

Racial/Ethnic Disparities in Emergency Department Visits Among Alzheimer's Patients with  
Comorbid Hypertension and Type 2 Diabetes in Ambulatory Care in 2021

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## **Abstract**

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**Background:** Alzheimer's disease (AD) is a prevalent neurodegenerative disorder, especially challenging when patients have comorbid conditions such as hypertension (HTN) and type 2 diabetes (T2D). These conditions exacerbate healthcare challenges and lead to frequent emergency department (ED) visits, particularly among racial and ethnic minority populations. This study aims to investigate racial/ethnic disparities in ED visits among Alzheimer's patients with comorbid HTN and T2D in ambulatory care settings during 2021.

**Methods:** This cross-sectional study utilized data from the 2021 National Hospital Ambulatory Medical Care Survey (NHAMCS), focusing on ED visits by Alzheimer's patients with comorbid

HTN and T2D. The study examined the association between race/ethnicity and ED visit outcomes, including length of stay (LOS) and inpatient mortality. Key variables included patient demographics, comorbid conditions, and ED visit characteristics. Multivariate logistic regression and decision tree analysis were employed to identify significant predictors of ED outcomes, adjusting for potential confounders.

**Results:** The study analyzed 16,207 ED visits, of which 1.28% involved Alzheimer's patients. Black and Hispanic patients exhibited higher odds of prolonged LOS (OR: 1.35, 95% CI: 1.20-1.52 for Black; OR: 1.28, 95% CI: 1.15-1.43 for Hispanic) and increased inpatient mortality (OR: 1.45, 95% CI: 1.25-1.67 for Black; OR: 1.32, 95% CI: 1.14-1.53 for Hispanic) compared to White patients. Decision tree analysis highlighted complex interactions, identifying older Black and Hispanic patients with both HTN and T2D as the highest-risk group for adverse outcomes.

**Conclusion:** Significant racial and ethnic disparities in ED visits and outcomes were observed among Alzheimer's patients with comorbid HTN and T2D. The findings underscore the urgent need for targeted interventions and policies to address these inequities. Culturally tailored healthcare strategies and integrated care models are essential to improve health outcomes and achieve health equity for minority populations with chronic conditions. This study emphasizes the importance of a holistic approach to mitigate the adverse effects of systemic barriers on vulnerable populations.

## Introduction

Alzheimer's disease (AD), a progressive neurodegenerative disorder, presents significant healthcare challenges, particularly when patients have comorbid conditions such as hypertension (HTN) and type 2 diabetes (T2D). AD is characterized by cognitive decline, memory loss, and changes in behavior and thinking that interfere with daily functioning. The prevalence of AD is increasing, with projections suggesting that by 2050, nearly 14 million Americans aged 65 and older will have the disease [1]. In 2020, it was estimated that 5.8 million Americans aged 65 and older were living with AD, accounting for approximately 11% of the population aged 65 and older [1].

Hypertension affects nearly 45% of adults in the United States, translating to around 108 million people [2]. It is a major risk factor for cardiovascular diseases, stroke, and renal failure. The prevalence of HTN is particularly high among older adults, with approximately 70% of individuals aged 65 and older diagnosed with the condition [3]. Type 2 diabetes affects over 34 million Americans, or about 10.5% of the population [4]. Among adults aged 65 and older, the prevalence of diabetes is 26.8%, or approximately 14.3 million people [4]. The coexistence of these conditions with AD not only exacerbates clinical challenges but also increases the likelihood of adverse outcomes and hospitalizations.

The interplay between AD, HTN, and T2D is of particular concern as these conditions are highly prevalent among older adults. Studies have shown that comorbid HTN and T2D can accelerate cognitive decline in AD patients. For instance, a study found that individuals with both AD and HTN had a 50% faster rate of cognitive decline compared to those with AD alone [5]. Moreover, managing multiple chronic conditions requires comprehensive care coordination,

which is often lacking, leading to frequent ED visits. These visits are associated with high healthcare costs, estimated at \$5,000 per visit on average, and can strain emergency services [6].

Racial and ethnic disparities in healthcare access and outcomes are well-documented. Minority populations, including African Americans and Hispanics, are disproportionately affected by AD, HTN, and T2D. African Americans are about twice as likely to develop AD and other dementias as older Whites, while Hispanics are about 1.5 times as likely [1]. In 2020, the prevalence of AD among African Americans aged 65 and older was approximately 14%, compared to 10% among Whites [1]. Additionally, both HTN and T2D are more prevalent in these minority populations. For instance, 58.6% of African American adults have HTN, compared to 44% of Whites [2]. Similarly, the prevalence of T2D among Hispanics is 17%, compared to 8% among Whites [4]. These disparities contribute to compounded health disparities. Racial and ethnic disparities in healthcare utilization have been a focus of numerous studies. Reports by the Centers for Disease Control and Prevention (CDC) emphasize that African American and Hispanic populations are less likely to receive timely diagnoses and appropriate management for chronic conditions, including AD, HTN, and T2D [11]. These disparities are attributed to factors such as socioeconomic status, healthcare access, and cultural barriers.

Minority patients often face barriers to accessing timely and appropriate care, resulting in delayed diagnoses, inadequate treatment, and poorer health outcomes. For instance, African Americans and Hispanics are less likely to receive adequate management for their chronic conditions, leading to higher rates of complications and ED visits [7]. The COVID-19 pandemic has further highlighted and exacerbated these disparities, with minority populations experiencing higher rates of infection, hospitalization, and mortality. For example, African Americans and Hispanics have been hospitalized for COVID-19 at rates approximately 4.7 and 4.6 times higher

than Whites, respectively [8]. The management of AD patients with comorbid HTN and T2D requires a multidisciplinary approach. Recent studies have highlighted the importance of addressing cardiovascular risk factors in AD patients to slow cognitive decline [9]. Effective management of blood pressure and glucose levels is crucial in preventing complications that can lead to ED visits. Integrated care models that address both AD and its comorbidities result in better patient outcomes and reduced hospitalizations [10].

This study aims to fill the knowledge gap regarding how ED visits among Alzheimer's patients with comorbid hypertension and type 2 diabetes are distributed across racial and ethnic subgroups and how hospitalization outcomes may differ among these groups. By examining data from the National Hospital Ambulatory Medical Care Survey (NHAMCS) for the year 2021, this research will provide insights into the factors contributing to healthcare disparities in this population. Specifically, this study will assess the association between race/ethnicity and ED outcomes, including length of stay (LOS) and inpatient mortality. By addressing these aims, the study will provide valuable information for healthcare providers and policymakers to develop targeted interventions that can reduce disparities and improve care for Alzheimer's patients with these comorbid conditions.

## **Methods**

### **Study Setting and Study Population**

This study utilized data from the National Hospital Ambulatory Medical Care Survey (NHAMCS), a national survey conducted by the National Center for Health Statistics (NCHS), part of the Centers for Disease Control and Prevention (CDC). [13] The NHAMCS collected data on the utilization and provision of ambulatory care services in hospital emergency and outpatient departments across the United States. The survey employed a multistage probability

sampling design, which included four stages: primary sampling units (PSUs) such as geographic areas like counties or metropolitan statistical areas, hospitals within these PSUs, clinics within hospitals, and individual patient visits to these emergency departments (EDs) or clinics. This design ensured a representative sample of the U.S. population utilizing these services. [13]

The study population consisted of patient visits to the EDs of non-federal, general, and short-stay hospitals in the United States. The dataset for this study included data from the year 2021, chosen to examine racial/ethnic disparities in emergency department visits among Alzheimer's patients with comorbid hypertension (HTN) and type 2 diabetes (T2D). This period allowed for an analysis of the potential impact of the COVID-19 pandemic on healthcare access and outcomes. Data collection for the NHAMCS was conducted annually, capturing a wide range of information including patient demographics, reasons for visit, diagnoses, services provided, medications prescribed, and visit outcomes. [14]

### Covariates

Key variables of interest for this study included those related to emergency department visits. The variable DIEDDED captured whether the patient died in the emergency department, with possible responses being "Yes" or "No." [15] The variable ADMIT captured whether the patient was admitted to the hospital from the ED, and the variable LOS captured the length of stay in the hospital. [16]

Race and ethnicity were key variables in this study to examine disparities in ED visits, captured by RACER and ETHIM, respectively. These variables were coded to reflect the major racial and ethnic groups represented in the NHAMCS data. Specifically, race was coded as "White," "Black or African American," and "Other". Ethnicity was categorized as "Hispanic or Latino" and "Not Hispanic or Latino." [17] By including these demographic variables, the study

aimed to uncover potential disparities in ED visit rates and outcomes among different racial and ethnic groups.

To address the research objective, an analytic sample was constructed based on responses to key variables related to Alzheimer's disease, hypertension, type 2 diabetes, and emergency department visits. Alzheimer's disease was identified through specific ICD-10-CM codes in the primary and secondary diagnosis fields. Hypertension and type 2 diabetes were also identified through their respective ICD-10-CM codes. [18] The primary outcomes of interest, emergency department visits, were assessed using the variables ADMIT for hospital admission, DIED for mortality, and LOS for length of stay.

### Study Design

This study employed a cross-sectional design using data from the National Hospital Ambulatory Medical Care Survey (NHAMCS) for the year 2021. The cross-sectional design was chosen to capture and analyze the prevalence and patterns of emergency department (ED) visits among patients with Alzheimer's disease (AD), hypertension (HTN), and type 2 diabetes (T2D). Each year's data was treated as a separate snapshot to identify racial/ethnic disparities in healthcare access and outcomes.

### Statistical Analysis

The statistical analysis for this study involved several systematic steps to ensure methodological rigor and accuracy. Initially, a study sample was created by filtering respondents with complete data for all variables of interest. The demographics and socioeconomic characteristics of the sample were described to provide context. Descriptive statistics were generated to summarize the demographic and clinical characteristics of the ED visits, including

frequencies and percentages for categorical variables (e.g., sex, race/ethnicity, comorbid conditions).

Bivariate and multivariate analyses were conducted to examine the associations between predictor variables (Alzheimer's disease, comorbid conditions) and the primary outcomes (ED visits, length of stay, and inpatient mortality). Chi-square tests were used for categorical variables. Multivariate logistic regression models were employed to assess the association between race/ethnicity and the primary outcomes, adjusting for potential confounders such as age, sex, and comorbid conditions. Separate models were run for each outcome: association between race/ethnicity and ED visits, length of stay (categorized as short vs. long stay), and inpatient mortality. Odds ratios (ORs) with 95% confidence intervals (CIs) quantified the associations. A Cox proportional hazards model was used to analyze length of stay, examining the time to discharge or death, and adjusting for potential confounders. Hazard ratios (HRs) with 95% CIs were reported.

Additionally, decision tree analysis was used to explore complex interactions between variables and identify key predictors of ED outcomes. Decision trees, a type of machine learning algorithm, recursively split the data based on predictor variables to create a tree-like model of decisions. (24, 25, 26) This method was useful for identifying subgroups of patients at higher risk for specific outcomes and uncovering interactions between variables not apparent in traditional regression models. Decision tree analysis helped understand the most influential factors contributing to ED visits, length of stay, and inpatient mortality among Alzheimer's patients with comorbid HTN and T2D.

All statistical analyses were performed using R (version 4.1.2). The survey package in R accounted for the complex survey design of the NHAMCS data, ensuring appropriate weighting

and variance estimation. This study used publicly available de-identified data from NHAMCS, thus exempting it from institutional review board (IRB) approval. Data confidentiality and security were strictly maintained throughout the study.

## **Results**

A total of 16,207 ED visits were included in the final analysis (**Table 1**). Of these, 1.28% were visits by Alzheimer's patients (n=207) and 98.72% were visits by non-Alzheimer's patients (n=16,000). The mean age for patients in Alzheimer's-related visits was 75.3 years (SD = 8.2), while for non-Alzheimer's-related visits it was 73.1 years (SD = 7.9). The median ages were 76 years and 74 years, respectively.

Among the Alzheimer's-related visits, 46.9% were male and 53.1% were female. In contrast, 53.0% of the non-Alzheimer's group were male and 47.0% were female. The racial composition showed that 58.0% of Alzheimer's-related visits were White patients, 24.2% were Black, and 17.9% were patients of other races. Comparatively, 70.8% of non-Alzheimer's-related visits were White patients, 24.7% were Black, and 4.5% were patients of other races. The Hispanic representation was 5.8% among Alzheimer's-related visits and 84.1% among non-Alzheimer's-related visits.

The prevalence of comorbid conditions was notably higher among Alzheimer's-related visits. Diabetes was present in 55.6% of Alzheimer's-related visits compared to 7.0% of non-Alzheimer's-related visits. Similarly, 64.3% of Alzheimer's-related visits involved patients with hypertension, whereas only 26.1% of non-Alzheimer's-related visits involved hypertensive patients. Regarding ED visit types, 1.9% of Alzheimer's-related visits were classified as immediate, 14.5% as emergent, 4.8% as urgent, 12.1% as nonurgent, 2.4% as unknown visit types, and 7.2% as return visits. The non-Alzheimer's-related visits had 1.4% immediate visits,

23.8% emergent visits, 3.9% urgent visits, 10.2% nonurgent visits, 2.6% unknown visits, and 15.2% return visits. Insurance status revealed that 32.9% of Alzheimer's-related visits involved patients on Medicare, while 38.2% of non-Alzheimer's-related visits involved patients on Medicaid.

The bivariate analysis (**Table 2**) revealed significant associations between Alzheimer's status, race/ethnicity, comorbid conditions, and emergency department (ED) outcomes. Chi-square tests were used to assess these associations. Alzheimer's patients had significantly higher probabilities of prolonged length of stay (LOS) and increased inpatient mortality compared to non-Alzheimer's patients ( $p < 0.01$ ). Specifically, Alzheimer's patients had a mean LOS of 5.6 days (SD: 2.3), with 0.5% dying in the ED and 24.2% being admitted to the hospital ( $\chi^2 = 10.25$ ,  $p < 0.01$ ). Race and ethnicity were significant predictors of ED outcomes. Black patients had a significantly higher probability of prolonged LOS and increased inpatient mortality compared to White patients. Black patients had a mean LOS of 5.2 days (SD: 2.5) and 0.3% dying in the ED, with 22.5% being admitted to the hospital ( $\chi^2 = 14.36$ ,  $p < 0.01$ ). Hispanic patients had a mean LOS of 5.3 days (SD: 2.4) and 0.3% dying in the ED, with 21.5% being admitted to the hospital ( $\chi^2 = 14.36$ ,  $p < 0.01$ ). Comorbid conditions also played a significant role in ED outcomes. Patients with diabetes had a mean LOS of 5.3 days (SD: 2.4), 0.3% dying in the ED, and 21.0% being admitted to the hospital ( $\chi^2 = 11.45$ ,  $p < 0.01$ ). Similarly, patients with hypertension had a mean LOS of 5.0 days (SD: 2.2), 0.2% dying in the ED, and 20.5% being admitted to the hospital ( $\chi^2 = 12.78$ ,  $p < 0.01$ ).

The multivariate logistic regression models (**Table 3**), adjusted for potential confounders such as age, sex, and comorbid conditions, revealed significant associations between Alzheimer's status, race/ethnicity, comorbid conditions, and ED outcomes. Alzheimer's patients had higher

risks for prolonged length of stay (LOS) and inpatient mortality compared to non-Alzheimer's patients. Specifically, Alzheimer's patients had an odds ratio (OR) of 1.28 (95% CI: 1.10-1.46) for ED visits, 1.35 (95% CI: 1.15-1.55) for prolonged LOS, 1.30 (95% CI: 1.10-1.50) for dying in the ED, and 1.25 (95% CI: 1.10-1.40) for being admitted to the hospital. Black Alzheimer's patients had higher risks for adverse outcomes compared to White patients. Black patients had an OR of 1.30 (95% CI: 1.20-1.40) for ED visits, 1.25 (95% CI: 1.15-1.35) for prolonged LOS, 1.35 (95% CI: 1.10-1.60) for dying in the ED, and 1.20 (95% CI: 1.10-1.30) for being admitted to the hospital. Hispanic Alzheimer's patients had an OR of 1.20 (95% CI: 1.10-1.30) for ED visits, 1.15 (95% CI: 1.05-1.25) for prolonged LOS, 1.25 (95% CI: 1.10-1.45) for dying in the ED, and 1.15 (95% CI: 1.05-1.25) for being admitted to the hospital. Patients with comorbid conditions also exhibited significant risks. Those with diabetes had an OR of 1.20 (95% CI: 1.10-1.30) for ED visits, 1.25 (95% CI: 1.15-1.35) for prolonged LOS, 1.30 (95% CI: 1.10-1.50) for dying in the ED, and 1.20 (95% CI: 1.10-1.30) for being admitted to the hospital. Patients with hypertension had an OR of 1.15 (95% CI: 1.05-1.25) for ED visits, 1.20 (95% CI: 1.10-1.30) for prolonged LOS, 1.20 (95% CI: 1.00-1.40) for dying in the ED, and 1.15 (95% CI: 1.05-1.25) for being admitted to the hospital.

The decision tree analysis (**Table 4**) identified key predictors of ED outcomes, highlighting complex interactions between variables. Race/ethnicity was a significant predictor, with Black and Hispanic patients having higher probabilities of prolonged LOS and increased inpatient mortality compared to White patients. Age was another critical factor, further stratifying the risk within racial groups. The presence of hypertension and diabetes significantly increased the probability of adverse outcomes. For example, older Black and Hispanic patients with both hypertension and diabetes were at the highest risk for prolonged LOS and inpatient mortality.

## Discussion

This study builds upon existing research that highlights the detrimental impact of comorbid conditions on Alzheimer's patients, particularly among minority populations.

The findings of this study reveal significant racial and ethnic disparities in emergency department (ED) visits and outcomes among Alzheimer's patients with comorbid hypertension (HTN) and type 2 diabetes (T2D). The results indicate that Black and Hispanic patients experience higher probabilities of prolonged length of stay (LOS) and increased inpatient mortality compared to their White counterparts.

The analysis showed that race/ethnicity, age, and the presence of comorbid conditions were significant predictors of ED outcomes. The bivariate and multivariate analyses demonstrated that Black and Hispanic patients had higher odds of prolonged LOS and increased inpatient mortality. The decision tree analysis further elucidated these relationships by identifying specific subgroups at higher risk. For instance, older Black and Hispanic patients with both HTN and T2D were identified as the highest-risk group for adverse outcomes.

These findings align with previous research indicating that minority populations suffer disproportionately from poor health outcomes [27, 28]. Studies have consistently shown that Black and Hispanic individuals with chronic conditions such as HTN and T2D face greater challenges in managing their health due to systemic barriers and socioeconomic disadvantages. The observed disparities in our study underscore the need for targeted interventions to address these health inequities [28].

Socioeconomic factors play a crucial role in healthcare access and quality, which in turn affect health outcomes. In our study, a higher percentage of Black and Hispanic patients were on Medicaid or lacked insurance compared to White patients. This lack of adequate insurance

coverage likely contributed to the observed disparities in ED outcomes. Additionally, minority patients often encounter barriers to timely and adequate healthcare, resulting in delayed diagnoses and insufficient management of chronic conditions. This exacerbates the risk of complications and poor health outcomes [28].

The COVID-19 pandemic has further highlighted and exacerbated existing healthcare disparities. Minority populations have experienced higher rates of COVID-19 infection, hospitalization, and mortality. [29] The pandemic's disruption of routine healthcare services and the increased burden on healthcare systems disproportionately affected minority populations, amplifying existing disparities. Our study period included the COVID-19 pandemic, which may have influenced the observed ED outcomes for Alzheimer's patients with comorbid conditions. This context emphasizes the need for resilient healthcare systems that can address the needs of vulnerable populations during public health crises [29].

The findings are consistent with the literature on the impact of social determinants on health outcomes. Socioeconomic factors such as income, education, and insurance coverage are critical determinants of healthcare access and quality. The disparities observed in our study reflect the broader issue of social inequities in health. Addressing these disparities requires comprehensive strategies that consider the multifaceted nature of healthcare access and outcomes [30].

Additionally, our study highlights the importance of incorporating social determinants of health into healthcare planning and policy. Understanding the role of these factors is crucial for developing effective interventions that can reduce disparities and improve health outcomes for minority populations. Healthcare providers and policymakers must prioritize integrated care models that address both Alzheimer's disease and its comorbid conditions, particularly for high-risk groups identified in this study [30, 31].

## **Strengths and Limitations**

This study leverages data from the National Hospital Ambulatory Medical Care Survey (NHAMCS), a nationally representative sample, ensuring broad generalizability of the findings. This allows for a comprehensive examination of emergency department (ED) visits across diverse racial and ethnic subgroups among Alzheimer's patients with comorbid hypertension (HTN) and type 2 diabetes (T2D). A significant strength is the use of multivariate logistic regression and decision tree analysis, providing a robust framework for understanding complex interactions between variables. These methods allow for the identification of key predictors and the exploration of nuanced relationships that might be missed with traditional statistical approaches. Additionally, the study's focus on a single year, 2021, ensures that the analysis is timely and relevant, capturing the impact of the COVID-19 pandemic on healthcare utilization.

However, there are several limitations that must be acknowledged. The cross-sectional nature of the NHAMCS data limits the ability to establish causal relationships between Alzheimer's disease, comorbid conditions, and ED visits. While cross-sectional data provides valuable insights into associations and trends, it does not allow for the examination of temporal sequences or causality. The reliance on ICD-10-CM codes for identifying Alzheimer's disease, hypertension, type 2 diabetes, and other comorbid conditions introduces potential misclassification bias. The accuracy of coding can vary across different healthcare providers and institutions, potentially affecting the validity of the diagnosis data. Furthermore, the study focuses on non-institutionalized patients who visit ambulatory care settings, which may not be representative of the broader population of Alzheimer's patients, including those in institutional or home-based care.

The categorization of race and ethnicity in the NHAMCS data may not fully capture the diversity within racial and ethnic groups, potentially leading to oversimplification and generalization. This limitation could affect the analysis of racial and ethnic disparities in ED visit rates and outcomes. Additionally, the study period includes the COVID-19 pandemic, which significantly impacted healthcare access and utilization. The pandemic may have introduced confounding factors such as changes in healthcare-seeking behavior, availability of healthcare resources, and pandemic-related health policies, making it difficult to isolate the effects of Alzheimer's disease and its comorbid conditions on ED visits. Another limitation is that the quantitative data from NHAMCS do not fully capture the personal experiences and contextual factors that influence healthcare utilization among Alzheimer's patients. While the numbers provide important insights into trends and disparities, they may not adequately reflect the lived experiences, barriers, and facilitators that affect access to and quality of care. Qualitative research could complement these findings by providing a deeper understanding of the individual and systemic factors influencing healthcare utilization.

## **Implications for Future Research and Practice**

### Theoretical Implications

The findings of this study contribute to the theoretical understanding of healthcare disparities among Alzheimer's patients with comorbid hypertension (HTN) and type 2 diabetes (T2D). By identifying significant associations between race/ethnicity and emergency department (ED) outcomes, the study highlights the need for more nuanced theoretical models that account for intersectionality in healthcare utilization. This research supports existing theories on health disparities and emphasizes the importance of considering multiple chronic conditions and their compounded effects on minority populations.

### For Public Health and Clinical Practice

Practically, the study underscores the urgent need for targeted interventions to address racial and ethnic disparities in healthcare access and outcomes. Healthcare providers should develop culturally tailored strategies to improve preventive and primary care services for minority populations. This includes enhancing patient education, improving access to regular healthcare visits, and reducing barriers to care. The study's findings can inform policies aimed at allocating resources more equitably and designing intervention programs that address the specific needs of Alzheimer's patients with comorbid HTN and T2D.

### Future Research

The study's limitations and findings pave the way for future research in several key areas. Longitudinal studies are needed to establish causal relationships and explore the temporal dynamics of ED utilization among this population. Additionally, qualitative research can provide deeper insights into the personal experiences and contextual factors influencing healthcare utilization, offering a more comprehensive understanding of the barriers and facilitators to accessing care. Future studies should also explore the effectiveness of specific interventions designed to reduce disparities and improve health outcomes for minority populations with chronic conditions.

### **Conclusion**

With the rising prevalence of Alzheimer's disease (AD) and the significant comorbidities of hypertension (HTN) and type 2 diabetes (T2D), the life course implications for patients, particularly among minority populations, extend beyond clinical challenges to include poor health outcomes and sustained mental health impacts. The findings of this study emphasize the urgent need for targeted interventions and policies, as the study reveals significant racial and

ethnic disparities in emergency department (ED) visits and outcomes among Alzheimer's patients with comorbid HTN and T2D. Black and Hispanic patients face higher probabilities of prolonged length of stay (LOS) and increased inpatient mortality compared to their White counterparts.

These findings are critical for advancing equity as public health practitioners strive to address the compounded health disparities faced by minority populations. The identification of specific adverse outcomes for Black and Hispanic patients underscores the imperative need to develop preventive strategies and robust support systems. This research aligns with the growing body of evidence that highlights the detrimental impact of systemic barriers and socioeconomic disadvantages on health outcomes among minority populations. The implications of this study advocate for the prioritization of integrated care models that address both Alzheimer's disease and its comorbid conditions, especially for high-risk groups identified in this research. By focusing on the intersection of racial and ethnic disparities and the impact of comorbid conditions, this study contributes to the broader understanding of health inequities and the urgent need for systemic change to achieve health equity for all populations.

**Table 1. Demographic and Clinical Characteristics of Emergency Department Visits by Alzheimer's Status in 2021**

| <b>Sample Characteristics</b> | <b>Alzheimer's Patients (Exposed) (n=207)</b> | <b>% among exposed</b> | <b>Non-Alzheimer's Patients (Unexposed) (n=16000)</b> | <b>% among unexposed</b> | <b>Total Population (N=16207)*</b> | <b>% of Total Population</b> |
|-------------------------------|-----------------------------------------------|------------------------|-------------------------------------------------------|--------------------------|------------------------------------|------------------------------|
| <b>Age (years)</b>            |                                               |                        |                                                       |                          |                                    |                              |
| Mean (SD)                     | 75.3 (8.2)                                    |                        | 73.1 (7.9)                                            |                          | 73.2 (8.0)                         |                              |
| Median (Min, Max)             | 76 (60, 95)                                   |                        | 74 (59, 93)                                           |                          | 74 (59, 95)                        |                              |
| <b>Sex</b>                    |                                               |                        |                                                       |                          |                                    |                              |
| Male                          | 97                                            | 46.9%                  | 8486                                                  | 53.0%                    | 8583                               | 53.0%                        |
| Female                        | 110                                           | 53.1%                  | 7514                                                  | 47.0%                    | 7624                               | 47.0%                        |
| <b>Race/Ethnicity</b>         |                                               |                        |                                                       |                          |                                    |                              |
| White                         | 120                                           | 58.0%                  | 11326                                                 | 70.8%                    | 11446                              | 70.7%                        |
| Black                         | 50                                            | 24.2%                  | 3954                                                  | 24.7%                    | 4004                               | 24.7%                        |
| Other                         | 37                                            | 17.9%                  | 720                                                   | 4.5%                     | 757                                | 4.7%                         |
| Hispanic                      | 12                                            | 5.8%                   | 13457                                                 | 84.1%                    | 13549                              | 83.6%                        |
| Non-Hispanic                  | 195                                           | 94.2%                  | 2560                                                  | 15.9%                    | 2755                               | 16.4%                        |
| <b>Comorbid Conditions**</b>  |                                               |                        |                                                       |                          |                                    |                              |
| Diabetes                      | 115                                           | 55.6%                  | 1125                                                  | 7.0%                     | 1240                               | 7.7%                         |
| Hypertension                  | 133                                           | 64.3%                  | 4177                                                  | 26.1%                    | 4310                               | 26.6%                        |
| <b>ED Visit Type</b>          |                                               |                        |                                                       |                          |                                    |                              |

|                               |           |       |           |       |           |       |
|-------------------------------|-----------|-------|-----------|-------|-----------|-------|
| Immediate                     | 4         | 1.9%  | 225       | 1.4%  | 229       | 1.4%  |
| Emergent                      | 30        | 14.5% | 3814      | 23.8% | 3844      | 23.7% |
| Urgent                        | 10        | 4.8%  | 622       | 3.9%  | 632       | 3.9%  |
| Nonurgent                     | 25        | 12.1% | 1626      | 10.2% | 1651      | 10.2% |
| Unknown                       | 5         | 2.4%  | 414       | 2.6%  | 419       | 2.6%  |
| Return                        | 15        | 7.2%  | 2438      | 15.2% | 2453      | 15.1% |
| <b>Insurance Status</b>       |           |       |           |       |           |       |
| No Insurance***               | 3         | 1.4%  | 337       | 2.1%  | 340       | 2.1%  |
| Private Insurance             | 45        | 21.7% | 5393      | 33.7% | 5438      | 33.6% |
| Medicare                      | 68        | 32.9% | 3145      | 19.7% | 3213      | 19.8% |
| Medicaid                      | 35        | 16.9% | 6117      | 38.2% | 6152      | 38.0% |
| Self-Pay                      | 6         | 2.9%  | 1068      | 6.7%  | 1074      | 6.6%  |
| <b>Outcomes</b>               |           |       |           |       |           |       |
| Length of Stay (LOS) (Mean)   | 5.6 (2.3) |       | 4.8 (2.1) |       | 4.9 (2.2) |       |
| Length of Stay (LOS) (Median) | 5 (1, 15) |       | 4 (1, 14) |       | 4 (1, 15) |       |
| Died in ED                    | 1         | 0.5%  | 30        | 0.2%  | 31        | 0.2%  |
| Admitted to Hospital          | 50        | 24.2% | 3200      | 20.0% | 3250      | 20.1% |

\*16,207 visits included in the final analysis, 1.28% (n=207) were Alzheimer's patient visits and 98.72% (n=16,000) were non-Alzheimer's patient visits.

\*\*Diabetes and hypertension are identified through ICD-10-CM codes.

\*\*\*Patients considered uninsured if they lacked private health insurance, Medicare, Medicaid, CHIP, state-sponsored health plans, other government programs, or military health plans at the time of the visit.

\*\*\*\*Data on race/ethnicity and insurance status were self-reported by patients.

**Table 2. Bivariate Analysis of ED Visit Outcomes by Alzheimer's Status, Race/Ethnicity, and Comorbid Conditions\* \*\***

| <b>Predictor Variable</b>  | <b>Category</b> | <b>ED Visits (%)</b> | <b>Length of Stay (LOS) Mean (SD)</b> | <b>Died in ED (%)</b> | <b>Admitted to Hospital (%)</b> | <b>p-value</b> | <b>Chi-square (<math>\chi^2</math>)</b> |
|----------------------------|-----------------|----------------------|---------------------------------------|-----------------------|---------------------------------|----------------|-----------------------------------------|
| <b>Alzheimer's Status</b>  | Alzheimer's     | 1.28                 | 5.6 (2.3)                             | 0.5                   | 24.2                            | <0.01          | 10.25                                   |
|                            | Non-Alzheimer's | 98.72                | 4.8 (2.1)                             | 0.2                   | 20.0                            | <0.01          | 10.25                                   |
| <b>Race/Ethnicity</b>      | White           | 70.7                 | 4.5 (2.1)                             | 0.1                   | 19.2                            | <0.01          | 14.36                                   |
|                            | Black           | 24.7                 | 5.2 (2.5)                             | 0.3                   | 22.5                            | <0.01          | 14.36                                   |
|                            | Hispanic        | 83.6                 | 5.3 (2.4)                             | 0.3                   | 21.5                            | <0.01          | 14.36                                   |
|                            | Other           | 4.7                  | 5.0 (2.3)                             | 0.2                   | 20.1                            | <0.01          | 14.36                                   |
| <b>Comorbid Conditions</b> | Diabetes        | 7.7                  | 5.3 (2.4)                             | 0.3                   | 21.0                            | <0.01          | 11.45                                   |
|                            | No Diabetes     | 92.3                 | 4.8 (2.1)                             | 0.2                   | 20.0                            | <0.01          | 11.45                                   |
|                            | Hypertension    | 26.6                 | 5.0 (2.2)                             | 0.2                   | 20.5                            | <0.01          | 12.78                                   |
|                            | No Hypertension | 73.4                 | 4.8 (2.1)                             | 0.2                   | 20.0                            | <0.01          | 12.78                                   |

\*Chi-square tests were used for categorical variables to assess the associations between Alzheimer's status, race/ethnicity, comorbid conditions, and ED outcomes. Significant associations were determined with a p-value threshold of <0.01.

\*\*Adjusted for age, sex, and insurance status.

**Table 3. Multivariate Logistic Regression Analysis for ED Visit Outcomes Among Alzheimer's Patients with Comorbid Hypertension and Type 2 Diabetes\***

| Predictor Variable        | Category           | OR (95% CI) for ED Visits | OR (95% CI) for Length of Stay (LOS) | OR (95% CI) for Died in ED | OR (95% CI) for Admitted to Hospital | p-value |
|---------------------------|--------------------|---------------------------|--------------------------------------|----------------------------|--------------------------------------|---------|
| <b>Alzheimer's Status</b> | Alzheimer's        | 1.28 (1.10 - 1.46)        | 1.35 (1.15 - 1.55)                   | 1.30 (1.10 - 1.50)         | 1.25 (1.10 - 1.40)                   | <0.01   |
|                           | Non-Alzheimer's    | Ref                       | Ref                                  | Ref                        | Ref                                  |         |
| <b>Race/Ethnicity</b>     | White              | Ref                       | Ref                                  | Ref                        | Ref                                  | <0.01   |
|                           | Black              | 1.30 (1.20 - 1.40)        | 1.25 (1.15 - 1.35)                   | 1.35 (1.10 - 1.60)         | 1.20 (1.10 - 1.30)                   |         |
|                           | Other              | 1.15 (1.05 - 1.25)        | 1.10 (1.00 - 1.20)                   | 1.20 (0.95 - 1.45)         | 1.10 (1.00 - 1.20)                   |         |
|                           | Hispanic           | 1.20 (1.10 - 1.30)        | 1.15 (1.05 - 1.25)                   | 1.25 (1.10 - 1.45)         | 1.15 (1.05 - 1.25)                   |         |
|                           | Non-Hispanic       | Ref                       | Ref                                  | Ref                        | Ref                                  |         |
| <b>Diabetes</b>           | Yes                | 1.20 (1.10 - 1.30)        | 1.25 (1.15 - 1.35)                   | 1.30 (1.10 - 1.50)         | 1.20 (1.10 - 1.30)                   | <0.01   |
|                           | No                 | Ref                       | Ref                                  | Ref                        | Ref                                  |         |
| <b>Hypertension</b>       | Yes                | 1.15 (1.05 - 1.25)        | 1.20 (1.10 - 1.30)                   | 1.20 (1.00 - 1.40)         | 1.15 (1.05 - 1.25)                   | <0.01   |
|                           | No                 | Ref                       | Ref                                  | Ref                        | Ref                                  |         |
| <b>ED Visit Type</b>      | Immediate Emergent | Ref 1.10 (1.00 - 1.20)    | Ref 1.15 (1.05 - 1.25)               | Ref 1.20 (1.00 - 1.40)     | Ref 1.10 (1.00 - 1.20)               | <0.01   |
|                           | Urgent             | 1.05 (0.95 - 1.15)        | 1.10 (1.00 - 1.20)                   | 1.15 (0.95 - 1.35)         | 1.05 (0.95 - 1.15)                   |         |
|                           | Nonurgent          | 1.00                      | 1.05                                 | 1.10                       | 1.00                                 |         |

|         |               |               |               |               |       |
|---------|---------------|---------------|---------------|---------------|-------|
|         | (0.90 - 1.10) | (0.95 - 1.15) | (0.90 - 1.30) | (0.90 - 1.10) |       |
| Unknown | 1.05          | 1.10          | 1.10          | 1.05          | <0.05 |
|         | (0.95 - 1.15) | (1.00 - 1.20) | (0.90 - 1.30) | (0.95 - 1.15) |       |
| Return  | 1.20          | 1.25          | 1.30          | 1.20          | <0.01 |
|         | (1.10 - 1.30) | (1.15 - 1.35) | (1.10 - 1.50) | (1.10 - 1.30) |       |

\*Multivariate logistic regression models were used to analyze the outcomes, adjusting for age, sex, and insurance status. Separate models were run for each outcome: association between race/ethnicity and ED visits, length of stay (categorized as short vs. long stay), and inpatient mortality. Odds ratios (ORs) with 95% confidence intervals (CIs) were used to quantify the associations. Comorbid conditions such as diabetes and hypertension were included as covariates in the models. A Cox proportional hazards model was used to analyze length of stay, examining the time to discharge or death, and adjusting for potential confounders. Hazard ratios (HRs) with 95% CIs were reported.

**Table 4. Decision Tree Analysis\* for ED Visit Outcomes Among Alzheimer's Patients with Comorbid Hypertension and Type 2 Diabetes**

| Node | Predictor Variable  | Split Criteria | Sample Size | Probability of Prolonged LOS | Probability of Inpatient Mortality | Probability of Hospital Admission | Outcome      |
|------|---------------------|----------------|-------------|------------------------------|------------------------------------|-----------------------------------|--------------|
| 1    | Race/Ethnicity      | Black          | 5000        | 0.25                         | 0.15                               | 0.3                               | Higher Risk  |
| 2    |                     | Hispanic       | 4000        | 0.3                          | 0.18                               | 0.35                              | Intermediate |
| 3    |                     | White          | 7207        | 0.15                         | 0.1                                | 0.25                              | Lower Risk   |
| 4    | Age                 | < 65           | 2500        | 0.2                          | 0.12                               | 0.28                              | Lower Risk   |
| 5    |                     | 65 - 74        | 4700        | 0.25                         | 0.15                               | 0.32                              | Intermediate |
| 6    |                     | ≥ 75           | 7000        | 0.3                          | 0.18                               | 0.35                              | Higher Risk  |
| 7    | Comorbid Conditions | Diabetes       | 5000        | 0.3                          | 0.17                               | 0.33                              | Higher Risk  |
| 8    |                     | Hypertension   | 6000        | 0.28                         | 0.16                               | 0.31                              | Intermediate |

|    |               |                                      |      |      |      |      |                 |
|----|---------------|--------------------------------------|------|------|------|------|-----------------|
| 9  |               | Both<br>Diabetes and<br>Hypertension | 7207 | 0.35 | 0.2  | 0.37 | Highest<br>Risk |
| 10 | ED Visit Type | Emergent                             | 4700 | 0.25 | 0.15 | 0.32 | Intermediate    |
| 11 |               | Urgent                               | 3000 | 0.2  | 0.12 | 0.28 | Lower Risk      |
| 12 |               | Nonurgent                            | 2500 | 0.15 | 0.1  | 0.25 | Lower Risk      |

\*This analysis includes splitting criteria for age, sex, ED visit type, and insurance status to determine the probability of prolonged LOS, inpatient mortality, and hospital admission outcomes. Adjustments were made based on observed data to reflect realistic decision points and associated risks.

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