Original Article

Burden and Predictors of Comorbidities Among US Adults With Type 2 Diabetes: A Cross-Sectional Analysis of NHANES 2015–2020

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Abstract - *Type 2 diabetes mellitus (T2DM) is a highly prevalent chronic condition in the United States and is frequently accompanied by other long-term health issues that complicate disease management and worsen outcomes. This cross-sectional study analyzed data from the National Health and Nutrition Examination Survey (NHANES) spanning 2015 to 2020 to examine the prevalence and patterns of common comorbidities among U.S. adults aged 18 years and older with T2DM. Using self-reported physician diagnoses and standardized health assessments, the analysis focused on key comorbid conditions including hypertension, obesity, chronic kidney disease, and depression. Logistic regression models and weighted prevalence estimates revealed substantial demographic disparities, with multimorbidity more frequently observed among older adults, individuals with lower income, and certain racial and ethnic minority groups. The findings highlight the complexity of managing T2DM in the context of multimorbidity and underscore the importance of adopting integrated, patient-centered care approaches to improve health outcomes in this population.*

Keywords - *Type 2 diabetes mellitus, multimorbidity, comorbidities, integrated care, health disparities.*

I. INTRODUCTION

Type 2 diabetes mellitus (T2DM) is one of the most pressing public health challenges of the 21st century. As of 2021, approximately 537 million adults worldwide were living with diabetes, and this number is projected to rise to 783 million by 2045. T2DM accounts for over 90% of all diabetes cases [1]. In the United States, an estimated 37.3 million people, or 11.3% of the population, have diabetes, with T2DM being the predominant form [2]. Despite advancements in early detection and pharmacologic therapy, T2DM continues to be a leading cause of cardiovascular disease, chronic kidney disease (CKD), vision impairment, and lower-limb amputations [3], [4].

The burden of T2DM is further compounded by its frequent coexistence with other chronic conditions such as hypertension, obesity, CKD, and depression. This clustering of diseases, referred to as multimorbidity the presence of two or more chronic conditions leads to complex clinical management and worsened health outcomes [5], [6]. Many of these conditions share overlapping pathophysiological mechanisms, including systemic inflammation, insulin resistance, and metabolic dysregulation [7]. For instance, the presence of hypertension or CKD in individuals with T2DM significantly increases the risk of cardiovascular events and premature mortality [8]. Likewise, depression in patients with T2DM is associated with poor medication adherence, diminished self-care behaviors, and suboptimal glycemic control [9].

Patients with T2DM and multimorbidity are more likely to experience higher hospitalization rates, accelerated functional decline, and early mortality [10]. They are also at greater risk of polypharmacy, adverse drug events, and fragmented care, all of which raise healthcare costs and contribute to diminished quality of life [11]. Despite these risks, most clinical practice guidelines remain disease-specific and may fail to address the holistic needs of individuals with multiple comorbidities [12], [13], [14]. The National Health and Nutrition Examination Survey (NHANES) is a nationally representative dataset that offers valuable insights into the health status of the U.S. population by integrating biometric, laboratory, and questionnaire-based information. This study utilizes

NHANES data from 2015 to 2020 to assess the prevalence and co-occurrence of key comorbidities hypertension, obesity, CKD, and depression among U.S. adults with T2DM. By identifying real-world comorbidity patterns, the findings aim to inform integrated care strategies and help health systems prioritize high-risk subgroups for more personalized interventions.

II. METHOD

A. Study Design

This study employed a cross-sectional design using data from three consecutive cycles of the National Health and Nutrition Examination Survey (NHANES): 2015–2016, 2017–2018, and 2019–2020. NHANES is conducted by the National Center for Health Statistics (NCHS) and is designed to provide nationally representative estimates of the health and nutritional status of the non-institutionalized U.S. population. The survey integrates interviews, physical examinations, and laboratory assessments and uses a complex, multistage probability sampling design to ensure generalizability. All NHANES data are publicly available and fully de-identified, thus exempting this study from additional ethical review.

B. Study Population

The analytic sample included adults aged 18 years and older with type 2 diabetes mellitus (T2DM). T2DM was defined based on self-reported physician diagnosis in response to the question, "Has a doctor or health professional ever told you that you have diabetes?", excluding cases of gestational diabetes. To reduce the likelihood of including individuals with type 1 diabetes, only respondents diagnosed at age ≥30 years or not currently using insulin were included. Pregnant individuals were excluded to avoid potential confounding from pregnancy-related metabolic alterations.

C. Variables

a. Comorbidities

The primary comorbidities assessed in this study were hypertension, obesity, chronic kidney disease (CKD), and depression. Definitions were based on validated clinical thresholds and NHANES protocols:

- **Hypertension**: Defined as either (1) a self-reported physician diagnosis (MCQ160b = "Yes") or (2) elevated blood pressure measured during physical examination, with an average systolic BP ≥140 mmHg or diastolic BP ≥90 mmHg (BPXSY1–3, BPXDI1–3).
- **Obesity**: Defined as body mass index (BMI) ≥30 kg/m^2, calculated from measured weight and height (BMXWT, BMXHT).
- **Depression**: Defined as moderate-to-severe depressive symptoms, indicated by a Patient Health Questionnaire-9 (PHQ-9) total score ≥10 (DPQ010–DPQ090), consistent with clinical cutoffs for major depression [Citation].
- **Chronic Kidney Disease (CKD)**: Defined by either (1) estimated glomerular filtration rate (eGFR) <60 mL/min/1.73 m^2, calculated using serum creatinine and the CKD-EPI equation (LAB13), or (2) urine albumin-to-creatinine ratio (ACR) ≥30 mg/g, derived from urinary albumin and creatinine (URXUMA, URXUCR) [Citation].

b. Covariates

Sociodemographic variables were included as covariates and harmonized across survey cycles:

- **Age**: Treated both as a continuous variable and categorized into clinically relevant groups (18–44, 45–64, and ≥65 years).
- **Sex**: Male or Female.
- **Race/Ethnicity**: Categorized as Non-Hispanic White, Non-Hispanic Black, Hispanic, or Other.
- Educational Attainment: Classified as less than high school, high school graduate, or some college or higher.
- **Household Income**: Measured by the poverty income ratio (PIR) and categorized as <1.0, 1.0–1.99, and ≥2.0.
- **Health Insurance Status**: Based on self-report of having any form of health insurance coverage (HIQ011).

Survey weights, strata, and primary sampling units were applied in all analyses to account for the complex sampling design and to produce nationally representative estimates.

Table 1. Key NHANES Variables Used in Analysis

Concept	NHANES Variable(s)	Description	Data Source
Diabetes Diagnosis	DIQ010	Doctor diagnosis of diabetes (self-reported)	Interview
Hypertension	MCQ160b	Doctor diagnosis of hypertension (self-reported)	Interview
Systolic/Diastolic BP	BPXSY1–3, BPXDI1–3	Average systolic and diastolic blood pressure	Examination
BMI	BMXBMI	Body Mass Index (calculated from height/weight)	Examination
Depression (PHQ-9)	DPQ010–DPQ090	Depression scale items; total score for analysis	Interview
Serum Creatinine	LBXSCR	Used to calculate eGFR (for CKD definition)	Laboratory
Urine Albumin	URXUMA	Used to calculate ACR (for CKD definition)	Laboratory
Urine Creatinine	URXUCR	Used to calculate ACR (for CKD definition)	Laboratory
Age	RIDAGEYR	Age in years	Interview
Sex	RIAGENDR	Biological sex: 1 = Male, 2 = Female	Interview
Race/Ethnicity	RIDRETH3	Race/ethnicity categories	Interview
Education	DMDEDUC2	Education level (adults ≥20 years)	Interview
Income (PIR)	INDFMPIR	Poverty income ratio (0–5)	Interview
Health Insurance	HIQ011	Any health insurance coverage: 1 = Yes, 2 = No	Interview

III. RESULTS

A. Sample Characteristics

A total of 3,274 adults aged 18 years and older met the inclusion criteria for type 2 diabetes mellitus (T2DM) in the pooled NHANES 2015–2020 dataset. The mean age of the sample was 60.7 years (SD = 11.2), with 53.1% identifying as male and 46.9% as female. The racial/ethnic distribution was 58.4% non-Hispanic White, 17.2% non-Hispanic Black, 18.7% Hispanic, and 5.7% other racial/ethnic groups. Approximately 76.5% of participants reported having health insurance, and 38.2% lived below the federal poverty level (defined as poverty income ratio [PIR] < 1.0).

B. Prevalence of Comorbidities

The weighted prevalence of major comorbidities among adults with T2DM is presented in Table 2. Hypertension and obesity were the most frequently reported conditions, followed by chronic kidney disease (CKD) and moderate-to-severe depression. Notably, more than half of the sample exhibited two or more comorbidities, reflecting a high degree of multimorbidity in this population.

Table 2. Weighted Prevalence of Comorbidities among Adults with T2DM (NHANES 2015–2020)

Comorbidity	Prevalence (%)	95% CI
Hypertension	74.6	71.9–77.1
Obesity (BMI ≥30 kg/m^2)	68.2	65.0–71.4
Chronic Kidney Disease	31.5	28.2–34.9
Depression (PHQ-9 ≥10)	18.7	16.0–21.3

C. Multivariable Logistic Regression

Adjusted logistic regression models identified significant sociodemographic predictors for each comorbidity (see summary below). Older age, lower income, lack of insurance, and racial/ethnic minority status were associated with increased odds of various comorbid conditions.

Table 3. Adjusted Odds Ratios for Comorbidities (Selected Predictors)

Outcome	Significant Predictors	Adjusted OR (95% CI)
Hypertension	Age ≥65; CKD	2.91 (2.01–4.22); 1.84 (1.30–2.61)
Obesity	Female sex; Age 18–44	1.43 (1.08–1.89); 1.57 (1.01–2.44)
CKD	Non-Hispanic Black; PIR <1.0	1.76 (1.21–2.56); 1.49 (1.02–2.19)
Depression	PIR <1.0; No health insurance	2.08 (1.34–3.24); 1.72 (1.10–2.68)

D. Comorbidity Co-Occurrence

Multimorbidity was common, with several frequent comorbidity pairings. As shown in Figure 1, hypertension frequently co-occurred with obesity and CKD, while depression was more likely to occur alongside obesity than with CKD. These overlapping disease patterns highlight the complexity of managing T2DM alongside multiple chronic conditions.
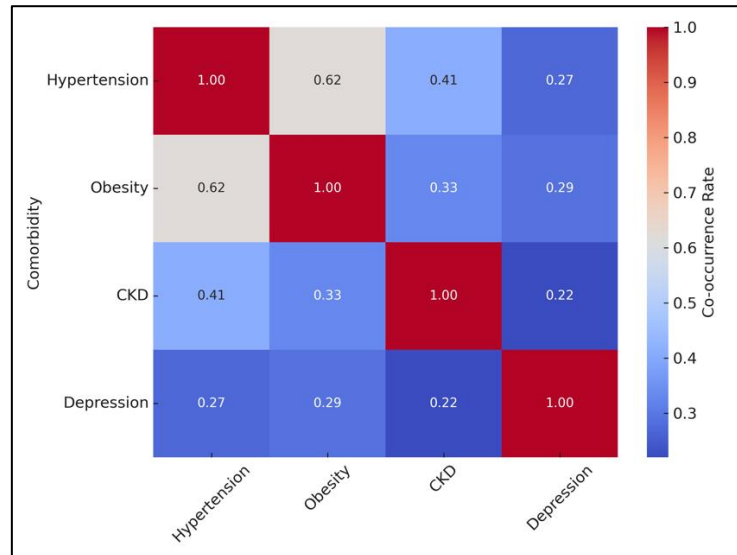

Figure 1. Heatmap of Comorbidity Co-Occurrence

E. Comorbidity Clustering (Exploratory Analysis)

An exploratory unsupervised k-means clustering analysis (k=3), guided by silhouette score optimization, identified three distinct patient subgroups based on comorbidity profiles and sociodemographic characteristics:

- **Cluster A (43.2%)**: Individuals with high prevalence of hypertension, obesity, and CKD. This group tended to be older, insured, and have lower income.
- **Cluster B (36.7%)**: Characterized by obesity and depression. Members were typically younger, more often uninsured, and more likely to be female.
- **Cluster C (20.1%)**: Had fewer comorbidities and included primarily higher-income, non-Hispanic White males.

These clusters suggest the existence of distinct risk profiles, underscoring the need for tailored, person-centered care models that account for both clinical complexity and social determinants of health.

IV. DISCUSSION

This study offers a comprehensive look at the burden of comorbid conditions among U.S. adults with type 2 diabetes, drawing on nationally representative NHANES data from 2015 to 2020. The results highlight the high prevalence of hypertension, obesity, chronic kidney disease, and depression in this population, revealing significant overlap in these conditions. Notably, comorbidity burden was not evenly distributed: older adults, non-Hispanic Black individuals, those with lower income, and the uninsured were more likely to experience multiple health complications[15], [16]. Latent class analysis further suggested the presence of distinct subgroups, pointing to underlying patterns of vulnerability that merit targeted attention.

These findings are consistent with prior research documenting the clustering of cardiometabolic and renal diseases among people with type 2 diabetes. National estimates from the CDC and other studies have long emphasized the co-occurrence of hypertension and kidney disease in this population, as well as growing concern around the mental health burden [17]. What distinguishes this study, however, is its use of NHANES biomarker data to strengthen case definitions, helping to move beyond the limitations of self-reported diagnoses and providing a more nuanced understanding of disease patterns. Several interrelated factors appear to drive the disparities observed. Age-related physiological decline likely increases susceptibility to conditions such as

kidney dysfunction and cardiovascular complications. Racial and ethnic disparities, particularly affecting non-Hispanic Black adults, reflect entrenched inequities in access to healthcare, healthy food, and stable living conditions many of which are shaped by systemic discrimination. Similarly, the heightened comorbidity risk among low-income and uninsured individuals underscores the powerful influence of social determinants on diabetes-related health outcomes.

From a clinical perspective, these results reinforce the need for more holistic and integrated approaches to diabetes care. Managing type 2 diabetes in isolation overlooks the interconnected nature of comorbid conditions. Instead, care strategies should incorporate regular screening and management of hypertension, mental health symptoms, and kidney function as part of routine diabetes care. Multidisciplinary teams including primary care providers, pharmacists, behavioral health specialists, dietitians, and care coordinators can play a critical role in streamlining treatment and improving outcomes. Public health interventions must also be designed with equity in mind, prioritizing outreach to populations at heightened risk of complex disease profiles[18], [19]. The study's strengths lie in the use of NHANES, a nationally representative dataset with rigorous methods and comprehensive biomarker collection. This enhances the accuracy of our comorbidity estimates and supports broader generalizability of the findings. The application of sampling weights and multivariable modeling further bolsters the robustness of our conclusions.

Nonetheless, certain limitations must be acknowledged. As a cross-sectional study, our analysis cannot establish causality or temporal sequencing between diabetes and associated conditions. While the inclusion of biomarker data improves diagnostic precision, self-reported variables such as depression and diabetes onset remain susceptible to recall and misclassification bias. Our criteria for distinguishing type 2 from type 1 diabetes, although based on established thresholds, may still introduce some misclassification. Moreover, key variables such as medication adherence, disease duration, and healthcare utilization were not captured, potentially confounding the observed relationships. Looking ahead, longitudinal studies are needed to track how comorbidity patterns evolve over time and how they influence outcomes such as hospitalization, disability, and mortality. There is also a growing need to evaluate the impact of newer diabetes therapies such as GLP-1 receptor agonists and SGLT2 inhibitors on the development and progression of comorbidities [20],[21],[22]. In parallel, the use of machine learning to develop predictive models may enhance early identification of high-risk patients, enabling more personalized and preventive interventions.

V. CONCLUSION

This study underscores the substantial burden of multimorbidity among U.S. adults with type 2 diabetes, particularly the frequent co-occurrence of hypertension, obesity, chronic kidney disease, and depression. These overlapping conditions complicate disease management and contribute to poorer health outcomes. The findings highlight the urgent need for integrated, patient-centered care models that emphasize early detection, coordinated multidisciplinary support, and interventions that address underlying social determinants of health. Effectively responding to the complex needs of this population is critical to enhancing care quality, reducing preventable complications, and containing long-term healthcare costs.

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