19 (0.54-2.65)	1.35 (0.67-2.72)	1.22 (0.50-2.94)	2.28 (1.21-4.32)	1.94 (0.89-4.21)	1.90 (0.83-4.38)	1.41 (0.55-3.65)	1.89 (0.87-4.11)
Other	1.03 (0.31-3.43)	0.80 (0.37-1.69)	0.29 (0.11-0.80)	1.6 (0.59-4.62)	1.74 (0.68-4.47)	1.99 (0.85-4.68)	0.90 (0.25-3.32)	0.90 (0.41-1.99)	0.33 (0.12-0.92)	2.09 (0.68-6.46)	2.16 (0.66-7.14)	3.04 (1.13-8.20)
Uninsured	0.08 (0.03-0.25)	1.14 (0.37-3.53)	0.50 (0.10-2.57)	5.82 (1.82-18.61)	7.40 (1.67-32.85)	4.14 (1.03-16.54)	0.10 (0.03-0.31)	1.19 (0.35-4.04)	0.56 (0.10-3.11)	5.96 (1.71-20.75)	9.63 (2.24-41.43)	4.59 (1.19-17.73)

^aAdjusted for age, sex, race, and education level^bReferences for variables: Last doctor visit: within past year (1); # of ER visits: 2+ visits (3); Delayed care: Yes (1); Took less medication: Yes (1); Did not get needed prescription: Yes(1)

Table 6
Weighted Odds Ratios and 95% Confidence Intervals for the Association between Medication Adherence, Healthcare Resource Utilization, and Insurance Status in Individuals with Diabetes

	Unadjusted						Adjusted ^a					
	Last doctor visit	# of ER visits		Delayed care	Took less medication	Did not get a needed prescription	Last doctor visit	# of ER visits		Delayed care	Took less medication	Did not get a needed prescription
		0	1					0	1			
Insurance (ref= Public)												
Private	1.09 (0.63-1.92)	1.57 (1.17-2.10)	0.99 (0.71-1.39)	1.21 (0.84-1.76)	1.46 (1.01-2.10)	1.54 (1.12-2.11)	1.27 (0.73-2.21)	1.59 (1.15-2.20)	1.02 (0.71-1.46)	1.00 (0.67-1.49)	1.14 (0.78-1.70)	1.33 (0.95-1.84)
Other	3.04 (1.12-8.27)	0.68 (0.46-1.01)	0.90 (0.56-1.44)	1.27 (0.69-2.33)	1.65 (0.94-2.89)	1.49 (0.92-2.41)	3.27 (1.18-9.04)	0.63 (0.41-0.95)	0.87 (0.54-1.42)	1.37 (0.73-2.56)	1.83 (1.02-3.27)	1.71 (1.05-3.27)
Uninsured	0.24 (0.12-0.50)	1.64 (0.81-3.34)	2.23 (1.00-4.98)	8.06 (4.76-13.64)	6.17 (3.57-10.66)	2.89 (1.74-4.82)	0.30 (0.15-0.61)	1.99 (0.93-4.23)	2.40 (1.02-5.63)	5.33 (3.11-9.12)	3.82 (2.16-6.73)	1.65 (0.95-2.88)

^aAdjusted for age, sex, race, and education level

^bReferences for variables: Last doctor visit: within past year (1); # of ER visits: 2+ visits (3); Delayed care: Yes (1); Took less medication: Yes (1); Did not get needed prescription: Yes(1)