NONINVASIVE SCREENING OF NONALCOHOLIC FATTY LIVER DISEASE AMONG PEOPLE LIVING WITH HIV

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN NURSING

THE UNIVERSITY OF TEXAS HEALTH SCIENCE CENTER AT HOUSTON

CIZIK SCHOOL OF NURSING

BY

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MARCH 20, 2023
Date

To the Dean for the School of Nursing:

I am submitting a dissertation written by Essi Havor and entitled "Noninvasive Screening of Nonalcoholic Fatty Liver Disease Among People Living With HIV." ."
I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Nursing.

Committee Chair

We have read this dissertation
and recommend its acceptance:

Accepted

Dean for the School of Nursing

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Noninvasive Screening of Nonalcoholic Fatty Liver Disease Among People Living with HIV

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Abstract

Background: Chronic comorbidities disproportionately affect people living with HIV (PLWH). An estimated 75% of PLWH have nonalcoholic fatty liver disease (NAFLD). With the high HIV prevalence in Houston/Harris County, Texas, it is necessary to know about NAFLD's prevalence and risk factors among PLWH to guide prevention strategies.

Specific Aims: This study aimed to: (1) examine the demographic, behavioral, clinical, and psychosocial characteristics of PLWH in Houston/Harris County, Texas, and to estimate the prevalence of NAFLD; (2) determine factors associated with the severity of NAFLD, and (3) identify specific predictors and their contribution to the severity of the disease in this population.

Methods: Data used for this study was obtained from the Medical Monitoring Project, a population-based cross-sectional survey conducted in Houston/Harris County, Texas, between 2015 to 2019. The triglyceride glucose index with a cut-off value of >8.38, was used to assess NAFLD. Descriptive statistics was used to describe the study population, and the Rao-Scott Chi-Square test was conducted to determine the independent associations between demographic, behavioral, clinical, and psychosocial characteristics and NAFLD. Multivariable logistic regression models were utilized to identify predictors of NAFLD. Furthermore, recursive partitioning analysis was performed to determine the contributions of the predictors to NAFLD severity.

Results: The analytical sample included 601 participants, representing 18,601 PLWH in Houston/Harris County, Texas. The overall prevalence of NAFLD was 98.20%. PLWH, who had a higher mean of alanine aminotransferase (29.43±0.79, p=0.0004) and a lower mean of high-density lipoprotein (48.50±0.63, *p*=0.0411), were at risk of developing NAFLD. Also, the use of an integrase strand transfer inhibitor was significantly (*p*=0.0376) associated with NAFLD. In the multivariable models, PLWH diagnosis between five and nine years were four times (aOR 3.64, 95% CI: 1.48-8.93, *p*=0.0050), and at least ten years or more were three times (aOR 3.23, 95% CI: 1.42-7.33, *p*=0.0052) more likely to have severe NAFLD compared to PLWH less than five years. The use of non-nucleoside reverse transcriptase inhibitors significantly increased the odds of severe NAFLD (aOR:15.78, 95% CI: 1.15 –216.69, *p*=0.0392). PLWH of Hispanic ethnicity were three times more likely to have severe NAFLD (aOR: 3.13, 95% CI: 1.21–8.13, *p*=0.0191) than other racial/ethnic groups. The recursive partitioning model analysis indicated that smoking, homelessness, and use of NNRTI significantly predicted moderate NAFLD (R^2=11.20%) with a proportional contribution of 42.2%, 33.9%, and 23.9%, respectively.

Conclusion: NAFLD is prevalent in PLWH in Houston/Harris County, Texas. This study revealed that multiple factors contribute to increased risk of NAFLD in PLWH. Early and prompt care of NAFLD will help reduce disease prevalence and save lives. Therefore, providers should closely monitor PLWH at high risk for NAFLD and refer them to a liver specialist.

Keywords: NAFLD, PLWH, HIV, Triglyceride glucose index, Houston, Harris County.

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Summary of Study

Nonalcoholic fatty liver disease (NAFLD) is becoming a global epidemic, affecting 25 – 30% of the world's population (Younossi et al., 2018). In people living with HIV (PLWH), up to 75% NAFLD prevalence rate and poor liver outcomes have been reported (Lemoine et al., 2019; Maurice et al., 2017; Pires et al., 2020). However, HIV-specific factors that increase the NAFLD risk in PLWH remain inconsistent. Therefore, this study sought to estimate the prevalence of nonalcoholic fatty liver disease and its predictors in a population-based sample of people living with HIV in Houston and Harris County, Texas.

This study received approval from the Houston Health Department Investigative Review and an exempt status approval from the University of Texas Health Science Center at Houston Committee for Protection of Human Subjects.

This dissertation research titled "Noninvasive Screening of Nonalcoholic Fatty Liver Disease Among People Living with HIV" contains two manuscripts:

Manuscript 1, titled: "Prevalence and Risk Factors Associated with the Presence of Nonalcoholic Fatty Liver Disease Among People Living with HIV: A Cross-sectional Study," examined the demographic, behavioral, clinical, and psychosocial characteristics of PLWH in Houston/Harris County, Texas, and estimate the prevalence of NAFLD.

Manuscript 2**,** titled "Prognostic Factors for Predicting Severity of Nonalcoholic Fatty Liver Disease in People Living with HIV: An Analysis of Medical Monitoring Project Data," determined factors associated with the severity of NAFLD, identified specific predictors and their proportional contributions to the severity of the disease.

Noninvasive Screening of Nonalcoholic Fatty Liver Disease Among People Living with HIV

Proposal

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Specific Aims

A recent study indicates that up to 76% of People Living with HIV (PLWH) are affected with nonalcoholic fatty liver disease (NAFLD) (Lemoine et al., 2019). Additionally, 85% of PLWH endure HIV stigma and discrimination (Katz et al., 2013), which are associated with chronic diseases, such as cardiovascular disorders and mental health disorders (Lindberg et al., 2020; Meng et al., 2020). HIV infection and antiretroviral medication exposure are also associated with an increased incidence of depression and anxiety (Deshmukh et al., 2017; Sarna et al., 2019). Because stigma, discrimination, and mental health disorders have been shown to significantly worsen health outcomes and reduce the quality of life in PLWH (Crockett et al., 2019; Turan et al., 2017), they may also contribute to the development and progression of NAFLD in PLWH. However, no studies have investigated the relationships between depression, anxiety, stigma, perceived discrimination, and NAFLD in PLWH, suggesting an urgent need for the current research.

The *primary objective* was to estimate the prevalence of NAFLD in a population-based sample of PLWH in Houston/Harris County, Texas, using a noninvasive biomarker.

The *secondary objective* of this study was to identify risk factors associated with the development and the severity of NAFLD in PLWH, specifically psychosocial risk factors (depression, anxiety, HIV stigma, and discrimination).

The *long-term goal* was to develop a risk stratification strategy and interventions to promote the early identification of subgroups of PLWH at higher risk for NAFLD. The *central hypothesis* was that specific risk factors increase susceptibility to NAFLD among

PLWH. The *rationale* for this study was that identifying factors contributing to increased risk for NAFLD may promote awareness and early intervention among individuals and their healthcare providers. The investigator pursued the following specific aims:

To estimate the prevalence of NAFLD (No NALFD/NAFLD) among PLWH in Houston/Harris County, Texas.

- Determine the overall prevalence of NAFLD in the study population.
- Determine the prevalence of NAFLD by sociodemographic, behavioral, clinical, and psychosocial factors.

Hypotheses: NAFLD was prevalent among PLWH, and the prevalence estimates vary significantly by sociodemographic, behavioral, clinical, and psychosocial factors.

To determine factors (sociodemographic, behavioral, clinical, psychosocial) associated with the severity of NAFLD (mild, moderate, severe) among PLWH in Houston/Harris County, Texas.

Hypothesis: There was a significant association between the severity of NAFLD and sociodemographic, behavioral, clinical, and psychosocial factors among PLWH in Houston/Harris County, Texas.

To determine the predictors of NAFLD presence (No NAFLD/NAFLD) and severity (mild, moderate, severe) among PLWH in Houston/Harris County, Texas.

- Identify sociodemographic, behavioral, clinical, and psychosocial factors that predict the presence of NAFLD.
- Identify sociodemographic, behavioral, clinical, and psychosocial factors that predict the severity of NAFLD.

- Determine the proportional contributions of identified predictors to NAFLD development and severity.

Hypotheses: (1) Age, race/ethnicity, gender at birth, viral load, depression, anxiety, stigma, and discrimination significantly predict NAFLD development and severity. (2) The level of contribution of identified predictors to the development and severity of NAFLD varied significantly.

The expected outcomes of this study were to determine the prevalence of NAFLD in PLWH in Houston/Harris County, Texas, and to identify the sociodemographic, behavioral, clinical, and psychosocial factors that predict the development and the severity of NAFLD in PLWH. This study's findings fill the knowledge gap, highlight programming areas, and facilitate discussions among stakeholders, including HIV care providers, patients, and policymakers. In particular, the results will inform public health initiatives that could help promote early identification of subgroups of PLWH at higher risk for NAFLD.

Background and Significance

Despite highly effective antiretroviral therapy, PLWHs are prone to NAFLD, the most common chronic liver disease and the second leading cause of death among PLWH (Smith et al., 2014). About 100 million Americans are estimated to have NAFLD by 2030 (Estes et al., 2018), with ten million of them progressing to hepatocellular carcinoma, dying prematurely of liver complications, and the remaining experiencing liver-related morbidity (Setiawan et al., 2016; Younossi et al., 2016). Despite the morbidity and mortality associated with NAFLD and $103 billion in annual medical costs related to treatment (Younossi et al., 2016), early identification of high-risk people like

PLWH remains challenging. PLWH without secondary causes of chronic liver disease has a 76% prevalence of NAFLD compared to 30% in the general population (Lemoine et al., 2019; Lombardi, 2017; Vuille-Lessard et al., 2016). Obesity and diabetes are risk factors for NAFLD in general and in HIV populations (Younossi et al., 2019). Still, specific factors associated with increased risk in PLWH have yet to be identified. Researchers have proposed several pathways to explain the increased susceptibility, but the findings are controversial and need further elucidation.

NAFLD and HIV Infection

Antiretroviral medication initiation and duration are frequent risk factors for NAFLD (Bourgi et al., 2020; Martínez-Sanz et al., 2021). For instance, Tenofovir alafenamide and integrase inhibitors were substantially related to weight gain and type 2 diabetes in a prospective longitudinal analysis of monoinfected PLWH (N=319), especially in male patients (with body mass index >23 kg/m^2) (Bischoff et al., 2021). These findings also highlight gender's influence on NAFLD.

Bischoff et al. (2021) further indicated that NAFLD occurs in lean individuals, suggesting that body mass index may not be a good predictor of NAFLD risk. Moreover, type 2 diabetes is associated with NAFLD and significantly contributes to the high frequency of metabolic syndrome in PLWH. Insulin resistance is associated with immune activity (low CD4 levels, detectable viral load) in a similar manner. In a prospective study of PLWH and NAFLD (N=61), switching from a protease inhibitor to raltegravir resulted in a significant decrease in NAFLD after 12 months (Calza et al., 2019). In establishing NAFLD prevention measures, the findings of these two studies are therefore relevant.

Several studies also suggest a significant association between demographic factors such as age, race/ethnicity, and NAFLD in the HIV and general populations (Tang et al., 2019; Zhang et al., 2021). For instance, men are at higher risk of NAFLD before 50 years, women's risk increases over 50 years (Li et al., 2022; Soti et al., 2018). A cross-sectional study using the U.S. National and Nutrition Examination Survey 2011-2016 data (N=4538) found that Hispanics had a greater prevalence of NAFLD, while non-Hispanic Blacks had a higher prevalence of severe NAFLD (Le et al., 2020). Patatin-like phospholipase domain-containing protein 3 (PNPLA3) was associated with the severity of the disease, which was observed among 40% of PLWH, with the highest frequency of the allele in Hispanics (Sherman et al., 2021).

Additionally, studies show that PLWH progress to fibrosis or liver cancer faster (Lemoine et al., 2019; Lui et al., 2016; Vodkin et al., 2015), with 13% of deaths in this population attributable to chronic liver disease (Smith et al., 2014).

NAFLD and Depression and Anxiety

Depression is two-to-four times higher in PLWH than in the general population, with a prevalence four times greater in HIV-infected females than HIV-uninfected males (Bing et al., 2001; Olley et al., 2006). Few studies have demonstrated that depression and anxiety are associated with NAFLD in PLWH. In a sample size of 567 biopsied NAFLD individuals, severe depressive symptoms were associated with advanced NAFLD (Youssef et al., 2013), and depressed individuals were 2.1 times more likely to have severe NAFLD. Kim et al. (2019) study (N=10,484) found that depressed individuals were more likely to develop NAFLD than non-depressed individuals, even after controlling for confounders. Lee & Park (2021) found a significant association between

NAFLD and depression (N=25,333), with a 44% increased risk of depression in women but not men. Tomeno et al. (2015) observed similar findings (N=258) and establishing an association between major depressive disorder and worse treatment outcomes. However, these studies excluded PLWH or did not specify the HIV status of their study participants.

NAFLD and HIV Stigma and Discrimination

With 85% of PLWH experiencing stigmatization (Baugher et al., 2019; Katz et al., 2013), HIV stigma is a severe public health concern (Ingram et al., 2019). It may result in worry, poor quality of life, and suicidal thoughts, as well as dangerous health-seeking behaviors, limited adherence to care and treatment, worsening NAFLD, and rapid development to liver cancer or cirrhosis (Fumaz et al., 2012; Gonzalez-Zacarias et al., 2016). In addition, HIV stigma and discrimination result in psychological distress. They are connected with depressive and anxious states, chronic illnesses such as insulin resistance and cardiovascular diseases, and hazardous health behaviors such as alcohol abuse and smoking (Macchi et al., 2020; Meng et al., 2020; Turan et al., 2016). Psychosocial variables, including sadness, anxiety, HIV stigma, and prejudice, may affect the efficacy of preventative and therapeutic methods for NAFLD. To comprehend how HIV stigma, discrimination, depression, and anxiety contribute to the development and severity of NAFLD (Calzadilla Bertot & Adams, 2016; Ingram et al., 2019), a study comparing the prevalence of NAFLD among PLWH experiencing these conditions is required.

Conceptual Framework

NAFLD is complex and multifactorial, suggesting that individual-level interventions alone may not address this epidemic. According to Bronfenbrenner (1977), an individual's health and health behavior are affected by the interaction between factors at the individual level (personal and biological characteristics) and the social system level (interpersonal, community, institutional, and policies). Therefore, the social-ecological model initially developed by Bronfenbrenner to understand the complex interplay between individual and social systems is well suited to inform the conceptual framework (Figure 1) that guided the proposed study. In this proposed framework, individual-level factors (e.g., race/ethnicity, smoking status) interact with each other and are thought to directly influence NAFLD outcomes (e.g., cirrhosis, fibrosis), while social factors (e.g., homelessness) also indirectly affect the outcomes of NAFLD. NAFLD negatively impacts an individual's quality of life, resulting in morbidity and premature death, and has social consequences that include straining health and economic resources. Therefore, effective management of comorbidities such as HIV infection, NAFLD requires an understanding of individual characteristics and social determinants of health.

Innovation

The proposed study is innovative as it is the first to examine psychosocial factors associated with NAFLD development among PLWH using a population-based sample. Specifically, it has the potential to identify the association between stigma, discrimination, and NAFLD among PLWH, a critical gap in the literature. The findings of this study could also strengthen the evidence of the association between depression, anxiety, and NAFLD. Such new evidence is needed to inform tailored NAFLD

prevention strategies for PLWH. In addition, this study is the first to use a simple, noninvasive, validated tool for a representative population-based sample of PLWH and the first to estimate NAFLD prevalence among PLWH in Houston/Harris County, Texas. The proposed study may add to existing knowledge of sociodemographic, clinical, and behavioral factors that increase susceptibility to NAFLD among PLWH. Identifying NAFLD's predictors, particularly psychosocial predictors among PLWH, will enable risk stratification strategies and early interventions, potentially improving the health outcomes of PLWH.

Approach

Research Design & Setting

The proposed study was a secondary data analysis of the Houston Medical Monitoring Project (MMP) cross-sectional population-based survey data collected between June 2015 and May 2020 among PLWH in Houston/Harris County, Texas.

Data Collection

Data Source

The data for this study was obtained from the Houston Health Department MMP. MMP is an ongoing national surveillance survey designed by the Centers for Disease Control and Prevention (CDC) to assess the experiences and needs of adults living with HIV in the United States. The project is supported by several government agencies and conducted by trained staff from state and local health departments (Beer et al., 2019). The MMP survey was designed to be representative of the adult HIV population living in the United States, and its goal was to monitor the sociodemographic, clinical, and behavioral characteristics of PLWH. The survey employs a two-stage sampling technique: the first

stage was from the U.S. national HIV population estimates (including the District of Columbia and Puerto Rico), and the second stage involved a simple random sampling of adults diagnosed with HIV from each funded jurisdiction (Beer et al., 2019). The CDC supports MMP in 23 jurisdictions: 16 states, six large metropolitan areas (including Texas and Houston), and Puerto Rico. The survey runs from June 1 of a given year to May 31 of the following year.

Data Collection Procedures

Data from 819 adults diagnosed with HIV in the Houston/Harris County, Texas, were collected between June 2015 through May 2020 via telephone or face-to-face interviews and medical record abstractions. Structured interviews were conducted by trained project personnel in English and Spanish using a questionnaire designed by the CDC. Eligible participants of the Houston MMP survey included individuals 18 years and older at the time of the interview, diagnosed with HIV, and resided in Houston/Harris County, Texas. Participants gave informed consent to participate in the survey and were interviewed by trained project staff. In addition, the clinical information of participants was collected via a 2-year retrospective review of medical records. Further information on the survey and the data collection procedures, including eligibility and sampling method used, are described in detail elsewhere (Beer et al., 2019; Johnson et al., 2020).

Sample Size and Power

Study Inclusion and Exclusion Criteria. For this proposed study, the sample included 18 and older participants who completed the survey between June 2015 and May 2020 and have data needed to calculate the Triglyceride Glucose (TyG) Index. Participants were excluded if they had a history of viral hepatitis (hepatitis B, hepatitis

C), documented liver disease, liver transplant, abdominal bypass surgery, or alcohol use disorder, and use of steatogenic medications (Chalasani et al., 2018).

Sample Size Estimation. Several studies found that the prevalence of NAFLD in the HIV population is higher than the estimated prevalence of 24% in the U.S. general population (Younossi et al., 2016). However, assuming similar prevalence in both people, the sample size available from the primary study is estimated as 0.24*819 = 197. Per calculations, to detect a medium effect size of 0.30, with 90% power, at an alpha level of 0.05, a sample size of *N*=183 was estimated using G-Power Software (Figure 2). Therefore, a final sample size of N=183 was sufficient for this proposed study and consequently ensured the reliability and validity of the study measures and findings.

Instruments

The MMP dataset comprises several sections, including but not limited to basic demographics, HIV medical care and services utilization, barriers and facilitators to care, HIV treatment and adherence, sexual behaviors, depression and anxiety, stigma, and discrimination. The scales used to measure stigma, discrimination, depression, and stress in MMP are as follows:

HIV Stigma Scale (Appendix A)

The HIV Stigma Scale measures internalized and externalized stigma using a validated 10-item HIV Stigma Scale on a 5-point Likert scale (Appendix A). HIV stigma was defined as the median score on the HIV stigma scale from 0 (no stigma) to 100 (high stigma). The scale has four subscales, each with a good internal consistency ranging from 0.72 to 0.84 (Beer et al., 2019; Williams et al., 2020).

Everyday Discrimination Scale (Appendix B)

A modified version of the Everyday Discrimination Scale (see Appendix B), an 8-item questionnaire, was used to measure perceived discrimination in HIV care (Bird et al., 2004). Perceived discrimination was defined as reporting at least one discriminatory experience in a healthcare setting since the HIV diagnosis (Baugher et al., 2019). The first seven items were rated on a five-point Likert scale (Cronbach $\alpha = 0.92$). Respondents who reported perceived discrimination were asked a series of follow-up questions (eight-item). The eight-item assessed behaviors associated with perceived discrimination (Cronbach $\alpha = 0.95$).

Patient Health Questionnaire Eight-item (PHQ-8) (Appendix C)

PHQ-8 measures the frequency of depressed mood among survey participants in the last two weeks before the interview using an eight-item questionnaire. A cutoff score of ≥ 10 indicates moderate or severe depression, with a sensitivity and specificity of 88% (Beer et al., 2019).

General Anxiety Disorder Seven-item (GAD-7) (Appendix D)

The GAD-7 measures the severity of anxiety experienced two weeks before the interview using a validated seven-item (Appendix D). The total score is categorized into four groups, where a cutoff anxiety score of ≥ 10 indicates moderate-to-severe GAD symptoms with adequate sensitivity (89%) and specificity (82%) (Beer et al., 2019).

Triglyceride Glucose (TyG) Index

NAFLD, which comprises steatosis, steatohepatitis, fibrosis, and cirrhosis in the absence of alcohol and other causes of liver disease, is defined as a higher than 5% buildup of fat in the liver (Chalasani et al., 2018). In this proposed study, the presence

and severity of NAFLD were assessed in the study sample using TyG Index, a noninvasive NAFLD screening tool.

Initialized as a measure of insulin resistance, the TyG index is defined as the logarithm of the product of fasting triglycerides and fasting plasma glucose divided by two (Simental-Mendía et al., 2008). Recent interest has focused on TyG as a simple and effective method for identifying persons at risk for NAFLD in clinical settings (Guerrero-Romero et al., 2016; Zhang et al., 2017) in diverse populations, including PLWH (Busca et al., 2022). Following is the TyG Index formula (Simental-Mendía et al., 2008):

TyG= Ln [Fasting Triglycerides (mg/dL) x Fasting Plasma Glucose (mg/dL)/2]

The established cutoff > 8.38 has a diagnostic accuracy of 90% (sensitivity = 94%; specificity = 57%) in a sample of monoinfected PLWH who underwent liver biopsies (Busca et al., 2022). Similar diagnostic accuracy was confirmed with the same cutoff >8.38 when validated in a general population and compared with liver biopsies; it had a positive predictive value of 99% for diagnosing 5% NAFLD, with sensitivity = 80% and specificity = 92% (Fedchuk et al., 2014). Additionally, a cutoff > 8.75 has a positive predictive value of only 64% for predicting >33% steatosis (sensitivity = 58%; specificity = 58%); a cutoff < 8.91 has a negative predictive value of 94.4% for excluding advanced fibrosis (Smiderle et al., 2021). Consequently, the following criteria are proposed to classify the severity of NAFLD in the study participants: TyG ≤ 8.38 (*no steatosis*; < 5%), 8.38 > TyG ≤ 8.75 (*mild steatosis*; 5-33%), 8.75 > TyG < 8.91 (*moderate steatosis; 33-66%*), and TyG ≥ 8.91 (*severe steatosis; >66%*).

Data Analysis

Data Management and Preparation

Variables to be included in the analyses are summarized in Tables 1-3 and briefly discussed below. The independent variables of interest were re-categorized if necessary. The TyG score was computed using clinical variables (fasting Triglyceride and plasma glucose). Comorbidities relevant to NAFLD (diabetes, obesity, hypertension, cardiovascular disease) were extracted from the medical records.

Outcome Measures. The primary outcome in this study was NAFLD, defined first as a categorical variable, the presence (yes/no), and later as the severity (mild, moderate, severe) of NAFLD, which was measured using the TyG Index.

Independent Variables. The independent variables were classified broadly under sociodemographic, behavioral, clinical, and psychosocial characteristics. A detailed list of the variables within each broad category and their respective levels/categories are presented in Table shells 1- 3.

Sociodemographic characteristics (Table 1): These variables included gender at birth, current gender, age group, education level, race/ethnicity, type of insurance (past 12 months), homelessness, sexual orientation, marital status, foreign-born, annual household income, poverty level, food insecurity (see Table 1).

Behavioral Characteristics (Table 1)*:* alcohol use, smoking status, non-injection drug use, and injection drug use in the last 12 months (see Table 1).

Clinical characteristics (Table 2): time since HIV diagnosis, BMI, antiretroviral therapy use, CD4 Count, Viral Load, and antiretroviral therapy adherence. Clinical

variables also included other chronic health conditions relevant to NAFLD (e.g., diabetes mellitus with no distinction between type 1 and type 2 hypertension).

Psychosocial characteristics (Table 3): depression, anxiety, HIV stigma, and discrimination.

Analysis Plan

Descriptive statistics, such as means (± standard errors), and coefficient of variation, were used to describe quantitative measures such as NAFLD, age, and clinical variables as applicable. In contrast, categorical variables were described using frequency runs and proportions. All proportional distributions were represented as weighted percentages generalizable to all PLWH residing in Houston/Harris County, Texas. Furthermore, bivariate analyses were conducted to determine the independent associations between the dependent measures (NAFLD status, NAFLD severity) and sociodemographic, behavioral, clinical, and psychosocial characteristics using the Rao-Scott Chi-Square test. Based on the MMP survey design, using the Rao-Scott Chi-Square test allows for a design-based test of goodness of fit using the survey weights. Following the results of the bivariate analyses, factors independently associated with the outcome measures were evaluated.

Sociodemographic, behavioral, clinical, and psychosocial variables associated with the outcome measures at p-value=0.10 or less were selected a priori for inclusion in the multivariable logistic regression models. Accordingly, the number of predictor variables that met the entry criteria varied slightly within each model. However, if not statistically significant in the bivariate analyses, the investigator forced epidemiologically important variables (age group, gender, and race/ethnicity), variables that are relevant

(diabetes, hypertension) in the development of NAFLD into all analytical models. Before carrying out the analyses, the investigator tested the dataset to ensure that multivariable logistic regression model assumptions were met. Furthermore, multicollinearity was evaluated by conducting a simple correlation analysis among the independent variables. Finally, the investigator used multivariable logistic regression to investigate the relationship between the explanatory variables (sociodemographic, behavioral, clinical, and psychosocial factors) and the severity of NAFLD.

These proposed analytical approaches allowed for simultaneous adjustments of the independent factors and any potential confounders due to bias and produced more efficient estimates of unadjusted and adjusted odds ratios and corresponding 95% confidence interval (CI) and *p*-values. All models' diagnostics and fit statistics were performed using the Log-likelihood test, uncertainty coefficient of determination, and corrected Akaike information criterion (AIC) and Bayesian information criterion (BIC) (Vrieze, 2012). In addition, a recursive partitioning analysis was performed to determine the contributions of significant predictors to the severity of NAFLD in the study sample. This analysis produced the response and count probabilities by the independent factors' levels, the number of splits, and the coefficient of determination (R^2).

All tests performed were two-tailed, with a probability value of 0.05 used as the threshold for declaring statistical significance. All statistical analyses applied survey procedures that considered the complex sampling design of the MMP and the associated unequal selection probabilities and non-response. Missingness was addressed using the Fully Efficient Fractional Imputation (FEFI) technique (Kim and Fuller, 2004; Fuller and Kim, 2005). FEFI uses information from all subjects to impute missing values in each

recipient unit. The PROC SURVEYIMPUTE (SAS/STAT User's Guide, SAS Institute, Cary, NC, USA) was used to create imputation-adjusted replicate weights, and to compute replication variance estimates. The investigator used SPSS version 28.0 (IBM SPSS Statistics for Windows, version 28) for initial data management, and subsequently SAS version 9.4 for statistical analyses. In addition, graphical representations, modeling, and data visualizations were carried out using the JMP statistical discovery™ software version 14.3 (SAS Institute, Cary, NC, USA).

Aim 1. To estimate the prevalence of NAFLD among PLWH in Houston/Harris County, Texas.

Descriptive statistics and bivariate analysis were used to test the hypotheses that NAFLD is prevalent among PLWH, and the prevalence estimates vary significantly by sociodemographic, behavioral, clinical, and psychosocial factors. These analyses generated evidence on NAFLD prevalence among PLWH in Houston/Harris County, Texas.

Aim 2. To determine the sociodemographic, behavioral, and clinical psychosocial factors associated with the severity of NAFLD (mild, moderate, severe) among PLWH in Houston/Harris County, Texas.

The Rao-Scott Chi-Square test was used to test the hypothesis that there is a significant association between the severity of NAFLD and sociodemographic, behavioral, clinical, and psychosocial factors among PLWH in Houston/Harris County, Texas. In addition, the findings of this study identified the subgroups of PLWH that are at higher risk for NAFLD for intervention purposes.

Aim 3. To determine the predictors of NAFLD development (No NAFLD/NALFD) and severity (mild, moderate, severe) among PLWH in Houston/Harris County, Texas.

In a Multivariable Logistic Regression Model, the investigator tested the hypothesis that race/ethnicity, HIV duration, viral load, smoking, and homelessness significantly predicted the severity of NAFLD.

In addition, Recursive Partitioning analysis was performed to test the hypothesis that the level of contribution of identified predictors to the severity of NAFLD vary significantly. These analyses characterized individuals at the highest risk for NAFLD who may benefit from close monitoring and early intervention.

Study Limitations, Potential Problems

The MMP uses a robust sampling methodology and a well-designed survey process; however, its purpose was not specifically designed to assess the presence of NAFLD among PLWH. Therefore, the NAFLD prevalence obtained with this data may not represent the true prevalence among PLWH in Houston/Harris County, Texas, as liver biopsy is the gold standard for diagnosing NAFLD (Chalasani et al., 2018). Unfortunately, liver biopsy information is not currently available in the MMP dataset.

Non-response in survey data can compromise the quality of survey results due to biased estimates and inaccurate representation of the survey population. MMP, like any other survey data, also has missing values for some items. Several imputation techniques can be used to impute missing values for survey data. The FEFI technique was chosen for imputation because it can be used for complex surveys with multi-stage designs; does not add any extra variability due to the selection of donors; does not use any explicit models,

uses only observed values as the imputed values and preserves the relationship between multiple survey items in the original data.

A significant limitation of using data from medical records is the potential for documentation errors. For example, laboratory reports such as glucose levels may not specify the participants' fasting status. Finally, the MMP dataset contains self-reported information, subject to recall bias and social desirability. Therefore, the investigator used the medical diagnosis where applicable to validate participants' responses. Because this project uses secondary data from a cross-sectional study, the investigator cannot establish causality.

Human Subjects, Risk and Benefits to Subjects

The MMP dataset is de-identified and contains no personal or other identifying information linked to the participants. Thus, this study presents no risk to the participants. The proposed research findings could improve the quality of care among PLWH and support using noninvasive tools to screen for NAFLD in clinical practice. In addition, the results of this study could inform the design of interventions among PLWH who experience stigma, discrimination, depression, and anxiety and may be at higher risk for NAFLD. The investigator received permission to use the MMP dataset for the proposed study, with an agreement to keep and use the dataset obtained from the Houston Health Department's secure network server. The MMP survey is a non-research public health surveillance activity; thus, it is not subject to human subjects' regulations, including institutional review board oversight. Nevertheless, the investigator sought and received the institutional review board's approval for the proposed study.

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Figure 1

Conceptual Framework of Factors Associated with Nonalcoholic Fatty Liver Disease (NAFLD) in PLWH

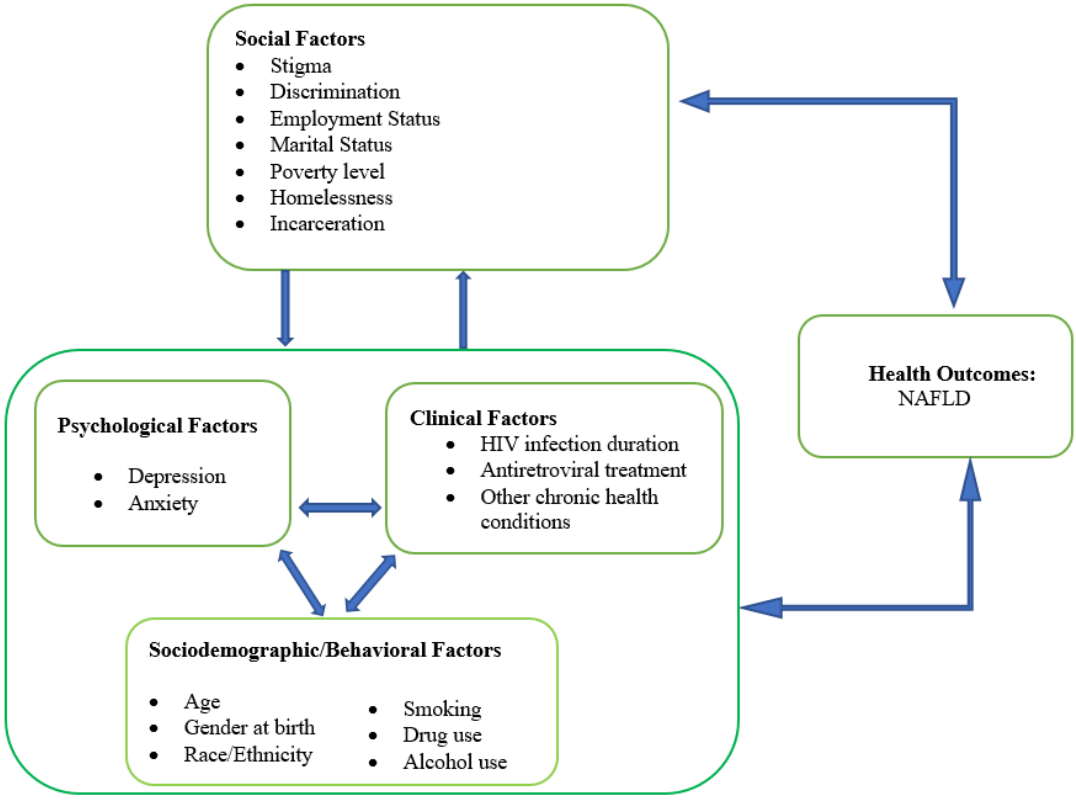
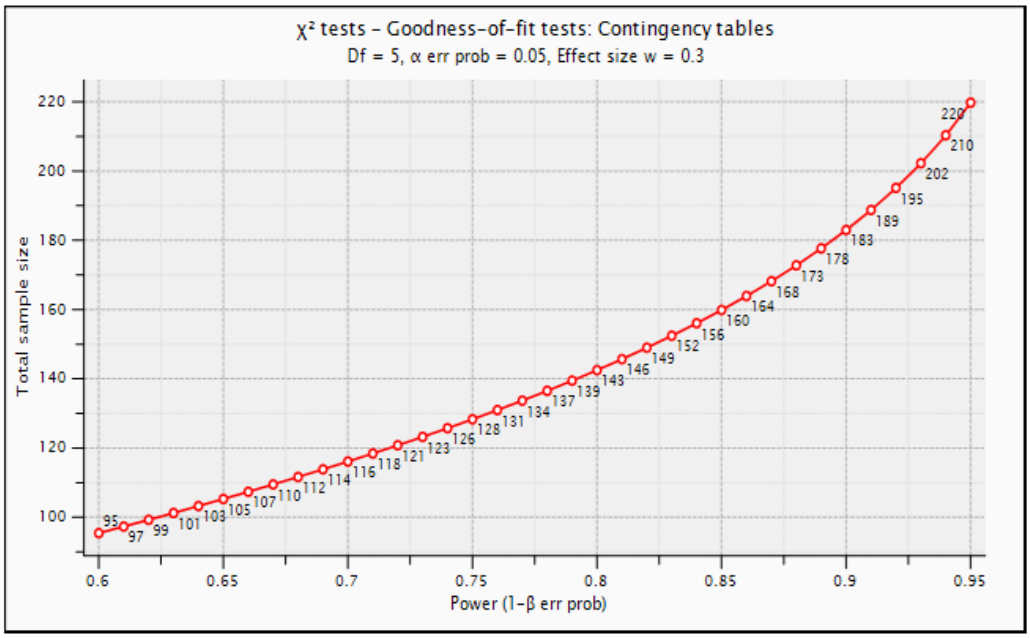


Figure 2

Study Sample Size Estimation



Appendix A

HIV Stigma Scale

HIV Stigma Scale

Questionnaire Items	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
Personalized Stigma					
I have been hurt by how people reacted to learning I have HIV					
I have stopped socializing with some people because of their reactions to my HIV status					
I have lost friends by telling them I have HIV					
Disclosure					
I am very careful who I tell that I have HIV					
I worry that people who know I have HIV will tell others					
Negative Self-image					
I feel that I am not as good a person as others because I have HIV					
Having HIV makes me feel unclean					
Having HIV makes me feel that I am a bad person					
Public Attitudes					
Most people think that a person with HIV is disgusting					
Most people with HIV are rejected when others find out					

Source: Wright, K., Naar-King, S., Lam, P., Templin, T., & Frey, M. (2007). Stigma scale revised: Reliability and validity of a brief measure of stigma for HIV+ youth. *Journal of Adolescent Health, 40*(1), 96-98.

Appendix B

Everyday Discrimination Scale

Everyday Discrimination Scale

In the past **12 months,** when receiving treatment for HIV:	Never	Rarely	About half the time	Most of the time	Always
How often were you treated with less courtesy than other people?					
How often were you treated with less respect than other people?					
How often have you received poorer service than others?					
How often has a doctor or nurse acted as if he or she thought you were not smart?					
How often has a doctor or nurse acted as if he or she was afraid of you?					
How often has a doctor or nurse acted as if he or she was better than you?					
How often have you felt like a doctor or nurse was not listening to what you were saying?					

If the respondent reports rarely (1), about half the time (2), most of the time (3) or always (4), ask the question below:

Did the discrimination occur because …	No	Yes	Do not Know	Refused to answer
Of your HIV infection				
Of your gender				
Of your sexual orientation or sexual practices?				
Of your race or ethnicity?				
Of your income or social class				
Someone at your doctor's office or clinic thought you injected drugs?				

Source: Bird, S. T., Bogart, L. M., & Delahanty, D. L. (2004). Health-related correlates of perceived discrimination in HIV care. *AIDS Patient Care and STDs*, *18*(1), 19-26.

Appendix C

Patient Health Questionnaire Eight-item (PHQ-8)

Patient Health Questionnaire Eight-item (PHQ-8)

Over the **last 2 weeks**, how often have you been bothered by any of the following problems?
*(circle **one** number on each line)*

How often during the past 2 weeks were you bothered by...	Not at all	Several days	More than half the days	Nearly every day
1. Little interest or pleasure in doing things	0	1	2	3
2. Feeling down, depressed, or hopeless	0	1	2	3
3. Trouble falling or staying asleep, or sleeping too much	0	1	2	3
4. Feeling tired or having little energy	0	1	2	3
5. Poor appetite or overeating	0	1	2	3
6. Feeling bad about yourself, or that you are a failure, or have let yourself or your family down	0	1	2	3
7. Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8. Moving or speaking so slowly that other people could have noticed. Or the opposite – being so fidgety or restless that you have been moving around a lot more than usual	0	1	2	3

Scoring

If two consecutive numbers are circled, score the higher (more distress) number. If the numbers are not consecutive, do not score the item. Score is the sum of the 8 items. If more than 1 item missing, set the value of the scale to missing. A score of 10 or greater is considered major depression, 20 or more is severe major depression.

Major depression" (≥ 5 symptoms) and "other depression" (2-4 symptoms) at least "more than half the days," and one of the symptoms must include anhedonia or feelings of hopelessness, or no depression (0- 1 symptom), per the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV).

Source: Kroenke, K., Strine, T. W., Spitzer, R. L., Williams, J. B., Berry, J. T., & Mokdad, A. H. (2009). The PHQ-8 as a measure of current depression in the general population. *Journal of Affective Disorders, 114*(1-3), 163-173.

Appendix D

General Anxiety Disorder Seven-item (GAD-7)

General Anxiety Disorder Seven-item (GAD-7)

Over the last two weeks, how often have you been bothered by the following problems?	Not at all	Several days	More than half the days	Nearly every day
1. Feeling nervous, anxious, or on edge	0	1	2	3
2. Not being able to stop or control worrying	0	1	2	3
3. Worrying too much about different things	0	1	2	3
4. Trouble relaxing	0	1	2	3
5. Being so restless that it is hard to sit still	0	1	2	3
6. Becoming easily annoyed or irritable	0	1	2	3
7. Feeling afraid, as if something awful might happen	0	1	2	3

Column totals _____ + _____ + _____ + _____ =

Total score _____

If you checked any problems, how difficult have they made it for you to do your work, take care of things at home, or get along with other people?

Not difficult at all	Somewhat difficult	Very difficult	Extremely difficult
☐	☐	☐	☐

Source: Primary Care Evaluation of Mental Disorders Patient Health Questionnaire (PRIME-MD-PHQ). The PHQ was developed by Drs. Robert L. Spitzer, Janet B.W. Williams, Kurt Kroenke, and colleagues. For research information, contact Dr. Spitzer at ris8@columbia.edu. PRIME-MD® is a trademark of Pfizer Inc. Copyright© 1999 Pfizer Inc. All rights reserved. Reproduced with permission

Scoring GAD-7 Anxiety Severity

This is calculated by assigning scores of 0, 1, 2, and 3 to the response categories, respectively, of "not at all," "several days," "more than half the days," and "nearly every day."
GAD-7 total score for the seven items ranges from 0 to 21.

0–4: minimal anxiety

5–9: mild anxiety

10–14: moderate anxiety

15–21: severe anxiety

Table 1

Sociodemographic and Behavioral Characteristics of Study Participants by NAFLD Status

Characteristics	NAFLD Status					
	Total, n (%)	**None**	**Mild**	**Moderate**	**Severe**	**χ2 p-value**
Sociodemographic						
Age group (years)						
18-29						
30-39						
40 – 49						
≥ 50						
Gender at Birth						
Male						
Female						
Sexual Orientation						
Lesbian or gay						
Heterosexual or Straight						
Bisexual						
Other						
Race/Ethnicity						
White (Non-Hispanic)						
Black (Non-Hispanic)						
Hispanic/Latino						
Other (Non-Hispanic)						
Educational Level						
< High school						
High School/ GED						
> High School						
Foreign-Born						
Yes						
No						
English- Speaking						
Yes						
No						
Homeless (last 12 months)						
No						
Yes						
Disability						
No						
Yes						
Marital Status						
Married						
Civil union/domestic partnership						
Divorced						
Widowed						
Separated						
Never married						

Table 1 (Continued)

Characteristics	NAFLD Status					
	Total, n (%)	**None**	**Mild**	**Moderate**	**Severe**	**χ2 p-value**
Insurance						
Private						
Public						
Ryan White Only						
Uninsured						
Employment Status						
Employed						
Unemployed						
Student						
Retired						
Annual Household Income (U.S. $)						
0 -19,999						
20,000 – 39,999						
40,000 -74,999						
≥75,000						
Poverty Level						
Above						
At or below						
Food Insecurity						
Yes						
No						
Incarceration						
No						
Yes						
Behavioral						
Smoking status (last 12 months)						
Never smoked						
Former smoker						
Current smoker						
Use of non-injection drugs (last 12 months)						
No						
Yes						
Use of injection drugs (last 12 months)						
No						
Yes						
Alcohol use (last 12 months)						
No						
Yes						

Table 2

Clinical Characteristics of Study Participants by NAFLD Status

Characteristics	NAFLD Status					
	Total, n (%)	**None**	**Mild**	**Moderate**	**Severe**	**χ2 p-value**
Age group at diagnosis 18-29 30-39 40 – 49 ≥ 50						
AST, U/L						
ALT, U/L						
Triglycerides, mg/dL						
HDL, mg/dL						
Systolic BP, mmHg						
Diastolic BP, mmHg						
Time since HIV diagnosis (years) < 5 years 5-9 years ≥ 10						
HIV infection stage 3 (AIDS) No Yes (CD4 ≤ 199)						
Lowest CD4 Count, past 12 months 0 – 199 200 – 349 350 – 499 ≥ 500						
ART Use (last 12 months) No Yes						
ART Use Duration (years) < 5 5-9 ≥ 10						
Viral Suppression Undetectable, < 200 copies/mL Detectable, ≥ 200 copies/mL						
Sustained viral suppression. Undetectable or < 200 copies/mL ≥ 200 copies/mL, or missing/unknown						
Chronic health conditions Diabetes Mellitus Hypertension Hyperlipidemia Cardiovascular disease Metabolic Syndrome Other						

Table 3

Psychosocial Characteristics of Study Participants by NAFLD Status

Characteristics	NAFLD Status					
	Total, n (%)	**None**	**Mild**	**Moderate**	**Severe**	**χ2 p-value**
Depression						
No Depression						
Major Depression						
Other Depression						
Anxiety						
No Anxiety						
Mild Anxiety						
Moderate Anxiety						
Severe Anxiety						
HIV Stigma (last 12 months)						
Yes						
No						
Discrimination (last 12 months)						
No						
Yes						

Manuscript 1

Prevalence and Risk Factors Associated with the Presence of Nonalcoholic Fatty Liver Disease Among People Living with HIV: A Cross-sectional Study

Abstract

Background: People living with the human immunodeficiency virus (HIV) are more likely to develop comorbidities such as nonalcoholic fatty liver disease (NAFLD). HIV infection and antiretroviral drug exposure have been suggested to significantly contribute to the prevalence of NAFLD among People living with HIV (PLWH). Many risk factors associated with NAFLD are preventable, but early screening and heightened awareness are required. Moreover, due to the adverse liver outcomes and poor quality of life associated with NAFLD and its complications, there is an urgent need to identify high risk individuals. The objective of this study was to estimate the prevalence of NAFLD among PLWH in Houston/Harris County, Texas.

Methods: Data used for this study was obtained from the Medical Monitoring Project, a population-based cross-sectional survey conducted in Houston/Harris County, Texas, between 2015 and 2020. The triglyceride glucose index (cutoff value of >8.38), a noninvasive biomarker derived from the logarithm of fasting triglyceride and blood glucose levels, was used to assess NAFLD. Descriptive statistics were used to describe the study population, and the Rao-Scott Chi-Square test was conducted to determine the independent associations between demographic, behavioral, clinical, and psychosocial characteristics, and the presence of NAFLD. Results were reported as weighted frequencies, percentages, and a 95% confidence interval (CI).

Results: Overall the prevalence of NAFLD was 98.20% in PLWH in Houston/Harris County, Texas between 2015-2019. The prevalence of NAFLD was higher among individuals 50 years of age and older, males, and Black PLWH. The use of the integrase strand transfer inhibitor (INSTI) was significantly associated with NAFLD (p=0.0376). Overall, participants with NAFLD were more likely to have higher alanine transaminase (29.43 ± 1.25; p= 0.0004), lower high-density lipoprotein (48.50 ± 0.63; p=0.0411), higher creatinine (1.14 ± 0.07; p=0.0090), and elevated fasting triglycerides (159.77 ± 1.25; p<0.0001). In addition, participants with NAFLD were more likely to have lower antiretroviral adherence (79 ± 1.70, p=0.4214), although this difference was not statistically significant.

Conclusion: PLWH are at increased risk for NAFLD. In addition to conventional risk factors (e.g., elevated fasting triglycerides, glucose, reduced HDL, and ALT), the use of an INSTI may be an HIV-specific risk factor. Providers should, therefore, closely monitor, screen, and counsel PLWH with these identified risk factors and refer them to a liver specialist.

Keywords: HIV, People living with HIV, PLWH, NAFLD, triglyceride glucose index.

Prevalence and Risk Factors Associated with the Presence of Nonalcoholic Fatty Liver Disease Among People Living with HIV: A Cross-sectional Study

Introduction

Despite highly effective antiretroviral therapy, people living with human immunodeficiency virus (HIV) are vulnerable to comorbidities such as nonalcoholic fatty liver disease (NAFLD). NAFLD is becoming the most prevalent form of chronic liver diseases and the second leading cause of death among people living with HIV (PLWH) (Smith et al., 2014; Wong et al., 2015). In the United States, NAFLD accounts for 75% of chronic liver diseases (Cotter & Rinella, 2020; Kim et al., 2013; Younossi et al., 2023). The prevalence of NAFLD is between 30% and 34% among the general non-HIV population (Younossi et al., 2023), and 76% in PLWH (Lemoine et al., 2019).

NAFLD is the accumulation of triglycerides in liver cells at a level of 5% or higher (Chalasani et al., 2018). The spectrum of NAFLD includes simple steatosis, nonalcoholic steatohepatitis (NASH), fibrosis, and cirrhosis in the absence of alcohol and other risk factors for liver disease (Younossi et al., 2016). NAFLD is a complex disease, and its pathogenesis in HIV infection is still unclear. While researchers continue to investigate the role of HIV infection and the precise mechanism of antiretroviral drugs in the development and severity of NAFLD, other comorbidities have been identified as significant contributors. For example, strong associations exist between NAFLD and insulin resistance, type 1 and type 2 diabetes, obesity, and hypertension (Cervo et al., 2022; Ding et al., 2017; Harrison et al., 2021; Mertens et al., 2021; Vodkin et al., 2015). These chronic conditions increase the risk of cardiovascular disease and death among PLWH (Kaplan et al., 2020). Risk factors such as older age, male gender, race, ethnicity,

and genetics are also associated with the development and severity of NAFLD (Harrison et al., 2021; Soti et al., 2018).

Chronic immune activation, inflammation, and antiretroviral therapy are additional drivers in HIV infection (Cassol et al., 2013; Maurice et al., 2019; Rasoulinejad et al., 2020; Vodkin et al., 2015). Several studies have also demonstrated that certain classes of antiretroviral medications (e.g., integrase and protease inhibitors) are associated with imbalanced lipid profiles and insulin dysregulation (Galdamez et al., 2019; Koethe et al., 2020; Maurice et al., 2017). HIV duration is also strongly associated with NAFLD (Maurice et al., 2017; Tiozzo et al., 2021). PLWH are at higher risk for severe NAFLD (Vodkin et al., 2015), thus it is necessary to identify modifiable risk factors that can inform risk stratification strategies and public health interventions.

Although liver biopsy is the gold standard for diagnosing NAFLD, its risks and costs limit its population-level implementation (Mosca et al., 2004). Noninvasive biomarkers developed using serum-based markers, are becoming more attractive and promising in predicting the presence of NAFLD (Hernandez Roman & Siddiqui, 2020; Simental-Mendía et al., 2021). As such, create an opportunity to identify those at a higher risk of developing NAFLD very early. For instance, the triglyceride-glucose (TyG) index, which was initially developed as a surrogate marker for insulin resistance (Guerrero-Romero et al., 2016; Simental-Mendía et al., 2008), is reliable in detecting at least 5% or more of fat in the liver in various populations (Fedchuk et al., 2014; Li et al., 2022; Zhang et al., 2017). In a meta-analysis, a higher TyG index was associated with an increased likelihood of NAFLD. Noninvasive biomarkers may be an independent

predictive tool for screening high-risk patients in clinical practice, particularly primary care (Beran et al., 2022).

NAFLD currently has no approved treatment. However, increased awareness may result in counseling and lifestyle modifications, the first and most effective strategies for preventing and slowing disease progression (Seth & Sherman, 2019). The limited treatment options and asymptomatic nature of NAFLD support the use of noninvasive biomarkers. Furthermore, the costs associated with NAFLD, and its complications continue to rise, placing a strain on healthcare resources. Inpatient hospitalization costs for NAFLD patients increased from $7.7 billion in 2007 to $19.9 billion in 2014 (Hirode et al., 2019). The lifetime cost of NASH per patient in the United States was determined to be $32,249 (Younossi et al., 2016). In addition to these costs, the loss of lives incurred by society makes the NAFLD epidemic an urgent public health crisis that must be addressed.

The asymptomatic nature of NAFLD affects both diagnosis and outcome. Individuals at risk can develop NASH, cirrhosis, fibrosis, and hepatocellular cancer (Mittal et al., 2016; Petrelli et al., 2022; Thomas et al., 2022). These adverse liver effects merit consideration. While elevated liver enzymes may potentially signal liver dysfunction, they don’t accurately help in identifying the presence of NAFLD, as NAFLD can also occur in individuals with normal liver enzymes (Cusi et al., 2022; Morrison et al., 2019). Because the progression of the disease does not follow a cyclical pattern, early diagnosis and monitoring of at-risk individuals are crucial for improving health outcomes.

Morbidity and mortality associated with NAFLD are costly. By 2030, 44% of the general population in the United States will have NAFLD, indicating that the economic burden will exceed $1 trillion (Estes et al., 2018; Noureddin & Rinella, 2015; Younossi et al., 2020). NAFLD is also the leading indication for liver transplantation in the United States, specifically NASH (Noureddin & Rinella, 2015). A Markov model predicts that the prevalence of NASH will rise from 20% to 27%, decompensated NASH cirrhosis will reach 168%, liver-related deaths will reach 178%, and incident hepatocellular carcinoma will reach 133% by 2030 (Estes et al., 2018). Despite these staggering statistics, early identification of high-risk individuals such as PLWH remains challenging.

The prevalence of NAFLD has been documented in PLWH in the United States (Morse et al., 2015; Sterling et al., 2013; Vodkin et al., 2015). While in Texas, the prevalence is 37.5% in the general population, 57% among those with diabetes, and 70% among overweight people (Harrison et al., 2021), the prevalence of PLWH in Houston and Harris County, Texas, remains unknown. Given the high HIV prevalence in Houston and Harris County, knowledge of the prevalence of NAFLD is needed to inform public health prevention strategies and policymakers. More importantly, such information is required to raise awareness among at-risk individuals and healthcare professionals. Consequently, this cross-sectional study aimed to estimate the prevalence of NAFLD among PLWH in Houston/Harris County, Texas.

Methods

Research Design and Setting

This was a cross-sectional study of the 2015–2019 cycle data from the Houston Medical Monitoring Project (MMP). The Houston MMP is an annual population-based

survey that collects data from a representative sample of PLWH in Houston and Harris County, Texas.

Data Source

The investigator used the 2015- 2019 cycles of Houston MMP data. For each annual cycle, data were collected between June of each cycle year and May of the subsequent cycle year. The MMP is an ongoing surveillance system of the Centers for Disease Control and Prevention (CDC) that collects and evaluates behavioral and clinical data among PLWH in 23 project areas from various US cities, states, and territories. The purpose of the survey is to generate nationally representative estimates of the behavioral and clinical characteristics of adults in the United States diagnosed with HIV.

The MMP uses a two-stage sampling method in which the first stage involves sampling 23 project areas from all 50 states including the District of Columbia, and Puerto Rico. During the second stage, random samples of HIV-positive adults 18 years and older were drawn from the National HIV Surveillance System (NHSS) for each participating state or territory. Each participant had an equal chance of being selected. The MMP sampling and weighting methodologies have been described in detail elsewhere (Johnson et al., 2020).

Behavioral data were collected via telephone or face-to-face interviews, and data from the medical records were two-year retrospectively abstracted. Adjusted for eligibility for response rate, the response rate for 2015 – 2019 cycles data ranged between 42.5% to 45%. The CDC weighted data based on known probabilities of selection at the state or territory and individual levels, as well as non-response (Pitt et al., 2021), and then

post-stratified to National HIV Surveillance System (NHSS) population totals (Heeringa et al., 2017).

Ethics

The University of Texas Health Science Center at Houston's Committee for the Protection of Human Subjects approved the study. In addition, a Data Use Agreement was obtained from the Houston Health Department.

Study Population

The study sample included 775 PLWH adults (≥18 years) from Houston/Harris County, Texas. Participants were identified through five continuous cycles of the MMP Survey (2015-2016, 2017-2018, 2018-2019, and 2019-2020). In this study, 174 participants were excluded due to identifiable causes of liver disease: Hepatitis B surface antigen or Hepatitis C antibody positivity (n=153), alcohol use disorders (n=27), liver disease (n=4), and steatogenic medication (Tamoxifen, n=2). The final analytical sample consisted of 601 individuals that represented a weighted population of 18,601 PLWH in Houston/Harris County, Texas.

Variables

Dependent Outcome. The primary outcome was the presence of NAFLD, defined as a TyG index > 8.38 (Busca et al., 2022; Fedchuk et al., 2014; Simental-Mendía et al., 2008). The TyG index is a validated measure of insulin resistance in various populations with HIV, metabolic disorders (diabetes, insulin resistance), and NAFLD (Busca et al., 2022; Carrasco et al., 2022; Smiderle et al., 2021; Sterling et al., 2022; Tamargo et al., 2021; Zhang et al., 2017). The formula for TyG index is given as follows:

TyG Index = Ln [Fasting Triglycerides (mg/dL) x Fasting Plasma Glucose (mg/dL)/2]

(Simental-Mendía et al., 2008).

The established cutoff value of > 8.38 was validated in biopsied monoinfected PLWH and demonstrated diagnostic accuracy of 90% (sensitivity = 94%; specificity = 56%) (Busca et al., 2022). Therefore, this study used a cutoff of TyG > 8.38 to predict NAFLD > 5%.

Independent Variables. Individual sociodemographic, behavioral, clinical, and psychosocial characteristics were reported twelve months before the participants' interview unless otherwise specified.

Self-reported sociodemographic, behavioral, and psychosocial variables were collected during face-to-face or telephone interviews. The sociodemographic characteristics included in the study were age group (18-29, 30-39, 40-49, ≥ 50); gender at birth (male, female); sexual orientation (homosexual, heterosexual, bisexual, other); race ethnicity (White, Black, Hispanic, Other); type of health insurance (any private, public only, Ryan White/AIDS Drug Assistance Program (ADAP) only, unspecified, uninsured); level of education (less than high school, high school or equivalent, more than high school); employment status was recoded (employed, unemployed, unable to work, other); annual household income ($0–19,999, $20,000–439,999, 440,000–74,999, $75,000 or more); poverty level (above the poverty level, at or below poverty level); marital status was recoded (married, in a civil union or domestic partnership, divorce/widowed/separated, single); English-speaking fluency (very well, well, not well, not at all); foreign-born status (no, yes), homeless status (no, yes); food insecurity (no, yes); any disability (no, yes). The "other" in the race/ethnicity category comprised Asian,

Native American/Alaskan Native, and Native Hawaiian/Pacific Islander. Poverty was measured using the U.S. Department of Health and Human Services guidelines, considering the federal poverty threshold corresponding to the calendar year for which income was asked.

Behavioral characteristics included smoking status (never, former, current); alcohol use (no, yes); use of non-injection drugs (no, yes); and use of injection drugs (no, yes) in the last 12 months before the interview. A drink was defined as drinking 12 ounces of beer, a 2-ounce glass of wine, or a 1.5-ounce shot of liquor.

Psychosocial variables such as depression diagnosis (no, yes) and anxiety diagnosis (no, yes) were retrieved from the medical records while stigma (no, yes); and discrimination (no, yes) were self-reported variables obtained from the interview data. HIV stigma was assessed using the 10-item HIV stigma scale modified by Wright et al. (2007), in which overall HIV stigma scores from participants' responses were summed up into a single score, then in a dichotomized variable used in this study. Discrimination was assessed by using a 3-item questionnaire about discrimination experienced in the health care system since the person first tested positive. Additional information on the measurement of stigma and discrimination has been described in Kota et al. (2022), and Williams et al. (2020).

Clinical variables were identified from the medical records two years before the interview, except for antiretroviral medication use (no, yes) and self-reported adherence scores in the 12 months prior to the interview. The average of selected laboratory and anthropometric results documented in the past two years was calculated. They included: weight (kg), height (inch), aspartate aminotransferase (AST), alanine transaminase

(ALT), fasting triglycerides, fasting glucose, high-density lipoprotein (HDL), low-density lipoprotein (LDL), cholesterol, platelets, albumin, total bilirubin, creatinine, total bilirubin. The mean of a participant's body mass index (BMI) was calculated by dividing the average weight (kg) by the average height (in meters^2), abstracted from the medical records over the two years prior to the interview.

Other clinical characteristics were categorized as: time since HIV diagnosis (in years), lowest Nadir Cluster of differentiation 4 (CD4) count (0-49, 50-199, 200-349, 350-499, ≥ 500), and durable viral load suppression [undetectable (≤ 200 copies), detectable (≥200 copies)]. The histories of chronic health conditions were identified from the medical records using the International Classification of Diseases, Tenth Revision (ICD-10), and then dichotomized (no, yes). The history of medications obtained from the medical records was classified using the Anatomical Therapeutic Chemical Classification System (World Health Organization, 2009). To ensure uniformity, the brand names of drugs were changed to their generic names. The medications were then categorized broadly as antiretroviral or highly active antiretroviral therapy, prescription medications for opportunistic infections, and chronic non-communicable diseases. Common chronic health conditions associated with NAFLD were defined using the medical diagnosis and use of lipid-lowering medication (dyslipidemia), anti-diabetic (type 2 diabetes mellitus), and anti-hypertensive (hypertension). Furthermore, prescriptions documented in the medical records were grouped into major categories. For example, antiretroviral drugs were classified into non-nucleoside reverse transcriptase inhibitors (NNRTIs), nucleoside reverse transcriptase inhibitors (NRTIs), protease inhibitors (PIs), fusion inhibitors, and integrase strand transfer inhibitors (INSTIs).

Statistical Analysis

MMP is a complex survey; therefore, appropriate 5-year weights and strata were applied. SAS 9.4 PROC SURVEYMEANS and SURVEYFREQ were used to obtain descriptive statistics for the study population. Descriptive statistics were reported as unweighted, and weighted frequency, percentages, and 95% confidence intervals (CI) for categorical variables. Mean and standard errors of the mean (SEM), CI, and coefficient of variation (CV) were used to describe quantitative clinical variables. All proportional distributions represented weighted percentages generalized to all PLWH residing in Houston/Harris County, Texas. Weighted prevalence estimates and 95% CI were calculated by characteristics of interest. The Rao-Scott Chi-Square test (a design-adjusted version of the Pearson chi-square test) was used to assess the independent associations between NAFLD (yes/no) and sociodemographic, behavioral, clinical, and psychosocial characteristics, with a p-value of <0.05 used as the minimum threshold for declaring statistically significance. All statistical analyses were performed using SAS version 9.4 software (SAS Institute, Cary, USA).

Results

Description of the Study Participants

The analytical sample included 601 participants, representing 18,601 PLWH in Houston/Harris County, Texas. Table 1 summarizes the demographic and behavioral characteristics of the study population. Most respondents were male (69.17%), Black/African Americans (53.33%), had completed education beyond high school (56.02%), 53.38% were at least 50 years or over, 77.57% spoke English very well, and 48.60% identified themselves as heterosexuals.

Approximately 38% of the study population were privately insured, 55% were single, 49% were employed, and 48.96% had an annual household income of less than $19,999. Most participants (58.53%) were above the poverty line, 90.98% were foreign-born, 24.23% of respondents reported food insecurity, and 9.02% were homeless in the 12 months preceding the interview. In addition, 41.04% of the participants reported having a disability. In the 12 months preceding the interview, nearly 60.00% of respondents reported alcohol consumption, 26.47% reported non-injection drug use, 29.20% were current smokers, and 1.34% reported injecting drugs.

Table 2 shows that 50.76% had been diagnosed with HIV within the past decade, 52.10% had AIDS, and 55% had the lowest nadir CD4 count. Almost 91% reported using antiretroviral medications, with 46.00% using INSTI, 73.35% using NRTI, 6.18 % using NNRTI, and 33.70% using PI. Approximately 37.00% of the study population was diagnosed with hypertension, 31.45% with dyslipidemia, and 12.29% with type 2 diabetes.

In Table 3, 23.68% and 12.95% of the study population were diagnosed with clinical depression and anxiety respectively. Of the 249 eligible participants who completed the questionnaire on stigma, 98% had experienced HIV stigma, and approximately 21% reported encountering discrimination in the healthcare setting.

Table 4 summarizes the weighted clinical characteristics of the eligible sample. The study population's mean [standard error of the mean (SEM)] BMI was 29.18±0.40 kg/m^2. The mean fasting triglycerides levels were 158.35±1.24 mg/dL, ALT was 29.30±1.23 U/L, and HDL was 48.65±0.63 mg/dL.

Estimated Prevalence of NAFLD

Overall, the estimated NAFLD prevalence was 98% in the study population (95% CI: 97.24 – 99.15, $p<0.0001$). Table 5 summarizes the prevalence of NAFLD across sociodemographic, and behavioral characteristics between the negative and positive groups. No statistically significant differences were observed between the two NAFLD groups by demographic, behavioral, and psychosocial characteristics. NAFLD prevalence varied by age group, with the 50 years age group having the highest prevalence (38.80%) and the 18-29 years age group having the lowest prevalence (12.05%); however, the difference was not statistically significant. While the prevalence of NAFLD was higher in men than in women and transgender individuals, 68.04%, 28.50%, and 1.65%, respectively, no statistically significant associations were observed. Similarly, no significant association was observed across race/ethnicity. Approximately 52% of the study population with NAFLD were Black/African American, 25% were Hispanic/Latino, and 16.53% were White. Furthermore, 42% of PLWH with public health insurance had NAFLD compared to 37% of those with private health insurance.

In Table 6, about 89.08% of participants with NAFLD reported taking antiretroviral medications, including INSTI (45.57%), NRTI (71.84%), NNRTI (6.18%), and PI (33.28%). Only the exposure to INSTI was significantly associated with NAFLD ($p=0.0376$). Participants with NAFLD were likely to have lower adherence to antiretroviral drugs, but the difference was not statistically significant (79 ± 1.70, $p=0.4214$).

Surprisingly, no significant associations were observed between NAFLD and psychosocial factors (Table 7). Across the clinical characteristics (Table 8), a few

statistically significant differences were observed. Overall, NAFLD was associated with higher ALT (29.43 ± 1.25, p=0.0004), reduced HDL (48.50 ± 0.63, p=0.0411); higher creatinine (1.14 ± 0.07, p=0.0090); elevated fasting triglycerides (159.77±1.19, p<0.0001), and fasting glucose (97.80 ± 0.46, p<0.0001).

Discussion

The current study is the first to use a noninvasive biomarker to estimate NAFLD prevalence in a representative population-based sample of PLWH in Houston/Harris County, Texas. The findings of this study show that NAFLD is prevalent in the PLWH in Houston/Harris County, Texas. While only HDL, fasting glucose, fasting triglycerides, creatinine, ALT, and INSTI were significantly associated with NAFLD, there are several critical key findings in this study.

First, the results of this study confirm that PLWH have a higher prevalence of NAFLD than 25-30% prevalence rate found in the general population (Younossi et al., 2023). Moreover, these estimates varied by individual characteristics in PLWH and the general population (Kirkegaard-Klitbo et al., 2020; Zhang et al., 2021). In monoinfected PLWH, systematic reviews found a prevalence of 42% (Maurice et al., 2017) and 30–100% (Pires et al., 2020). However, the inclusion of patients with high aminotransferase levels in studies selected by Pires et al. (2020) may have overestimated the prevalence of NAFLD. The diagnostic modalities for NAFLD also contributed to the difference in prevalence estimates in these reviews.

Conversely, this study showed that HIV viral loas was not associated with NAFLD, which is consistent with other studies' findings (Maurice et al. 2017; Pires et al. 2020). This study also showed that age, duration of HIV infection, and CD4 nadir were not

associated with NAFLD, which were consistent with Maurice et al. (2017). However, in contrast, age was reported to be strongly associated with the risk of NAFLD in a cross-sectional study by Qian et al. (2016).

Second, the difference between the NAFLD prevalence observed in this study and that reported by previous studies in populations with comparable characteristics was marginally greater. The TyG index identified NAFLD in 88.4% of subjects in a cross-sectional study involving 69 biopsied PLWH (Busca et al., 2022). The prevalence of NAFLD in this study corresponds to the expected rate among overweight individuals; therefore, these estimates are not shocking. Keeping in mind that the study population was overweight, with a mean BMI of 29.2 ±0.4 kg/m^2, and that there is evidence that nearly 70% of overweight subjects and up to 90% of the obese have NAFLD (Quek et al., 2023; Williams et al., 2011). However, the mean BMI in our study population was higher than previously reported figure for PLWH (Vuille-Lessard et al., 2016). While a high BMI is a considerable risk factor for NAFLD, up to 25% of individuals with a BMI less than $25kg/m^2$ have been reported to have NAFLD (Albhaisi et al., 2019; Francque & Wong, 2022; Golabi et al., 2019; Young et al., 2020; Zou et al., 2020). This suggests that BMI may not be a reliable predictor of NAFLD risk.

The mean fasting triglyceride level (158 mg/dL) in the current study was slightly higher than the standard value of 150 mg/dL, and LDL level (103mg/dL) were equally higher than the optimal value of less than 100 mg/dL (Grundy et al., 2005). Despite a low proportion of study participants with type 2 diabetes (12.29%), higher mean of fasting triglycerides and LDL suggest that this study population had an unhealthy metabolic profile.

Third, antiretroviral therapy is a well-known factor for weight gain in PLWH, increasing the risk of NAFLD (Bischoff et al., 2021; Kanters et al., 2022). Only the INSTI regimen was significantly associated with NAFLD in this study, consistent with previous research studies (Bischoff et al., 2021; Galdamez et al., 2019; Kirkegaard-Klitbo et al., 2020). Contrary to this study's findings, other studies have found a significant association between NAFLD and exposure to other antiretroviral drug classes: PI (Calza et al., 2019) and NNRTI (Sax et al., 2020; Van Welzen et al., 2019).

Notably, the study participants' mean systolic and diastolic blood pressures were within the clinically recommended normal ranges. Therefore, it is not surprising that this study found no significant associations between hypertension, systolic and diastolic blood pressures, and NAFLD. These may suggest effective management and control of hypertension among study subjects diagnosed with the condition.

This current study also found significant associations between creatinine level and NAFLD, which remain consistent with previous studies (Mikolasevic et al., 2013; Niu et al., 2022). Creatinine level plays an essential role in chronic kidney disease and has also been associated with NAFLD (Kiapidou et al., 2020; Önnerhag et al., 2019).

In contrast to previous research (Golovaty et al., 2020; Tamargo et al., 2021), this study did not find a significant association between food insecurity and NAFLD.

Also, there were no statistically significant associations between race and ethnicity. However, the prevalence of NAFLD was greater among Black/African Americans than Hispanics and Whites. This may be due to the high proportion of Black/African Americans in the study population. However, there is evidence that Hispanics have a higher prevalence and are more likely to have a severe form of NAFLD

(Harrison et al., 2021; Kim et al., 2013; Rich et al., 2018; Soti et al., 2018; Zhang et al., 2021). Similarly, it is well-established that there are gender differences in the prevalence of NAFLD, with males being at a higher risk than females (Busca et al., 2022; Maurice et al., 2017; Morrison et al., 2019; Soti et al., 2018; Van Welzen et al., 2019). Nonetheless, this study was unable to demonstrate this difference.

Meanwhile, several studies have found significant associations between chronic liver disease and depression and anxiety (Choi et al., 2021; Lee & Park, 2021; Ntona et al., 2023; Xiao et al., 2013).

Substance use is a common behavioral risk factor in PLWH (Hartzler et al., 2017). As expected, about 1.34%, and 26.47% of the study population reported using injection drugs, or non-injection drugs in the 12 months preceding the interview, respectively. While this study excluded respondents with alcohol use disorder, 59.55% reported alcohol use in the 12 months prior to the interview. These findings indicate that PLWH may be underdiagnosed with substance use disorder. The links between substance use and chronic liver disease are well established (Patel et al., 2018). However, there is inconsistence evidence on association between recreational drugs and NAFLD. A few published studies have shown that illicit drug is a protective factor (Farooqui et al., 2019; Lai et al., 2017; Penner et al., 2013). Nonetheless, almost 40% of people who reported not drinking alcohol in the last 12 months before the interview had NAFLD, a prevalence rate that is still higher than the 25–30% documented in the general US population (Younossi et al., 2023; Younossi et al., 2019).

Strengths and Limitations

Several merits exist in the current study. It is the first study to establish NAFLD prevalence among PLWH in Houston and Harris County, Texas. It is also the first to report the prevalence of NAFLD using the TyG index in a population-based sample of PLWH. The TyG index is a novel biomarker extensively studied and has consistently demonstrated high accuracy and concordance with ultrasound and liver biopsy (Guo et al., 2020; Rivière et al., 2022). Second, MMP employs a robust sampling methodology that uses weighted sampling to provide representative estimates among PLWH in Houston/Harris County, Texas. Furthermore, medical chart abstractions provided a well-rounded representation of clinical data that allowed for measuring various factors. As such, the findings are generalizable to the HIV population in Houston/Harris County.

The large sample size is a strength of the study, as many studies on NAFLD in PLWH have small sample sizes (Morse et al., 2015; Sterling et al., 2013; Vodkin et al., 2015). In addition, the findings of this study corroborate those of previous research, thereby bolstering the evidence regarding the relationships between NAFLD and elevated ALT, fasting triglycerides, fasting glucose, low HLD, and exposure to INSTI. Finally, the availability of data from medical records reduced the recall bias often associated with the use of self-reported data, thereby improving the internal validity of this study.

Nonetheless, there are some limitations to this study. First, due to the study's cross-sectional design, a causal relationship between NAFLD and the independent factors could not be established; thus, the study's findings should be interpreted with caution. Second, while the TyG has fewer limitations than other biomarkers, several biomarkers are unreliable in detecting NAFLD the TyG index has fewer limitations. One significant

limitation is its threshold, which ranges from 8.38 to 8.76 (Guo et al., 2020; Smiderle et al., 2021; Zhang et al., 2017; Zheng et al., 2018). The current study used the lowest threshold of 8.38, which may have overestimated the prevalence of NAFLD.

Nonetheless, while liver biopsy remains the gold standard for assessing NAFLD, this data was not collected as part of the MMP Survey. In addition, the data showed limited variation (Table 4), which may limit the investigators' ability to demonstrate significant associations between NAFLD and many independent characteristics. MMP data also lacked fasting insulin levels, which are important components of NAFLD evaluation.

Furthermore, using a clinical diagnosis of alcohol use disorder can reduce recall bias and, as a result, accurately estimate the prevalence of NAFLD in the study population. It is possible, however, that this factor may be one of the sources of the high NAFLD prevalence reported in our current study. In addition, if PLWH are correctly identified and diagnosed, they can benefit from substance use counseling and education. Finally, while current gender is a vital variable in HIV research, this study used gender at birth to stay consistent with previous research and allow for better comparisons.

Implications for Research and Practice

People who are overweight or obese are two-to-three times more likely to develop a severe form of NAFLD (Cusi et al., 2022). This study demonstrated that NAFLD is prevalent among PLWH and is strongly associated with selected metabolic factors. Due to the elevated BMI, triglycerides, and decreased HDL in this study population, it is imperative to identify patients at risk for NAFLD. Therefore, clinicians caring for PLWH should adopt proactive strategies to enhance early identification of individuals who may

be at risk of NAFLD. A handful of biomarkers, such as the TyG index, therefore, provide this opportunity and are simple to use in clinical practice.

The findings of this study suggest that clinicians caring for the HIV population should pay close attention to the traditional and HIV-specific risk factors strongly linked to the development and progression of NAFLD. In this study, over 65% of PLWH older than 40 had NAFLD, highlighting the need to monitor this age group for metabolic risk factors known to be associated with NAFLD. NAFLD is significantly related to older age (Lin et al., 2022).

There is an urgent need to raise clinicians' awareness of NAFLD. Current NAFLD awareness among healthcare professionals across all specialties is suboptimal (Cusi et al., 2022). First, providers should educate themselves about NAFLD, its associated risk factors, and treatment to educate better and counsel their patients who exhibit these risk factors.

Finally, future research should investigate the relationships between normal creatinine and fasting glucose levels in NAFLD. Changing one's lifestyle is currently the most effective method for reversing and slowing the progression of NAFLD. However, lifestyle modifications are not easy and sustainable, as research indicates that 7 to 10% weight loss is necessary to improve NAFLD (Vilar-Gomez et al., 2017). Thus, there is a need for effective therapeutic interventions. While this study demonstrated that HIV stigma and discrimination are prevalent in PLWH, no significant associations were observed between stigma, discrimination, depression, anxiety, and NAFLD. Future research should further examine the associations between HIV stigma, discrimination, and NAFLD.

Conclusion

This study showed that NAFLD prevalence was 98% in PLWH in Houston/Harris County, Texas. About 46% of those with NAFLD used INSTI. PLWH with elevated ALT, fasting triglycerides, and decreased HDL are at an increased risk of NAFLD. Higher fasting glucose levels and creatinine were significantly associated with increased NAFLD risk, irrespective of being within the normal range. There is an urgent need to raise public and healthcare provider awareness of NAFLD. Clinicians should be aware of the high prevalence of NAFLD among PLWH. Assessing NAFLD risk should be made a top priority as this will allow for early counseling and referral to prevent liver-related complications.

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Table 1

Sociodemographic and Behavioral Characteristics of People Living with HIV in Houston/Harris County, Texas - Houston MMP, 2015-2019.

Characteristics	Unweighted, N = 601	Weighted, N = 18,601 n (%)	95% CI	Test Statistics	
				χ2 value[1]	p-value
Sociodemographic					
Age Group (Years)				68.99	<0.0001****
18 - 29	66	2,264 (12.17)	9.06 – 15.28		
30 - 39	130	4,238 (22.78)	18.81 – 26.75		
40 - 49	162	4,767 (25.63)	21.82 – 29.43		
≥ 50	243	7,332 (39.42)	35.04 – 43.79		
Gender at Birth				84.75	<0.0001****
Male	407	13,124 (70.69)	66.70 – 74.71		
Female	193	5,441 (29.31)	25.29 – 33.33		
Sexual Orientation				282.60	<0.0001****
Homosexual	235	7,346 (40.15)	35.70 – 44.60		
Heterosexual	298	8,893 (48.60)	44.09 – 53.11		
Bisexual	48	1,598 (8.74)	6.15 – 11.33		
Other	13	460 (2.51)	1.03 – 4.00		
Race/Ethnicity				244.58	<0.0001****
White, Non-Hispanic	96	3,122 (16.78)	13.33 – 20.24		
Black, Non-Hispanic	324	9,920 (53.33)	48.83 – 57.83		
Hispanic or Latino	157	4,793 (25.77)	21.84 – 29.69		
Other	24	766 (4.12)	2.32 – 5.92		
Health Insurance Type				379.70	<0.0001****
Any Private	223	6,969 (38.12)	33.71 – 42.53		
Public Only	257	7,859 (42.99)	38.53 – 47.44		
Ryan White/ADAP Only	93	2,786 (15.24)	12.08 – 18.40		
Unspecified	7	170 (0.93)	0.24 – 1.62		
Uninsured	12	497 (2.72)	1.07 – 4.37		
Marital Status				257.43	<0.0001****
Married	102	3,121 (16.92)	13.52 – 20.32		
In a civil union or domestic partnership	43	1,285 (6.97)	4.74 – 9.19		
Divorce/Widowed/Separated	141	3,920 (21.25)	17.75 – 24.74		
Single	312	10,122 (54.87)	50.40 – 59.34		
Education Level				119.13	<0.0001****
<High School	117	3,367 (18.22)	14.86 – 21.58		
High School Diploma or Equivalent	157	4760 (25.76)	21.87 – 29.65		
>High School	325	10351 (56.02)	51.58 – 60.46		
Employment Status				155.52	<0.0001****
Employed	291	8,977 (48.58)	44.09 – 53.07		
Unemployed	115	3,922 (21.23)	17.30 – 25.15		
Unable to Work	126	3,600 (19.48)	16.11 – 22.85		
Other	67	1,979 (10.71)	8.02 – 13.40		
Annual Household Income (US$)				135.88	<0.0001****
0 – 19,999	282	8,142 (48.96)	44.29 – 53.64		
20,000 – 39,999	127	3,989 (23.99)	19.89 – 28.08		
40,000 – 74,999	91	2,848 (17.13)	13.52 – 20.73		
75,000 and more	46	1,650 (9.92)	6.70 – 13.14		

Table 1 (continued)

Poverty Level				13.26	0.0003****
At or Below Poverty Level	241	6,895 (41.47)	36.92 – 46.01		
Above Poverty Level	305	9,734 (58.53)	53.99 – 63.08		
English Language				819.66	<0.0001****
Very Well	462	14,334 (77.57)	73.86 – 81.29		
Well	94	2,984 (16.15)	12.80 – 19.50		
Not Well	23	606 (3.28)	1.92 – 4.64		
Not at All	20	555 (3.00)	1.54 – 4.46		
Foreign Born				219.97	<0.0001****
No	479	15,085 (81.64)	78.39 – 84.88		
Yes	120	3,393 (18.36)	15.12 – 21.61		
Homeless				339.55	<0.0001****
No	546	16,811 (90.98)	88.47 – 93.48		
Yes	53	1,667 (9.02)	6.52 – 11.53		
Food Insecurity				131.16	<0.0001****
No	449	13,977 (75.77)	71.98 – 79.56		
Yes	149	4,470 (24.23)	20.44 – 28.02		
Any Disability				14.89	<0.0001****
No	355	10,835 (58.96)	54.47 – 63.45		
Yes	241	7,7543 (41.04)	36.55 – 45.53		
Behavioral [π]					
Smoking Status				172.41	<0.0001****
Never Smoker	353	1,0896 (59.05)	54.65 – 63.45		
Former Smoker	72	2,169 (11.76)	9.03 –1 4.49		
Current Smoker	173	5,388 (29.20)	25.10 – 33.30		
Alcohol Use				18.14	<0.0001****
No	257	7,474 (40.45)	36.12 – 44.76		
Yes	342	11,004 (59.55)	55.22 – 63.88		
Use of non-injection drugs				95.59	<0.0001****
No	454	13,572 (73.53)	69.36 – 77.71		
Yes	144	4,885 (26.47)	22.29 – 30.64		
Use of injection drugs				541.50	<0.0001****
No	591	18,231 (98.66)	97.72 – 99.61		
Yes	8	247 (1.34)	0.40 – 2.28		

Notes. [1] $\chi 2$ value based on the Rao–Scott modified statistic, which provides a design-based goodness-of-fit test using survey weights.
[π]Self-reported measure, 12 months prior to the interview
Significance level: *=p<0.05; **=p<0.01; ***=p<0.001; ****=p<0.0001; ns= Not significant > 0.05.

Abbreviations. CI = confidence interval; AIDS Drug Assistance Program (ADAP); US = United States; PLWH = people living with HIV

Table 2

Clinical Characteristics of People Living with HIV in Houston/Harris County, Texas - Houston MMP, 2015-2019

Parameters	Unweighted, (N = 601)	Weighted, (N = 18,601) n (%)	95% CI	Test Statistics	
				χ2 value[1]	p-value
Time since HIV Diagnosis (years)				64.60	<0.0001****
< 5	124	4,023 (21.63)	17.76 – 25.50		
5 – 9	160	5,137 (27.61)	23.52 – 31.71		
≥ 10	317	9,441 (50.76)	46.26 – 55.26		
HIV infection stage 3 (AIDS)				0.84	0.3599
No	275	8,911 (47.90)	43.41 – 52.40		
Yes	326	9,690 (52.10)	47.60 – 56.59		
Lowest Nadir CD4 Count$^{\pi}$				354.99	<0.0001****
0 - 49	30	779 (5.57)	3.57 – 7.57		
50 – 199	42	1137 (8.13)	5.66 – 10.60		
200 – 349	63	1,948 (13.93)	10.41 – 17.46		
350 – 499	87	2,435 (17.42)	13.83 – 21.01		
≥ 500	268	7,681 (54.94)	50.18 – 59.70		
Current ART Use				213.92	<0.0001****
No	38	1,705 (9.23)	6.05 – 12.40		
Yes	561	16,774 (90.77)	87.60 – 93.95		
ART Regimen					
INSTI				3.58	0.0586
No	321	9,581 (54.14)	49.85 – 58.43		
Yes	259	8,115 (45.86)	41.57 – 50.15		
NRTI				119.45	<0.0001****
No	143	4,715 (26.65)	22.93 – 30.36		
Yes	437	12,981 (73.35)	69.64 – 77.07		
NNRTI				319.56	<0.0001****
No	547	16,604 (93.82)	91.50 – 96.14		
Yes	33	1,093 (6.18)	3.86 – 8.50		
Protease Inhibitors				50.07	<0.0001****
No	384	11,733 (66.30)	62.02 – 70.58		
Yes	196	5,963 (33.70)	29.42 – 37.98		
Durable Viral Suppression $^{\pi}$				8.12	0.0044**
Undetectable, < 200 copies/mL	372	10,548 (56.71)	52.12 – 61.29		
Detectable, ≥ 200 copied/mL	229	8,053 (43.29)	38.71 – 47.88		
Chronic Health Conditions$^{€}$					
Diabetes Mellitus, Type 2				293.73	<0.0001****
No	504	15,518 (87.71)	84.87 – 90.55		
Yes	76	2,174 (12.29)	9.45 – 15.13		
Hypertension				34.99	<0.0001****
No	360	11,256 (63.47)	59.16 – 67.78		
Yes	222	6,478 (36.53)	32.22 – 40.84		
Dyslipidemia				68.98	<0.0001****
No	399	12,602 (68.54)	64.46 – 72.61		
Yes	197	5,785 (31.46)	27.39 – 35.54		

Notes. [1] $\chi 2$ value based on the Rao–Scott modified statistic, which provides a design-based goodness-of-fit test using survey weights.

$^{€}$These variables were obtained from the medical records data.

Significance level: *=p<0.05; **=p<0.01; ***=p<0.001; ****=p<0.0001; ns= Not significant > 0.05.

Abbreviations. ART = antiretroviral therapy; CD4 = Cluster of differentiation 4; NNRTI = non-nucleoside reverse transcriptase inhibitors; NRTI = nucleoside reverse transcriptase inhibitors; PI = protease inhibitors; INSTI = integrase strand transfer inhibitors.

Table 3

Psychosocial Characteristics of People Living with HIV in Houston/Harris County, Texas - Houston MMP, 2015-2019

Characteristics	Unweighted, (N =601)	Weighted, (N = 18,601) n (%)	95% CI	Test Statistics	
				χ2 value[1]	p-value
Depression Status[€]				122.66	<0.0001****
No	461	14,033 (76.32)	72.35 – 80.29		
Yes	135	4,355 (23.68)	19.71 – 27.65		
Anxiety Status[€]				259.85	<0.0001****
No	519	16,005 (87.05)	84.01 – 90.08		
Yes	77	2,382 (12.95)	9.92 – 15.99		
HIV Stigma [π]				265.87	<0.0001****
No	6	167 (2.00)	0.38 – 3.62		
Yes	243	8,177 (98.00)	96.38 – 99.62		
Discrimination [π]				79.42	<0.0001****
No	197	6,518 (79.05)	73.83 – 84.27		
Yes	56	1,728 (20.95)	15.73 – 26.17		

Notes. [€]These variables were obtained from the medical records data. [π]These measures were self-reported during the past 12 months. [1] $\chi 2$ value based on the Rao–Scott modified statistic, which provides a design-based goodness-of-fit test using survey weights. Significance level: ****=p<0.0001

Abbreviations. CI = confidence interval.

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Table 4

Laboratory Markers of People Living with HIV in Houston/Harris County, Texas - Houston MMP, 2015-2019

Parameters	Unweighted, (N = 601)	Weighted, (N = 18,601)	Mean ± SEM	CV
Body Mass Index (kg/m^2)	568	17,238	29.18 ± 0.40	0.01
AST, U/L	601	18,601	25.96 ± 0.79	0.03
ALT, U/L	601	18,601	29.30 ± 1.23	0.03
Triglycerides, mg/dL (fasting)	601	18,601	158.35 ± 1.24	0.01
HDL, mg/dL	601	18,601	48.65 ± 0.63	0.01
LDL, mg/dL	601	18,601	102.96 ± 1.28	0.01
Cholesterol	601	18,601	179.15 ± 1.61	0.01
Glucose, mg/dL (fasting)	601	18,601	97.56 ± 0.45	0.00
Creatinine, mg/mL	601	18,601	1.13 ± 0.06	0.06
Platelets, 10^9/L	572	17,396	232.16 ± 4.15	0.02
Albumin	601	18,601	4.17 ± 0.04	0.01
Total Bilirubin, mg/dL	601	18,601	0.66 ±0.05	0.08
Systolic Blood Pressure, mmHg	595	18,402	125.21 ± 1.4	0.01
Diastolic Blood Pressure, mmHg	595	18,402	78.22 ± 0.77	0.01
ART Adherence Score[π]	601	18,601	78.83 ± 1.67	0.01

Notes. [π]Self-reported measure. Significance level: *=p<0.05; **=p<0.01; ***=p<0.001; ****=p<0.0001; ns= Not significant > 0.05.

Abbreviations. **CI**: Confidence Interval; ***CV***= Coefficient of variation; ***SEM =*** Standard Error of the Mean; **ALT**= alanine transaminase; **AST** = aspartate aminotransferase; **BMI** = body mass index; **HDL** = high-density lipoprotein; **LDL** = low-density lipoprotein; **ART** = antiretroviral therapy.

Table 5

Sociodemographic and Behavioral Characteristics by NAFLD Status - Houston MMP, 2015-2019

Characteristics	Total Unweighted Sample	Total Weighted Sample, n (%)	NAFLD				Test Statistics	
			Negative Group (TyG ≤ 8.38)		Positive Group (TyG > 8.38)			
			Weighted, n (%)[₴]	95% CI	Weighted, n (%)[₴]	95% CI	χ2 value[1]	p-value
Overall	601	18,601	336 (1.80)	0.85 – 2.76	18,266 (98.20)	97.24 – 99.15	700.39	<0.0001****
Sociodemographic								
Age Group (Years)							0.80	0.8494[ns]
18 - 29	66	2,264 (12.17)	23 (0.12)	0.00 – 0.37	2,241 (12.05)	8.94 – 15.15		
30 - 39	130	4,238 (22.78)	85 (0.45)	0.00 – 0.98	4,153 (22.33)	18.37 – 26.28		
40 - 49	162	4,767 (25.63)	113 (0.61)	0.07 – 1.15	4,654 (25.02)	21.23 – 28.80		
≥ 50	243	7,332 (39.42)	115 (0.62)	0.07 – 1.16	7,217 (38.80)	34.44 – 43.17		
Gender at Birth							0.50	0.4779[ns]
Male	407	13,124 (70.69)	209 (1.12)	0.34 – 1.91	12,915 (69.57)	65.51 – 73.62		
Female	187	5,441 (29.31)	127 (0.68)	0.13 – 1.24	5,314 (28.63)	24.62 – 32.63		
Sexual Orientation							---- ∞	---- ∞
Homosexual	235	7,346 (40.15)	121 (0.66)	0.08 – 1.25	7,225 (39.49)	35.05 – 43.92		
Heterosexual	298	8,893 (48.60)	178 (0.97)	0.30 – 1.65	8,715 (47.63)	43.13 – 52.14		
Bisexual	48	1,598 (8.74)	----	----	1,598 (8.74)	6.15 – 11.33		
Other	13	460 (2.51)	36 (0.20)	0.00 – 0.59	424 (2.31)	0.88 – 3.75		
Race/Ethnicity							0.4981	0.9193[ns]
White, Non-Hispanic	96	3,122 (16.78)	48 (0.26)	0.00 – 0.61	3,074 (16.53)	13.08 – 19.97		
Black, Non-Hispanic	324	9,920 (53.33)	193 (1.04)	0.31 – 1.77	9,727 (52.29)	47.79 – 56.79		
Hispanic or Latino	157	4,793 (25.77)	71 (0.38)	0.00 – 0.82	4,721 (25.38)	21.47 – 29.30		
Other	1	766 (4.12)	23 (0.13)	0.00 – 0.37	743 (3.99)	2.21 – 5.78		
Health Insurance Type							---- ∞	---- ∞
Any Private	223	6,969 (38.12)	158 (0.86)	0.16 – 1.57	6,811 (37.26)	32.86 – 41.65		
Public Only	257	7,859 (42.99)	178 (0.97)	0.30 – 1.65	7,681 (42.02)	37.56 – 46.48		
Ryan White/ADAP Only	93	2,786 (15.24)	----	----	2,786 (15.24)	12.08 – 18.40		
Unspecified	7	170 (0.93)	----	----	170 (0.93)	0.24 – 1.62		
Uninsured	12	497 (2.72)	----	----	497 (2.72)	1.07 – 4.37		
Marital Status							---- ∞	---- ∞
Married	102	3,121 (16.92)	----	----	3,121 (16.92)	13.77 – 20.69		
In a civil union or domestic partnership	43	1,285 (6.97)	----	----	1,285 (6.97)	4.83 – 9.36		
Divorce/Widowed/Separated	141	3,920 (21.25)	88 (0.48)	0.01 – 0.94	3,832 (20.77)	17.62 – 24.69		
Single	312	10,122 (54.87)	248 (1.34)	0.50 – 2.19	9,874 (53.53)	49.98 – 59.05		

Table 5 (Continued)

Education Level							2.76	0.2515[ns]
<High School	117	3,367 (18.22)	17 (0.09)	0.00 – 0.28	3,350 (18.13)	14.77 – 21.49		
High School Diploma or Equivalent	157	4,760 (25.76)	39 (0.37)	0.00 – 0.79	4,692 (25.39)	21.52 – 29.26		
>High School	325	10,351 (56.02)	250 (1.35)	0.50 – 2.21	10,100 (54.66)	50.20 – 59.12		
Employment Status							3.86	0.2767[ns]
Employed	291	8,977 (48.58)	205 (1.11)	0.33 – 1.88	8,772 (47.47))	43.00 – 51.95		
Unemployed	115	3,922 (21.23)	23 (0.13)	0.00 – 0.38	3,899 (21.10)	17.18 – 25.02		
Unable to Work	126	3,600 (19.48)	38 (0.21)	0.00 – 0.50	3,562 (19.28)	15.91 – 22.64		
Other	67	19,79 (10.71)	70 (0.38)	0.00 – 0.81	1,909 (10.33)	7.67 – 12.99		
Annual Household Income (US$)							2.77	0.4283[ns]
0 – 19,999	282	8,142 (48.96)	161 (0.97)	0.25 – 1.69	7,981 (47.99)	43.31 – 52.67		
20,000 – 39,999	127	3,989 (23.99)	39 (0.24)	0.00 – 0.57	3,949 (23.75)	19.66 – 27.84		
40,000 – 74,999	91	2,848 (17.13)	108 (0.65)	0.00 – 1.30	2,740 (16.48)	12.91 – 20.04		
75,000 and more	46	1,650 (9.92)	27 (0.16)	0.00 – 0.48	1,623 (9.76)	6.55 – 12.97		
Poverty Level							0.03	0.8547[ns]
At or Below Poverty Level	241	6,895 (41.47)	205 (1.23)	0.37 – 2.09	6,764 (40.68)	36.14 – 45.21		
Above Poverty Level	305	9,734 (58.53)	131 (0.79)	0.15 – 1.42	9,529 (57.30)	52.75 – 61.86		
English Language							---- [∞]	----[∞]
Very Well	462	14,334 (77.57)	286 (1.55)	0.66 – 2.43	14,049 (76.03)	72.25 – 79.81		
Well	94	2,984 (16.15)	50 (0.27)	0.00 – 0.65	2,933 (15.88)	12.54 – 19.21		
Not Well	23	606 (3.28)	----	----	606 (3.28)	1.92 – 4.64		
Not at All	20	555 (3.00)	----	----	555 (3.00)	1.54 – 4.46		
Foreign Born							1.29	0.2565[ns]
No	479	15,085 (81.64)	313 (1.69)	0.76 – 2.62	14,772 (79.94)	76.60 – 83.29		
Yes	120	3,393 (18.36)	23 (0.13)	0.00 – 0.37	3,370 (18.24)	15.12 – 21.61		
Homeless							----[∞]	----[∞]
No	546	16,811 (90.98)	336 (1.82)	0.86 – 2.78	16,475 (89.16)	86.52 – 91.80		
Yes	53	1,667 (9.02)	----	----	1,667 (9.02)	6.52 – 11.53		
Food Insecurity							0.28	0.5959[ns]
No	449	1,3977 (75.77)	274 (1.48)	0.60 – 2.37	13,703 (74.28)	70.45 – 78.12		
Yes	149	4,470 (24.23)	62 (0.34)	0.00 – 0.72	4,409 (23.90)	20.11 – 27.68		
Any Disability							0.15	0.7010[ns]
No	355	10,835 (58.96)	215 (1.17)	0.41 – 1.93	10,620 (58.95)	53.29 – 62.28		
Yes	241	7,543 (41.04)	120 (0.66)	0.06 – 1.25	7,423 (40.39)	35.90 – 44.87		
Behavioral [π]								
Smoking Status							1.95	0.3776[ns]
Never Smoker	353	10,896 (59.05)	189 (1.03)	0.30 – 1.75	10,707 (58.02)	53.61 – 62.43		
Former Smoker	72	2,169 (11.76)	78 (0.42)	0.00 – 0.90	2,091 (11.33)	8.64 – 14.03		
Current Smoker	173	5,388 (29.20)	68 (0.37)	0.00 – 0.79	5,320 (28.83)	24.74 – 32.92		

Table 5 (Continued)

Alcohol Use							0.002	0.9611[ns]
No	257	7,474 (40.45)	138 (0.75)	0.15 – 1.34	7,336 (39.70)	35.39 – 44.02		
Yes	342	11,004 (59.55)	198 (1.07)	0.31 – 1.83	10,806 (58.48)	54.13 – 62.83		
Use of non-injection drugs							0.03	0.8574[ns]
No	454	13,572 (73.53)	254 (1.38)	0.56 – 2.20	13,317 (72.15)	67.95 – 76.35		
Yes	144	4,885 (26.47)	81 (0.44)	0.00 – 0.95	4,804 (26.03)	21.87 – 30.19		
Use of injection drugs							----[∞]	----[∞]
No	591	18,231 (98.66)	336 (1.82)	0.86 – 2.78	17,895 (96.85)	95.51 – 98.18		
Yes	14	247 (1.34)	----	----	247 (1.34)	0.39 – 2.28		

Notes. [1] $\chi 2$ value based on the Rao–Scott modified statistic, which provides a design-based goodness-of-fit test using survey weights.

[∞]Represent suppression of value because it is below threshold.

[ƨ]Column percentages; within a given level of the characteristic, some percentages may not add up to exactly 100 due to rounding.

[1]p-values are from Rao-Scott chi2 test. Significance level: *=p<0.05; **=p<0.01; ***=p<0.001; ****=p<0.0001; ns= Not significant (p > 0.05)

Abbreviations. CI: Confidence Interval; US = United States

Table 6

Clinical Characteristics of People Living with HIV by NAFLD Status, Houston MMP, 2015-2019

Characteristics	Total Unweighted, n	Total Weighted, n (%)	Negative NAFLD Group (TyG ≤ 8.38)		Positive NAFLD Group (TyG > 8.38)		Test Statistics	
			Weighted, n (%)	95% CI	Weighted n (%)	95% CI	**χ2 value[1]**	**p-value**
Time since HIV Diagnosis (years)							1.51	0.4712[ns]
< 5	124	4,023 (21.63)	38 (0.20)	0.00 – 0.49	3,985 (21.42)	17.56 – 25.29		
5 – 9	160	5,137 (27.61)	133 (0.71)	0.08 – 1.35	5,004 (26.90)	22.83 – 30.97		
≥ 10	317	9,441 (50.76)	165 (0.34	0.23 – 1.55	9,277 (49.87)	45.38 – 54.36		
HIV infection stage 3 (AIDS)							1.21	0.2713[ns]
No	275	8,911 (47.90)	112 (0.60)	0.07 – 1.13	8,799 (47.30)	42.82 – 51.80		
Yes	326	9,690 (52.10)	224 (1.20)	0.40 – 2.00	9,467 (50.89)	46.40 – 55.39		
Lowest Nadir CD4 Count[π]							----[∞]	----[∞]
0 – 49	30	779 (5.57)	17 (0.12)	0.00 – 0.36	762 (5.45)	3.46 – 7.43		
50 – 199	42	1,137 (8.13)	70 (0.50)	0.00 – 1.07	1,067 (7.63)	5.21 – 10.24		
200 – 349	63	1,948 (13.93)	0	----	1,948 (13.93)	10.61 – 17.79		
350 – 499	87	2,435 (17.42)	25 (0.18)	0.00 – 0.53	2410 (17.24)	13.93 – 21.22		
≥ 500	268	7,681 (54.94)	151 (1.08)	49.10 – 58.63	7,531 (53.87)	50.08 – 59.72		
Current ART Use							0.11	0.7452[ns]
No	38	1,705 (9.23)	23 (0.12)	0.00 – 0.36	1,682 (9.10)	5.94 – 12.27		
Yes	561	16,774 (90.77)	313 (1.69)	0.77 – 2.62	16,461 (89.08)	87.83 – 92.33		
ART Regimen[π]								
INSTI							4.32	0.0376**
No	321	9,581 (54.14)	263 (1.19)	0.60 – 2.38	9,318 (52.65)	48.34 – 56.97		
Yes	259	8,115 (45.86)	52 (0.29)	0.00 – 0.70	8,064 (45.57)	41.28 – 49.86		
NRTI							0.90	0.3433
No	143	4,715 (26.65)	48 (0.27)	0.00 – 0.64	4,668 (26.38)	22.66 – 30.09		
Yes	437	12,981 (73.35)	267 (1.51)	0.61 – 2.41	12,714 (71.84)	68.06 – 75.63		
NNRTI							----[∞]	----[∞]
No	547	16,604 (93.82)	315 (1.78)	0.80 – 2.76	16,289 (92.04)	89.55 – 94.54		
Yes	33	1,093 (6.18)	----	----	1,093 (6.18)	3.86 – 8.50		
Protease Inhibitors							0.29	0.5916[ns]
No	384	11,733 (66.30)	232 (1.31)	0.50 – 2.13	11,501 (64.99)	60.70 – 69.28		
Yes	196	5,963 (33.70)	83 (0.47)	0.00 – 1.01	5,881 (33.23)	28.96 – 37.50		
Durable Viral Suppression [π]							0.00	0.9825[ns]
Undetectable, < 200 copies/mL	372	10,548 (56.71)	189 (1.02)	0.29 – 1.74	10,359 (56.71)	51.12 – 61.29		
Detectable, ≥ 200 copied/mL	229	8,053 (43.29)	146 (0.79)	0.16 – 1.41	7,907 (42.51)	37.91 – 47.10		

Table 6 (Continued)

Diagnosed Chronic Health Conditions								
Diabetes Mellitus, Type 2							----∞	----∞
No	504	15,518 (87.71)	315 (1.78)	0.80 – 2.76	15,203 (85.93)	82.96 – 88.90		
Yes	76	2,174 (12.29)	0	----	2,174 (12.29)	9.45 – 15.13	----∞	----∞
Hypertension							2.36	0.1242^{ns}
No	360	11,256 (63.47)	265 (1.50)	0.60 – 2.39	10,990 (61.97)	57.63 – 66.32		
Yes	222	6,478 (36.53)	50 (0.28)	0.00 – 0.67	6,428 (36.25)	31.95 – 40.55		
Dyslipidemia							0.11	0.7395^{ns}
No	399	12,602 (68.54)	244 (1.33)	0.50 – 2.16	12,359 (67.21			
Yes	197	5,785 (23.68)	92 (0.50)	0.01 – 0.99	5,693 (30.96)	26.90 – 35.02		

Notes. [1] $\chi 2$ value based on the Rao–Scott modified statistic, which provides a design-based goodness-of-fit test using survey weights. [∞]Represent suppression of value because it is below threshold.

[π]values in the last 12 months prior to the interview. Significance level: *=p<0.05; **=p<0.01; ***=p<0.001; ****=p<0.0001; ns= Not significant > 0.05.

Abbreviation. ART = antiretroviral therapy; CD4 = Cluster of differentiation 4; NNRTI = non-nucleoside reverse transcriptase inhibitors; NRTI = nucleoside reverse transcriptase inhibitors; PI = protease inhibitors; INSTI = integrase strand transfer inhibitors.

Table 7

Psychosocial Characteristics of People Living with HIV by NAFLD Status, Houston MMP, 2015-2019

Characteristics	Total Unweighted, n	Total Weighted, n (%)	NAFLD Negative Group (TyG ≤ 8.38) Weighted, n (%)[ƨ]	95% CI	NAFLD Positive Group (TyG > 8.38) Weighted, n (%)[ƨ]	95% CI	Test Statistics χ2 value[1]	p-value
Depression Status[€]							0.20	0.6538[ns]
No	461	14,033 (76.32)	239 (1.30)	0.48 – 2.12	13,794 (75.02)	71.01 – 79.03		
Yes	135	4,355 (23.68)	97 (0.53)	0.01 – 1.04	4,258 (23.16)	19.20 – 27.11		
Anxiety Status[€]							3.09	0.0786[ns]
No	519	16,005 (87.05)	238 (1.30)	0.48 – 2.11	15,767 (85.75)	71.01 – 79.03		
Yes	77	2,382 (12.95)	97 (0.53)	0.01 – 1.05	2,285 (12.42)	19.20 – 27.11		
HIV Stigma [π]							----[∞]	----[∞]
No	6	167 (2.00)	0	----	167 (2.00)	0.38 – 3.62		
Yes	243	8,177 (98.00)	130 (1.56)	0.16 – 2.96	8,047 (96.44)	94.31 – 98.57		
Discrimination [π]							0.04	0.8455[ns]
No	197	6,518 (79.05)	107 (1.30)	0.00 – 2.61	6,410 (77.74)	72.42 – 83.06		
Yes	56	1,728 (20.95)	23 (0.28)	0.00 – 0.82	1,705 (20.68)	15.47 – 25.88		

Notes. [1] $\chi 2$ value based on the Rao–Scott modified statistic, which provides a design-based goodness-of-fit test using survey weights.

[ƨ]Within a given level of the characteristic, some column percentages may not add up to exactly 100 due to rounding; [π]values in the last 12 months.

Significance level: *=p<0.05; **=p<0.01; ***=p<0.001; ****=p<0.0001; ns= Not significant > 0.05.

Abbreviations. **HIV =** human Immunodeficiency Virus

Table 8

Laboratory Markers and Biometrics of People Living with HIV by NAFLD Status, Houston MMP, 2015- 2019

Parameters	Total Unweighted,	Total Weighted,	NAFLD				Test Statistics	
			Negative Group (TyG ≤ 8.38)		Positive Group (TyG > 8.38)			
	N	N	Weighted, n	Mean (SEM)	Weighted, n	Mean (SEM)	t-value	p-value
Overall	601	18,601	336		18,266			
Body Mass Index (kg/m^2)	568	17,238	313	29.11 (1.21)	16,925	29.18 (0.40)	- 0.05	0.9566^{ns}
AST, U/L	601	18,601	336	30.14 (6.02)	18,266	25.88 (0.79)	0.70	0.4837^{ns}
ALT, U/L	601	18,601	336	22.07 (1.66)	18,266	29.43 (1.25)	- 3.54	0.0004***
Triglycerides, mg/dL (fasting)	601	18,601	336	81.00 (5.21)	18,266	159.77 (1.19)	- 14.75	<0.0001****
HDL, mg/dL	601	18,601	336	56.66 (3.94)	18,266	48.50 (0.63)	2.05	0.0411*
LDL, mg/dL	601	18,601	336	101.49 (7.86)	18,266	102.99 (1.30)	- 0.19	0.8507^{ns}
Cholesterol	601	18,601	336	170.49 (8.68)	18,266	179.30 (1.63)	- 1.00	0.3182^{ns}
Glucose, mg/dL (fasting)	601	18,601	336	84.53 (2.31)	18,266	97.80 (0.46)	-5.64	<0.0001****
Creatinine, mg/mL	601	18,601	336	0.87 (0.08)	18,266	1.14 (0.07)	- 2.62	0.0090**
Platelets, 10^9/L	572	17,396	336	234.74 (14.60)	17,060	232.11 (4.22)	0.17	0.8622^{ns}
Albumin	601	18,601	336	4.33 (0.10)	18,266	4.17 (0.04)	1.59	0.1132^{ns}
Total Bilirubin, mg/dL	601	18,601	336	0.63 (0.23)	18,266	0.66 (0.06)	- 0.12	0.9054^{ns}
Systolic Blood Pressure, mmHg	595	18,402	336	126 (2.39)	18,067	125 (1.22)	0.33	0.7391^{ns}
Diastolic Blood Pressure, mmHg	595	18,402	336	80 (1.58)	18,067	78 (0.78)	0.97	0.3331^{ns}
ART Adherence Score	601	18,601	336	84 (6.31)	18,266	79 (1.70)	0.80	0.4214^{ns}

Notes. Significance level: *=p<0.05; **=p<0.01; ***=p<0.001; ****=p<0.0001; ns= Not significant > 0.05.

Abbreviations. **CI:** Confidence Interval; ***SEM*** **=** Standard Error of the Mean; **ALT**= alanine transaminase; **AST** = aspartate aminotransferase; **BMI** = body mass index; HDL = high-density lipoprotein; **LDL** = low-density lipoprotein; **ART** = antiretroviral therapy.

Manuscript 2

Prognostic Factors for Predicting Severity of Nonalcoholic Fatty Liver Disease in People Living with HIV: An Analysis of Medical Monitoring Project Data

Abstract

Background: Prevention of nonalcoholic steatohepatitis and fibrosis in HIV-positive individuals is essential for reducing morbidity and mortality associated with nonalcoholic fatty liver disease (NAFLD). In addition, early identification of people living with HIV (PLWH) at a higher risk of fibrosis and nonalcoholic steatohepatitis would reduce the strain on the economy, society, and health resources. However, risk factors indicating which people are more likely to develop nonalcoholic steatohepatitis and fibrosis require further investigation. Understanding these risk factors is crucial to improving patient care and creating appropriate risk stratification and preventative strategies.

Objectives: This study aimed to determine factors associated with the severity of NAFLD in a population-based sample of PLWH in Houston, Texas, as well as to identify specific factors and their level of contribution to the severity of the disease.

Methods: The prevalence of NAFLD was estimated using the triglyceride glucose index in a sample of 587 PLWH. The Rao-Scott Chi-Square test was used to examine the relationship between sociodemographic, behavioral, clinical, and psychological characteristics and the severity of NAFLD. Subsequently, multivariable logistic regression models were utilized to determine related factors. In addition, a recursive partitioning analysis was conducted to examine the extent to which variables contributed to the severity of NAFLD.

Results: Almost 13.5% (95% CI: 10.61–16.49) of the 587 eligible participants, who represent 18,266 PLWH in Houston/Harris County, Texas, had mild, 26.5% (95% CI: 22.47–30.49) moderate, and 60% (95% CI: 55.53–64.42) severe NAFLD. In the multivariable logistic regression analyses, age between 30 and 39 years (aOR = 0.20; 95% CI: 0.04–0.92, p = 0.0390), former smoking (aOR = 0.23; 95% CI: 0.07–0.69), and homelessness were protective factors, whereas people who had been exposed to non-nucleoside reverse transcriptase inhibitors had higher odds (aOR = 15.78; 95% CI: 1.15 – 216.69, *p*=0.0392), time since HIV diagnosis (aOR = 3.64; 95% CI: 1.48 – 8.93, *p*=0.0050), and Hispanic ethnicity (aOR = 3.13, 95% CI: 1.21 – 8.13, *p*=0.0191), were associated with severe NAFLD. Hispanics/Latino, those living with HIV for more than five years, and those exposed to non-nucleoside reverse transcriptase inhibitors are at a greater risk for developing liver fibrosis. The recursive partitioning model analysis indicated that smoking, homelessness, and use of NNRTI significantly predicted moderate NAFLD (R^2=11.20%) with a proportional contribution of 42.2%, 33.9%, and 23.9%, respectively.

Conclusion: Clinicians should consider using the triglyceride-glucose index or a comparable index as a routine evaluation tool. Early and prompt care of NAFLD, particularly liver fibrosis, will reduce the prevalence of the disease and save lives.

Keywords: PLWH, HIV, Liver Fibrosis, Nonalcoholic Fatty Liver Disease, NAFLD.

Prognostic Factors for Predicting Severity of Nonalcoholic Fatty Liver Disease in People Living with HIV: An Analysis of Medical Monitoring Project Data

Introduction

Approximately 22% of people living with HIV (PLWH) and nonalcoholic fatty liver disease (NAFLD) had advanced fibrosis compared to 10% in the general population in the United States (Maurice et al., 2017; Le et al., 2017). NAFLD is associated with mortality and morbidity attributable to liver fibrosis (Younossi et al., 2021). The current United States (U.S.) guidelines do not suggest NAFLD screening for high-risk people (Corey, 2020). The goal of screening at-risk individuals for NAFLD is to identify early occurrences of nonalcoholic steatohepatitis (NASH) and fibrosis for management.

By 2030, around 80% of PLWH will have at least one age-related comorbidity, and 30% will have at least three (Serrano-Villar et al., 2016). A previous study revealed that PLWH with NAFLD have an elevated risk for NASH and liver fibrosis, regardless of viral hepatitis co-infection, whereas 20–64%, 19%–33%, and 14%–63% had NASH, fibrosis, and NASH with fibrosis, respectively (Lake et al., 2022; Morrison et al., 2019). Up to 37% of the uninfected general population of the United States develops NASH (Vodkin et al., 2015), and between 10%–15% develop severe fibrosis (Choi et al., 2021; Le et al., 2019; Zhang et al., 2021). Approximately 14% of asymptomatic middle-aged Americans in Texas had NASH, and 6% had severe liver fibrosis, according to (Harrison et al., 2021). In the context of fibrosis, risk stratification is essential for identifying people at a higher risk of liver-related complications. However, there is little research investigating these anomalies among PLWH in Greater Houston

Currently five genetic polymorphisms are identified in NAFLD research, and are associated with advanced fibrosis, with the human patatin-like phospholipase domain-containing-3 variant being the most prominent (Campos-Murguía et al., 2020; Kim & Park, 2020). Several variants underlie racial and ethnic disparities in NAFLD frequency and severity (Jonas & Schürmann, 2021; Younossi et al., 2016). Hispanics are more likely to develop NAFLD than other races (Zhang et al., 2021). Metabolic and cardiovascular risk factors have been extensively studied (Cervo et al., 2022; El Hadi et al., 2019; Maurice et al., 2017). Research also linked comorbidities to environmental issues such as healthcare access, built environment quality, and resources (Rajak et al., 2022; Sen et al., 2022). These factors worsen liver fibrosis and liver outcomes. HIV and antiretroviral medications may synergistically increase NASH and liver fibrosis in PLWH (Lake et al., 2022; Maurice et al., 2017; Squillace et al., 2019; Van Welzen et al., 2019).

The ideal method for diagnosing NASH and fibrosis is liver biopsy. Population-based liver biopsies, however, are neither feasible nor cost-effective due to the fact that 25–30% of the U.S. population may have NAFLD (Younossi et al., 2016, 2023). Although ultrasound diagnostics are widely accessible, less expensive, and are the recommended first-line approach, they have a number of drawbacks (Squillace et al., 2019). Consideration of the use of reliable noninvasive biomarkers in primary care settings may be a valuable way for identifying NAFLD patients, particularly in the present environment in which there are no approved therapies (Chamroonkul & Bansal, 2019).

Several noninvasive biomarkers [e.g., fatty liver index (FLI), NAFLD liver fat score (NAFLD-LFS), Fibrosis-4 index (FIB-4), and NAFLD fibrosis score (NFS)]

accurately predict the presence of liver steatosis and identify liver fibrosis cases (Campos-Murguía et al., 2020; Hernandez Roman & Siddiqui, 2020). In recent research, a triglyceride-glucose (TyG) index cutoff value of 8.91 accurately ruled out advanced fibrosis, stages 3 and 4 (Smiderle et al., 2021). The TyG index, which requires just two commonly measured laboratory markers (fasting triglycerides and glucose), might be a game-changer. Consequently, the TyG index may serve as the first step in risk stratification and help in identifying people at high risk for liver fibrosis, including PLWH. There is currently no information available on the prevalence of advanced fibrosis among PLWH in Houston. The objectives of this research were to assess the severity of NAFLD in a population-based sample of PLWH in Houston and Harris County, Texas, to identify factors that predict NAFLD severity, and to quantify the contribution of each predictor.

Conceptual Framework

NAFLD is complex and multifactorial, suggesting that individual-level interventions alone may not address this epidemic. According to Bronfenbrenner (1977), an individual's health and health behavior are affected by the interaction between factors at the individual level (personal and biological characteristics) and the social system level (inter-personal, community, institutional, and policies). Therefore, the social-ecological model initially developed by Bronfenbrenner to understand the complex interplay between individual and social systems is well suited to inform the conceptual framework (Figure 1) that guided the proposed study. In this proposed framework, individual-level factors (e.g., race/ethnicity, smoking status) interact with each other and are thought to directly influence NAFLD outcomes (e.g., cirrhosis, fibrosis), while social factors (e.g.,

homeless-ness) also indirectly affect the outcomes of NAFLD. NAFLD negatively impacts an individual's quality of life, resulting in morbidity and premature death, and has social consequences that include straining health and economic resources. Therefore, effective management of comorbidities such as HIV infection, NAFLD requires an understanding of individual characteristics, and social determinants of health.

Methods

Study Design and Setting

This cross-sectional analysis used the 2015–2019 Houston Medical Monitoring Project (MMP) data cycles. The Houston MMP is a population-based, annual survey that collects information from a representative sample of PLWH in Houston and Harris County, Texas. The Houston MMP collects data annually between June of each cycle year and May of the next cycle year. MMP is an ongoing surveillance system of the Centers for Disease Control and Prevention (CDC) that collects and assesses behavioral and clinical data on PLWH in Houston and Harris County, Texas. The MMP sample and weighting methodologies are detailed elsewhere (Beer et al., 2019; Johnson et al., 2020).

Study Population

The study subjects were 18 or older and voluntarily participated in the Houston MMP Survey from 2015 to 2019. The data collection methodology has been documented elsewhere. The initial study included 601 eligible participants. This study excluded additional participants (n=14) who were not suspected of having NAFLD. The analytical sample consisted of 587 PLWH (weighted N=18,266).

Human Subjects Protection

This study received approval from the Houston Health Department Investigative Review and an exempt status approval from the University of Texas Health Science Center at Houston Committee for Protection of Human Subjects.

Analytical Measures

Dependent Variable

The primary outcome measure was NAFLD (mild, moderate, severe) as measured by the triglyceride glucose (TyG) index. The logarithm of the product of fasting triglycerides and fasting plasma glucose divided by two constitutes the TyG index.:

TyG = Ln [Fasting Triglycerides (mg/dL) x Fasting Plasma Glucose (mg/dL)/2]

(Simental-Mendía et al., 2008).

A cutoff value of >8.75 has a positive predictive value of 64% for predicting >33% of liver steatosis (sensitivity=58%; specificity=58%) (Fedchuk et al., 2014); a cutoff value of 8.91 has a negative predictive value of 94.4% for ruling out advanced fibrosis (Smiderle et al., 2021). Therefore, here is the proposed criteria: $8.38 > TyG \leq 8.75$ (mild steatosis; 5-33%); $8.75 > TyG < 8.91$ (moderate steatosis; 33-66%); and $TyG \geq 8.91$ (severe steatosis; >66%).

Independent Variables

Unless otherwise stated, individual demographic, behavioral, clinical, and psychosocial factors were reported twelve months before the participants' interview. Detailed breakdowns of the categories were discussed previously in the methods section of the proposal. Age, gender at birth, sexual orientation, race and ethnicity, type of health insurance, education, work status, poverty level, marital status, English-speaking

proficiency, foreign-born status, homeless status, food insecurity, and any disability were among the demographic characteristics. Poverty was determined using the rules of the US Department of Health and Human Services, taking into account the federal poverty criterion for the calendar year in question.

Behavioral factors were smoking status, alcohol usage, non-injection drug use, and injection drug use in the 12 months before the interview. Drinking 12 ounces of beer, a 2-ounce glass of wine, or a 1.5-ounce shot of liquor was considered a drink.

From the medical records data, psychosocial characteristics such as depression and anxiety levels were extracted. Furthermore, from the interview data, stigma and discrimination were self-reported characteristics. The 10-item HIV stigma scale modified by Wright et al.(2007) was used to measure stigma, with total stigma scores from participants' replies resulting in a dichotomized variable utilized in this research. More information on measuring stigma and discrimination have been described in Kota et al. (2022), and Williams et al. (2020).

Except for antiretroviral drug usage and self-reported adherence ratings, clinical characteristics were extracted from medical records two years before the interview. calculated the mean of selected laboratory and anthropometric findings over the previous two years. Weight (kg), height (inches), aspartate aminotransferase (AST), alanine transaminase (ALT), fasting triglycerides, fasting glucose, high-density lipoprotein (HDL), low-density lipoprotein (LDL), cholesterol, platelets, albumin, total bilirubin, creatinine, and total bilirubin were measured. The mean of a participant's body mass index (BMI) was determined by dividing the average weight (kg) by the average height (in meters^2) extracted from medical records for the two years preceding the interview.

Other clinical criteria were duration since HIV diagnosis (in years), the lowest Nadir Cluster of Differentiation 4 (CD4) count, and long-lasting viral load reduction. From the medical records, the histories of chronic health disorders were determined. The specified diagnosis and usage of lipid-lowering medicine (dyslipidemia), anti-diabetic (type 2 diabetes mellitus), and anti-hypertensive medications characterized common chronic health disorders related to NAFLD (hypertension). In addition, medications recorded in medical records were classified into key categories.

Statistical Analyses

Descriptive statistics, such as means (± standard errors) and coefficient of variation, were used to describe quantitative measures. In contrast, categorical variables were described using frequency and proportions. All proportional distributions were represented as weighted percentages that are generalizable to all PLWH residing in Houston and Harris County, Texas. Bivariate associations between the severity of NAFLD and sociodemographic, behavioral, psychosocial, and clinical variables were conducted using the Rao-Scott chi-square test.

Following the results of the bivariate analyses, factors independently associated with NAFLD were evaluated. Only independent variables that met the statistical threshold of p-value ≤ 0.10 were selected a priori for inclusion in the multivariable logistic regression models. Epidemiologically important variables such as age, gender, and race/ethnicity that were not statistically significant in the bivariate analyses were forced into all analytical models. Due to the high number of variables that met the p-value ≤ 0.10, exploratory factor analysis was used to select the final variables that were entered into the final models. Also included in the models were variables (e.g., diabetes,

hypertension, dyslipidemia, protease inhibitor, INSTI) relevant to NAFLD based on the literature review.

Multivariable logistic regression model assumptions were tested and met. Furthermore, multicollinearity was evaluated by conducting a simple correlation analysis among the independent variables. Finally, the multivariable logistic regression models were constructed with mild vs. moderate, moderate vs. severe, and mild vs. severe as outcomes.

All models' diagnostics and fit statistics were performed using the log-likelihood test and corrected Akaike information criterion (AIC) (Vrieze, 2012). Odds ratios with 95% confidence intervals were reported. A recursive partitioning analysis was later performed to determine the contributions of significant predictors to the development and severity of NAFLD in the study population. This analysis produced the response and count probabilities by the independent factors' levels, the number of splits, and the coefficient of determination (R^2).

All tests performed were two-tailed, with a probability value of 0.05 used as the minimum threshold for declaring statistical significance. All statistical analyses applied survey procedures that considered the complex sampling design of the MMP and the associated unequal selection probabilities and non-response. Data management and statistical analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC, USA).

Results

Participants Characteristics and Factors Associated with Severity of NAFLD

Of the 587 eligible participants with TyG-defined NAFLD, which represent 18,266 PLWH in Houston/Harris County, Texas, 13.5% (95% CI: 10.61 – 16.49) had mild NAFLD, 26.5% (95% CI: 22.47 – 30.49), had moderate NAFLD, and 60% (95% CI: 55.53 – 64.42) had severe NAFLD. Table 1 presents the sociodemographic and behavioral characteristics by the severity of NAFLD (mild, moderate, and severe).

Nearly a quarter (22.35%, 95% CI: 18.69–26.00) of the study population diagnosed with HIV had severe NAFLD and were 50 years of age or older. Males had a higher prevalence compared to females across all degrees of severity (mild: 10.13% vs. 3.44%; moderate: 18.30% vs. 8.23%; and 42.42% vs. 17.48%). The prevalence estimates are almost equally distributed between people with private and public insurance (e.g., mild: 5.57% vs. 5.13%). About 35% (95% CI: 29.93–39.33) of people with severe NAFLD reported annual household income above the poverty level. Of the 24.34% of PLWH who reported food insecurity, 15.04% (95% CI: 11.79–18.28, p=0.0872) had severe NAFLD. People who did not report homelessness in the 12 months prior to the interview were more likely to have severe NAFLD than the homeless population, and the differences were statistically significant (55.21%, CI: 50.69–59.73, vs. 5%, CI: 3.10–6.91; p=0.0066). Interestingly, never-smokers had a higher prevalence and were more likely to have severe NAFLD than current and former smokers. The differences were statistically significant (35% vs. 18% and 7%, respectively, p=0.0497).

Table 2 shows that almost 30% of people with HIV infection over ten years had severe NAFLD (95% CI: 25.64 – 33.70, p=0.0393). Significant associations were also

noted between NAFLD severity groups and exposure to non-nucleoside reverse transcriptase inhibitors (NNRTI) (p=0.0102). No significant differences were observed across psychosocial characteristics (Table 3).

In Table 4, PLWH with severe NAFLD were more likely to have a higher mean BMI (29.84 ± 0.60 kg/m^2 vs. 28.47 ± 0.79 kg/m^2, *p*=0.0297) compared to people in the mild NAFLD group. No statistically significant differences were observed across clinical variables between the mild and moderate groups. Differences in mean ALT were statistically significant between mild and severe groups (*p*=0.0078). Statistically significant differences were also found between the moderate and severe groups across total bilirubin and systolic blood pressure. The risk of NAFLD increases with higher BMI, AST, and ALT.

Predictors of NAFLD Severity

Table 5 illustrates the adjusted odds ratios, their corresponding 95% CIs and the significance of the associated p-values. No multicollinearity was observed, and all model assumptions were met. Principal factor analysis was used to select variables, and variables loading factor-one with positive eigenvalues were selected and entered into the final models. Mild vs. severe and mild vs. moderate models demonstrated a significant goodness of fit. The adjusted multivariable models showed that among PLWH in Houston and Harris County, Texas, homelessness, smoking, and age were protective factors, while NNRTI, time since HIV diagnosis, and Hispanic ethnicity were significant predictors of severe NAFLD.

In the logistic regression model assessing the odds of progressing to moderate NAFLD in participants with mild NAFLD, people who experienced homelessness and

were former smokers had lower odds than non-smokers (aOR: 0.20; 95% CI: 0.04–0.92, *p*=0.0390), and (aOR: 0.23; 95% CI: 0.07–0.69), respectively, while people who had exposure to NNRTI had higher odds with an unreliable CI (aOR: 15.78; 95% CI: 1.15–216.69, *p*=0.0392). In the mild vs. severe NAFLD model, participants who had HIV diagnosis between five and nine years, more significant than ten years, and were Hispanic had higher odds of having severe NAFLD (aOR: 3.64; 95% CI: 1.48 – 8.93, *p*=0.0050), (aOR: 3.23; 95% CI: 1.42 – 7.33, *p*=0.0052), (aOR: 3.13, 95% CI: 1.21 – 8.13, *p*=0.0191), respectively. In the moderate vs. severe logistic model, compared to PLWH less than five years, PLWH within five and nine years in the moderate NAFLD group had a 3.5-fold increased likelihood (95% CI: 1.60–7.48, *p*=0.0017), and PLWH greater than ten years had a 2.7-fold increased likelihood (95% CI: 1.32–5.62, *p*=0.0068) of progressing to severe NAFLD. Also, PLWH who were between 30 and 39 years old were 0.3 times less likely than PLWH within 18 and 29 years to develop severe NAFLD.

The recursive partitioning analysis based on the best fit of the independent factors produced a decision tree with 11 splits. The mild vs. moderate model indicated, smoking - four splits (G^2 = 442.81, 42.20%), homelessness – 3 splits (G^2 = 355.03, 33.90%), and use of NNRTI with 4 splits (G^2 = 25075, 23.90%) (Table 6). The model resulted in an entropy coefficient of determination (R^2) of 0.112, and a misclassification rate of 0.2838. The recursive partitioning model analysis indicated that smoking, homelessness, and use of NNRTI significantly predicted moderate NAFLD (R2=11.20%) with a proportional contribution of 42.2%, 33.9%, and 23.9%, respectively.

Discussion

In this study, NAFLD prevalence estimates increased with severity and ranged from 13.5% (mild) to 60% (severe). With TyG-defined NAFLD and a cutoff value of 8.91 (Smiderle et al., 2021), this suggests that approximately 60% of the study sample had advanced fibrosis. Estimates of the prevalence of liver fibrosis in PLWH differed greatly. While the prevalence of severe NAFLD observed in this study is greater than previously reported, studies included in the review by Morrison et al. (2019) revealed a rate as high as 63%, which is consistent with the results of this study. Fourman et al. (2021) found that 43% of PLWH (n=58) had liver fibrosis. These studies' wide range of estimations may be attributed to the diagnostic methods employed. Regardless of modality, these estimates are higher than those reported for populations without HIV (Zhang et al., 2021). This shows that non-traditional factors may also contribute to the high prevalence of NAFLD among PLWH.

Consistent with the findings of earlier research (Kirkegaard-Klitbo et al., 2020; Lake et al., 2022; Squillace et al., 2019; Van Welzen et al., 2019), this study identified time since HIV diagnosis and NNRTI use as substantial predictors of severe NAFLD. However, Maurice et al. (2017) found no relationship between HIV infection duration and NAFLD. In addition, this analysis showed no significant associations between NAFLD and the use of other antiretroviral drugs, and HIV-specific variables such as CD4 lowest nadir and persistent viral load reduction were not identified in the review by Maurice et al. (2017).

Higher BMI, AST, ALT, LDL, total bilirubin, systolic and diastolic blood pressure, fasting triglycerides, and glucose significantly increased the risk of severe

NAFLD in PLWH These findings support previous studies (Lemoine et al., 2022; Maurice et al., 2017; Mohr et al., 2015). Many of these clinical variables, which indirectly are markers of hypertension (e.g., systolic and diastolic blood pressure), diabetes (fasting glucose), and dyslipidemia (HDL, LDL, Triglycerides), were not significant in the bivariate analyses. Hispanic ethnicity was strongly associated with NAFLD, which explains the reported high prevalence estimates. In this study, Hispanic ethnicity was not significant in the bivariate analysis. In the multivariable logistic regression model, it emerged as a substantial predictor for moderate to severe NAFLD, accounting for 51% of the variance in NAFLD severity. The racial and ethnic disparities have been attributed to genetic polymorphisms (Chew et al., 2022; Kim & Park, 2020; Lake et al., 2022). It is important to note that the frequency of NAFLD also differs across Hispanic communities, with Mexicans having a greater risk than Dominicans and Puerto Ricans (Younossi et al., 2018).

A few protective factors were identified in this study. They included younger age (30 to 39 years), former smoking, and homelessness. The associations between age and severe NAFLD have been an issue of contention. In this study, the prevalence of NAFLD was greater with older age (50), while the risk of having severe NAFLD was lower among those between the ages of 18 and 29; however, this difference was not statistically significant in either the bivariate or multivariate models. These results are comparable to those of Chew et al. (2022) but contradict those of Kirkegaard-Klitbo et al. (2020), who found higher odds of 3.34 ($p<0.01$).

Unexpectedly, homelessness was identified as a protective factor. Among homeless groups, overutilization of services, notably HIV care in the public hospital

system, might be a probable cause (Buck et al., 2012). It is also plausible that this group's increased prevalence of drug use, such as cocaine and marijuana (Santa Maria et al., 2018), might partly explain this phenomenon. However, previous research has shown a favorable impact of marijuana use on fasting insulin (Penner et al., 2013) and did not find a significant association with the development of liver fibrosis (Kelly et al., 2016). Marijuana use slowed the progression of liver fibrosis in NAFLD patients, according to a meta-analysis (Farooqui et al., 2019). In contrast, another study found that cocaine use may have adverse implications and may hasten the course of NAFLD, particularly in PLWH exposed to proton inhibitors (Lai et al., 2017). These inconsistent findings need further investigation.

The strong association between former smoking status and severe NAFLD is another highlight of this study. People who had formerly smoked had lower odds than those who had never smoked. This demonstrates the health benefits of smoking cessation. Previous research has found significant associations between smoking and severe NAFLD (Liu et al., 2017; Rezayat et al., 2018) and demonstrated that smoking cessation improves NAFLD (Takenaka et al., 2020). However, about 30% of the study population reported smoking at the time of the interview and 12 months before. This finding should be concerning and suggests that current smoking cessation programs among PLWH need to be strengthened. Smoking is related to increased mortality, particularly among PLWH (Helleberg et al., 2013); consequently, clinicians should examine their patients' smoking status at each visit, regardless of their antiretroviral status, and support them in quitting.

Lastly, in this study, the researchers could not build a positive relationship between food insecurity and advanced fibrosis, although previous research has shown

that food insecurity is a strong predictor of this condition (Golovaty et al., 2020; Tamargo et al., 2021). Surprisingly, there were no significant associations between psychosocial variables and severe NAFLD, while the odds increased the risk of severe NAFLD.

Limitations and Strengths

This study's findings are subject to a few limitations. First, the MMP data were collected for public surveillance purposes, thus it is not intended for NAFLD assessment. Second, this study did not use the recommended diagnostic method (liver biopsy) to assess NAFLD severity. As the TyG index is a screening tool, it cannot precisely grade the severity of NAFLD; consequently, additional diagnostic tools must be used. Thirdly, although the study demonstrated that NNRTI is a strong predictor of NAFLD, a potential error in medical records data may influence the findings. Fourth, because this research was cross-sectional, causality could not be established. Lastly, this research could not evaluate the influence of food and physical activity, risk factors for NAFLD (Riazi et al., 2019).

This research contributed to the evidence that PLWH are at a greater risk for NAFLD. The findings of this study also validate existing evidence that time since HIV diagnosis and exposure to NNRTI are significant predictors of NAFLD. Moreover, it strengthens the findings that Hispanic ethnicity strongly predicts NAFLD. Previously, younger age was identified as a protective factor, and this research confirms the same result in PLWH. A noteworthy result of this research was the identification of homelessness as a protective factor against severe NAFLD among PLWH in Houston and Harris County, Texas. This finding contributes to the literature, however further

investigations are needed. Lastly, since the study sample is representative, the findings may be generalizable to the HIV population in Houston and Harris County, Texas.

Implications for Research and Practice

This study's results have several implications for clinical practice. Clinicians should integrate a simple, noninvasive NAFLD screening tool into the HIV standard of care to identify and educate patients about liver fibrosis, specifically Hispanic PLWH, and those who have been living with HIV for more than five years and use NNRTI. Nearly 40% of people with NAFLD may develop fibrosis that leads to liver cancer with a mortality risk that is more than three times higher than NAFLD patients without fibrosis (McPherson et al., 2017). Screening patients for liver fibrosis may increase awareness, uptake of nutrition counseling, and ultimately improve behavior modification. This study found that homelessness is a protective factor against severe NAFLD. It is unclear what other factors impact this association. Further research is required to understand the effect of homelessness on the development and progression of NAFLD.

Conclusion

Despite the improved metabolic profile of recent antiviral regimens, PLWH continue to be at greater risk for NAFLD and develop severe NAFLD more rapidly.

In clinical practice, Hispanic PLWH for more than five years, and those using non-nucleoside reverse transcriptase inhibitors should be closely monitored. Clinicians may consider using the triglyceride-glucose index or a comparable index as a routine evaluation tool. Early and prompt care of individuals with NAFLD, specifically liver fibrosis, will reduce the prevalence of the disease and save lives**.**

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Table 1

Sociodemographic, and Behavioral Characteristics of Study Participants with NAFLD by Severity Status - Houston MMP, 2015-2019.

			Positive NAFLD Group (TyG > 8.38)							
Characteristics	Unweighted,	Weighted,	Mild (8.38 > TyG ≤ 8.75)		Moderate (8.75 > TyG < 8.91)		Severe TyG ≥ 8.91		Test Statistics	
			n (%)	CI (95%)	n (%)	CI (95%)	n (%)	CI (95%)	**χ2 value[1]**	**p-value**
Overall	587	18,266	2,475 (13.55)	10.61 – 16.49	4,836 (26.48)	22.47 – 30.48	10,955 (59.98)	55.53 – 64.42	169.20	<0.0001
Sociodemographic										
Age Group (Years)									6.25	0.3955
18 - 29	65	2,241	215 (1.17)	0.35 – 2.00	425 (2.33)	0.83 – 3.83	1,601 (8.77)	6.00 – 11.54		
30 - 39	127	4,153	706 (3.87)	2.02 – 5.71	1,082 (5.92)	3.94 – 7.91	2,365 (12.95)	9.54 – 16.36		
40 - 49	157	4,654	504 (2.76)	1.43 – 4.09	1,243 (6.80)	4.71 – 8.90	2,907 (15.91)	12.63 – 19.19		
≥ 50	238	7,217	1,050 (5.75)	3.85 – 7.65	2,086 (11.42)	8.36 – 14.48	4,082 (22.35)	18.69 – 26.00		
Gender at Birth									0.73	0.6956
Male	399	12,915	1,848 (10.13)	7.50 – 12.77	3,335 (18.30)	14.71 – 21.88	7,732 (42.42)	37.87 – 46.96		
Female	187	5,314	627 (3.44)	1.97 – 4.91	1,500 (8.23)	5.85 – 10.61	3,187 (17.48)	14.02 – 20.94		
Sexual Orientation									2.40	0.8792
Homosexual	230	7,225	1,016 (5.66)	3.72 – 7.60	2,137 (11.90)	8.90 – 14.89	4,072 (22.67)	18.72 – 26.62		
Heterosexual	290	8,715	1,115 (6.21)	4.19 – 8.23	2,130 (11.86)	9.00 – 14.72	5,470 (30.45)	26.22 – 34.69		
Bisexual	48	15,98	209 (1.16)	0.35 – 1.98	459 (2.55)	0.91 – 4.20	931 (5.18)	3.18 – 7.18		
Other	12	424	42 (0.23)	0.00 – 0.70	90 (0.50)	0.01 – 1.00	291 (1.62)	0.32 – 2.93		
Race/Ethnicity									7.16	0.3060
White, Non-Hispanic	94	3,074	484 (2.65)	1.36 – 3.93	889 (4.87)	2.72 – 7.02	1,701 (9.31)	6.56 – 12.07		
Black, Non-Hispanic	316	9,727	1,399 (7.66)	5.33 – 9.98	2,436 (13.34)	10.31 – 16.36	5,892 (32.26)	27.97 – 36.54		
Hispanic or Latino	154	4,721	397 (2.17)	1.07 – 3.27	1,371 (7.51)	5.13 – 9.88	2,954 (16.17)	12.77 – 19.57		
Other	23	743	196 (1.07)	0.04 – 2.11	139 (0.76)	0.15 – 1.38	408 (2.23)	0.84 – 3.63		
Health Insurance Type									4.79	0.7798
Any Private	217	6,811	1,000 (5.57)	3.79 – 7.35	1,854 (10.33)	7.55 – 13.11	3,957 (22.05)	18.09 – 26.01		
Public Only	249	7,681	921 (5.130	7.55 – 13.11	1,829 (10.19)	7.44 – 12.94	4,932 (27.48)	23.33 – 31.64		
Ryan White/ADAP Only	93	2786	372 (2.07)	0.76 – 3.38	863 (4.81)	2.86 – 6.75	1,551 (8.64)	6.20 – 11.08		
Unspecified	7	170	46 (0.26)	0.00 – 0.61	71 (0.40)	0.00 – 0.84	53 (0.29)	0.00 – 0.70		
Uninsured	12	497	44 (0.24)	0.00 – 0.73	164 (0.91)	0.00 – 1.99	289 (1.61)	0.40 – 2.83		
Marital Status									2.51	0.8678
Married	102	3121	398 (2.20)	1.05 – 3.35	925 (5.11)	3.19 – 7.03	1,798 (9.92)	7.06 – 12.79		

Table 1 (Continued)

In a civil union or domestic partnership	43	1,285	149 (0.82)	0.10 – 1.55	328 (1.81)	0.59 – 3.04	808 (4.46)	2.64 – 6.28		
Divorce/Widowed/ Separated	137	3,832	605 (3.34)	1.88 – 4.81	1,103 (6.09)	3.96 – 8.22	2,123 (11.72)	9.01 – 14.44		
Single	302	9,874	1,231 (6.79)	10.32 – 16.72	2,448 (13.52)	10.32 – 16.72	6,195 (34.20)	29.75 – 38.66		
Education Level									3.55	0.4704
<High School	116	3,350	462 (2.55)	1.09 – 4.00	941 (5.19)	3.34 – 7.04	1,947 (10.73)	8.01 – 13.45		
High School Diploma or Equivalent	154	4,692	533 (2.94)	1.60 – 4.28	1,012 (5.58)	3.54 – 7.62	3,147 (17.35)	13.90 – 20.79		
>High School	315	10,100	1,388 (7.65)	5.49 – 9.81	2,883 (15.89)	12.46 – 19.32	5,830 (32.13)	27.75 – 36.52		
Employment Status									3.07	0.8001
Employed	283	8,772	1,206 (6.65)	4.51 – 8.78	2,222 (12.25)	9.35 – 15.14	5,345 (29.46)	25.27 – 33.66		
Unemployed	114	3,899	464 (2.56)	1.18 – 3.94	1117 (6.16)	3.83 – 8.49	2,317 (12.77)	9.41 – 16.14		
Unable to Work	124	3,562	353 (1.94)	0.91 – 2.97	986 (5.43)	3.50 – 7.36	2,224 (12.26)	9.39 – 15.12		
Other	64	1,909	360 (1.98)	0.94 – 3.03	511 (2.82)	1.15 – 4.48	1,038 (5.72)	3.72 – 7.72		
Annual Household Income (US$)									6.69	0.3502
0 – 19,999	275	7,981	894 (5.48)	3.47 - 7.50	2,017 (12.38)	9.36 – 15.40	5,070 (31.11)	26.83 – 35.39		
20,000 – 39,999	125	3,949	705 (4.33)	2.45 – 6.20	923 (5.66)	2.45 – 6.20	2,321 (14.25)	10.85 – 17.65		
40,000 – 74,999	87	2,740	409 (2.51)	1.27 – 3.75	681 (4.18)	2.48 – 5.88	1,651 (10.13)	6.93 – 13.33		
75,000 and more	45	1,623	133 (0.82)	0.10 – 1.54	610 (3.75)	1.66 – 5.83	880 (5.40)	2.82 – 7.98		
Poverty Level									0.82	0.6630
At or Below Poverty Level	235	6,764	809 (4.96)	3.03 – 6.90	1,676 (10.29)	7.56 – 13.01	4,279 (26.26)	22.21 – 30.31		
Above Poverty Level	297	9,529	1,332 (8.18)	5.78 – 10.57	2,555 (15.68)	12.07 – 19.29	5,642 (34.63)	29.93 – 39.33		
English Language									3.80	0.7041
Very Well	450	14,049	1,901 (10.48)	7.92 – 13.04	3,837 (21.15)	17.48 – 24.84	8,311 (45.81)	41.23 – 50.38		
Well	92	2,933	322 (1.78)	0.64 – 2.92	813 (4.48)	2.44 – 6.51	1,799 (9.91)	7.21 – 12.62		
Not Well	23	606	113 (0.63)	0.01 – 1.24	85 (0.47)	0.01 – 0.93	408 (2.25)	1.09 – 3.40		
Not at All	20	555	46 (0.25)	0.00 – 0.60	102 (0.56)	0.00 – 1.12	407 (2.25)	0.90 – 3.59		
Foreign Born									0.95	0.6226
No	466	14,772	1,935 (10.67)	8.06 – 13.27	3,814 (21.02)	17.25 – 24.80	9,023 (49.73)	45.16 – 54.31		
Yes	119	3,370	448 (2.47)	1.24 – 3.70	1,022 (5.63)	3.69 – 7.57	1,901 (10.48)	7.89 – 13.06		
Homeless									10.05	0.0066**
No	532	16,475	1,916 (10.56)	8.04 – 13.08	4,543 (25.04)	21.09 – 28.98	10,016 (55.21)	50.69 – 59.73		
Yes	53	1,667	467 (2.57)	1.14 – 4.00	293 (1.62)	0.48 – 2.75	908 (5.00)	3.10 – 6.91		
Food Insecurity									0.92	0.0872
No	438	13,703	1,829 (10.10)	7.68 – 12.51	3,705 (20.46)	16.72 – 24.20	8,169 (45.11)	40.53 – 49.69		
Yes	146	4,409	554 (3.06)	1.44 – 4.68	1,131 (6.24)	4.20 – 8.29	2,724 (15.04)	11.79 – 18.28		
Any Disability									0.70	0.7035
No	346	10,620	1,515 (8.40)	6.02 – 10.78	2,795 (15.49)	12.18 – 18.80	6,310 (34.97)	30.61 – 39.34		
Yes	236	7,423	868 (4.81)	3.11 – 6.51	2,009 (11.13)	8.25 – 14.02	4,546 (25.20)	21.07 – 29.33		

Table 1 (Continued)

Behavioral $^{\pi}$										
Smoking Status									9.50	0.0497*
Never Smoker	345	10,707	1,218 (6.72)	4.68 – 8.76	3,081 (17.01)	13.55 – 20.46	6,407 (35.37)	30.92 – 39.82		
Former Smoker	69	2,091	492 (2.71)	1.39 – 4.04	314 (1.74)	0.74 – 2.73	1,285 (7.09)	4.80 – 9.39		
Current Smoker	170	3,206	673 (3.71)	2.08 – 5.35	1,440 (7.95)	5.46 – 10.44	3,206 (17.70)	14.21 – 21.19		
Alcohol Use									0.14	0.9316
No	251	7,336	930 (5.12)	3.29 -6.95	1,919 (10.58)	7.92 – 13.24	4,488 (24.74)	20.95 – 28.52		
Yes	334	10,806	1,453 (8.01)	5.74 – 10.27	2,917 (16.08)	12.62 – 19.53	6,436 (35.48)	30.98 – 39.98		
Use of non-injection drugs									0.82	0.6625
No	443	13,317	1,716 (9.47)	7.13 – 11.81	3,688 (20.35)	16.73 -23.98	7,913 (43.67)	39.14 – 48.20		
Yes	141	4,804	667 (3.68)	1.96 – 5.40	1,126 (6.22)	3.91 – 8.52	3,011 (16.61)	12.94 – 20.29		
Use of injection drugs									----$^{\infty}$	----$^{\infty}$
No	577	17,895	2,277 (12.55)	9.78 – 15.32	4,836 (26.65)	22.63 – 30.68	10,782 (59.43)	54.99 – 63.87		
Yes	8	247	106 (0.58)	0.00 – 1.25	0	----$^{\infty}$	142 (0.78)	0.09 – 1.47		

Notes. $^{\pi}$ self-reported measures in the last 12 months.

$^{\infty}$ Value was inestimable due to small cell size or missing cases for factor levels.

[1] $\chi 2$ value based on the Rao–Scott modified statistic, which provides a design-based goodness-of-fit test using survey weights.

Significance level: *=p<0.05; **=p<0.01; ns= Not significant (p> 0.05).

Abbreviations. US = United States

Table 2

Clinical Characteristics of Study Participants with NAFLD by Severity Status - Houston Medical Monitoring Project, 2015-2019.

Characteristics	**Total Unweighted, (N = 587)**	**Total Weighted, (N = 182,66)**	**Mild NAFLD** (8.38 > TyG ≤ 8.75) (n =2,475)		**Moderate** (8.75 > TyG < 8.91) (n = 4,836)		**Severe** TyG ≥ 8.91 (n = 10,955)		**Test Statistics**	
			Weighted, n (%)	95% CI	Weighted, n (%)	95% CI	Weighted, n (%)	95% CI	**χ2 value[1]**	**p-value**
Time since HIV Diagnosis (years)									10.07	0.0393*
< 5	122	3,985	816 (4.47)	2.48 – 6.45	1,066 (5.83)	3.76 -7.91	2,103 (11.52)	8.35 – 14.68		
5 – 9	155	5,004	508 (2.78)	1.54 – 4.02	1,064 (5.82)	3.76 – 7.88	3,432 (18.79)	15.03 – 22.55		
≥ 10	310	9,277	1,151 (6.30)	4.32 – 8.27	2,707 (14.82)	11.53 – 18.11	5,419 (29.67)	25.64 – 33.70		
HIV infection stage 3 (AIDS)									3.79	0.1503
No	270	8,799	1,024 (5.61)	3.49 – 7.73	2,108 (11.54)	8.71 – 14.37	5,667 (31.03)	26.65 – 35.40		
Yes	317	9,467	1,451 (7.94)	5.76 – 10.12	2,728 (14.94)	11.65 – 18.23	5,288 (28.95)	24.94 – 32.95		
Lowest Nadir CD4 Count[π]									0.46	0.9645
0 - 49	29	762	123 (0.89)	0.00 – 1.79	225 (1.64)	0.54 – 2.74	414 (3.02)	1.54 – 4.50		
50 – 199	39	1,067	184 (1.34)	0.34 – 2.34	159 (1.16)	0.22 – 2.10	724 (5.28)	3.19 – 7.37		
200 – 349	63	1,948	451 (3.29)	1.19 – 5.39	545 (3.97)	1.96 – 5.98	952 (6.94)	4.50 – 9.39		
350 – 499	86	2,410	299 (2.18)	0.87 – 3.49	579 (4.22)	2.19 – 6.26	1,532 (11.17)	8.20 – 14.14		
≥ 500	262	7,531	977 (7.12)	4.80 – 9.44	2,008 (14.64)	11.35 – 17.93	4,546 (33.14)	28.45 – 37.83		
Current ART Use									2.09	0.3519
No	37	1,682	87 (0.48)	0.00 – 1.22	546 (3.01)	1.13 – 4.89	1,049 (5.78)	3.13 – 8.43		
Yes	548	16,461	2,296 (12.65)	9.89 – 15.41	4,290 (23.65)	19.86 – 27.43	9,875 (54.43)	49.87 – 58.99		
ART Regimen										
INSTI									0.31	08574
No	310	9,318	1,297 (7.46)	5.13 – 9.79	2,437 (14.02)	10.85 – 17.19	5,584 (32.13)	27.85 – 36.41		
Yes	257	8,064	1,050 (6.04)	4.05 – 8.03	2,283 (13.14)	10.02 – 16.25	4,730 (27.22)	23.22 -31.21		
NRTI									1.16	0.5597
No	141	4,668	758 (4.36)	2.61 – 6.11	1,208 (6.95)	4.81 – 9.08	2,702 (15.55)	12.17 – 18.92		
Yes	426	12,714	1,589 (9.14)	6.65 – 11.64	3,512 (20.21)	16.44 – 23.97	7,612 (43.80)	39.34 – 48.25		
NNRTI									9.18	0.0102*
No	534	16,289	2,299 (13.23)	10.27 – 16.18	4,186 (24.08)	20.22 – 27.95	9,803 (56.40)	51.86 – 60.93		
Yes	33	1,093	48 (0.27)	0.00 – 0.65	534 (3.07)	1.14 – 5.00	512 (2.94)	1.56 – 4.33		
Protease Inhibitors									1.71	0.4245
No	374	11,501	1,508 (8.67)	6.31 – 11.03	2,929 (16.85)	13.39 – 20.31	7,064 (40.64)	36.18 – 45.10		
Yes	193	5,881	839 (4.83)	2.86 – 6.80	1,791 (10.30)	7.50 – 13.11	3,251 (18.70)	15.06 – 22.35		

Table 2
(Continued)

									2.49	0.2874
Durable Viral Suppression[π]										
Undetectable, < 200 copies/mL	364	10,359	1,606 (8.79)	6.36 – 11.23	2,564 (14.04)	11.20 – 16.87	6,188 (33.88)	29.73 – 38.03		
Detectable, ≥ 200 copied/mL	223	7,907	869 (4.76)	2.94 – 6.57	2,271 (12.44)	9.12 – 15.75	4,767 (26.10)	21.73 – 30.46		
Diagnosed Chronic Health Conditions [€]										
Diabetes Mellitus, Type 2									0.67	0.7171
No	491	15,203	2,010 (11.57)	8.73 – 14.40	4,190 (24.11)	20.17 – 28.05	9,003 (51.81)	47.22 – 56.40		
Yes	76	2,174	337 (1.94)	0.91 – 2.96	503 (2.90)	1.28 – 4.51	1,334 (7.68)	5.38 – 9.97		
Hypertension									0.58	0.7468
No	349	10,990	1,408 (8.08)	5.58 – 10.59	2,900 (16.65)	13.27 – 20.03	6,682 (38.36)	33.85 – 42.88		
Yes	220	6,428	939 (5.39)	3.64 – 7.14	1,793 (10.30)	7.41 – 13.18	3,696 (21.22)	17.57 – 24.87		
Dyslipidemia									0.71	0.7020
No	389	12,359	1,606 (8.89)	6.34 – 11.45	3,196 (17.70)	14.30 – 21.10	7,557 (41.87)	37.29 – 46.45		
Yes	193	5,693	869 (4.81)	3.14 – 6.49	1,543 (8.55)	5.93 – 11.17	3,280 (18.17)	14.82 – 21.53		

Notes. [€]Medical records data; [π]self-reported measures in 12 months prior to interview.

[1] $\chi 2$ value based on the Rao–Scott modified statistics, which provides a design-based goodness-of-fit test using survey weights.

Significance level: *=p<0.05; **=p<0.01; ***=p<0.001; ****=p<0.0001; ns= Not significant (p> 0.05).

Abbreviations. HIV = Human Immunodeficiency Virus; CD4 = Cluster of differentiation 4; NNRTI = non-nucleoside reverse transcriptase inhibitors; NRTI = nucleoside reverse transcriptase inhibitors; PI = protease inhibitors; INSTI = integrase strand transfer inhibitors.

Table 3

Psychosocial Characteristics of Study Participants with NAFLD By Severity Status, Houston Medical Monitoring Project, 2015-2019

Characteristics	Total Unweighted	Total Weighted	Mild (8.38 > TyG ≤ 8.75) (n =2,475)		Moderate (8.75 > TyG < 8.91) (n = 4,836)		Severe TyG ≥ 8.91 (n = 10,955)		Test Statistics	
			Weighted n (%)	95% CI	Weighted n (%)	95% CI	Weighted n (%)	95% CI	**χ2 value[1]**	**p-value**
Depression Status[€]									0.28	0.8694
No	451	13,794	1,864 (10.32)	7.77 – 12.89	3,555 (19.69)	16.16 – 23.22	7,557 (41.87)	41.81 – 50.98		
Yes	131	4,258	611 (3.38)	1.75 – 5.02	1,184 (6.56)	4.10 – 9.02	2,463 (13.64)	10.39 – 16.90		
Anxiety Status[€]									2.33	0.3119
No	509	15,767	2,183 (12.09)	9.56 – 14.93	3,957 (21.92)	18.30 – 25.53	9,628 (53.33)	48.79 – 57.88		
Yes	73	2,285	292 (1.62)	0.64 – 2.60	783 (4.34)	2.07 – 6.60	1,210 (6.70)	4.68 – 8.72		
HIV Stigma [π]									3.03	0.2196
No	6	167	64 (0.78)	0.00 – 1.86	20 (0.24)	0.00 – 0.71	83 (1.02)	0.00 – 2.17		
Yes	238	8,047	1,161 (14.13)	9.68 – 18.58	2,148 (26.16)	20.27 – 32.05	4,738 (57.68)	51.06 – 64.31		
Discrimination[π]									1.32	0.5169
No	193	6,410	1,009 (12.43)	8.19 – 16.67	1,789 (22.04)	16.59 – 27.49	3,613 (44.52)	37.90 – 51.14		
Yes	55	1,705	211 (2.60)	0.65 – 4.54	384 (4.73)	2.21 – 7.24	1,111 (13.68)	9.09 – 18.28		

Notes. [1] $\chi 2$ value based on the Rao–Scott modified statistics, which provides a design-based goodness-of-fit test using survey weights.

[€]Medical records data; [π]self-reported measures in 12 months prior to interview.

Abbreviations. HIV= Human Immunodeficiency Virus.

Table 4

Laboratory Markers of NAFLD by Severity Among People Living with HIV - Houston Medical Monitoring Project, 2015-2019.

Parameters	Unweighted (N = 587)	Weighted (N = 18,266)	Mild NAFLD (8.38 > TyG ≤ 8.75) *(n = 2,475)*		Moderate NAFLD (8.75 > TyG < 8.91) (n = 4,836)		Severe NAFLD TyG ≥ 8.91 (n = 10,955)		F-value	p-values[1]
			Weighted, n	Mean (SEM)	Weighted, n	Mean (SEM)	Weighted, **n**	Mean (SEM)		
Body Mass Index (kg/m²)	555	16,925	2,328	28.47 (0.79)	4,568	28.11 (0.52)	10,028	29.84 (0.60)	2.47	0.0853
AST, U/L	587	18,266	2,475	24.54 (1.83)	4,836	24.06 (1.11)	10,955	26.99 (1.15)	1.80	0.1667
ALT, U/L	587	18,266	2,475	25.01 (1.44) [a]	4,836	27.08 (1.41) [a,b]	10,955	31.47 (1.95) [b]	3.57	0.0288*
Triglycerides, mg/dL (fasting)	587	18,266	2,475	131.17 (1.66)	4,836	147.78 (1.02)	10,955	171.52 (1.50)	1.40	0.2486
HDL, mg/dL	587	18,266	2,475	49.13 (1.63)	4,836	48.96 (1.42)	10,955	48.16 (0.76)	0.23	0.7979
LDL, mg/dL	587	18,266	2,475	102.75 (3.19)	4,836	106.95 (2.58)	10,955	101.30 (1.69)	1.67	0.1888
Cholesterol	587	18,266	2,475	181.04 (3.80)	4,836	182.44 (3.27)	10,955	117.53 (2.14)	0.90	0.4070
Glucose, mg/dL (fasting)	587	18,266	2,475	88.33 (0.98)	4,836	93.90 (0.66)	10,955	101.65 (0.60)	2.09	0.1245
Creatinine, mg/mL	587	18,266	2,475	1.02 (0.07)	4,836	1.35 (0.20)	10,955	1.07 (0.07)	1.26	0.2846
Platelets, 10^9/L	558	17,060	2,350	232.21 (11.67)	4,580	231.76 (5.83)	10,131	232.24 (6.02)	0.00	0.9982
Albumin	587	18,266	2,475	4.16 (0.09)	4,836	4.22 (0.09)	10,955	4.14 (0.05)	0.28	0.7536
Total Bilirubin, mg/dL	587	18,266	2,475	0.62 (0.09) [a]	4,836	0.51(0.04) [a,b]	10,955	0.74 (0.09) [a,c]	3.25	0.0396*
Systolic Blood Pressure, mmHg	581	18,067	2,475	126 (2.25) [a]	4,782	129 (1.19) [a,b]	10,810	123(1.88) [a,c]	3.01	0.0503*
Diastolic Blood Pressure, mmHg	581	18,067	2,475	78 (1.48)	4,782	80 (0.84)	10,810	77 (1.20)	1.98	0.1392
Antiretroviral Adherence Score	587	18,266	2,475	82.41 (4.43)	4,836	78.57 (3.37)	10,955	77.98 (2.19)	0.40	0.6674

Notes. [1]P-values from analysis of variance, were used to compare the differences of selected characteristics between NAFLD subjects by staging.
Within parameters, means ± SEM, with different superscript(s) are significantly different (p<0.05).
Significance level: *=p<0.05; ns= Not significant (p > 0.05).
Abbreviations. CI = confidence interval; LDL = Low-density lipoprotein; HDL = High-density Lipoprotein; AST = Aspartate Transaminase; ALT = Alanine Transaminase

Table 5

Adjusted Odd Ratios of NAFLD Severity among People Living with HIV- Houston Medical Monitoring Project, 2015 – 2019.

Characteristics	Model 1[β]		Model 2[β]		Model 3[β]	
	aOR (95% CI)	p-value[1]	aOR (95% CI)	p-value[1]	aOR (95% CI)	p-value[1]
Age Group (Years)						
18 – 29 (Ref)	1.00	-	1.00	-	1.00	-
30 - 39	1.19 (0.20 – 7.08)	0.8509	0.39 (0.11 -1.47)	0.1649	0.32 (0.12 – 0.90)	0.0301*
40 - 49	1.26 (0.21 – 7.66)	0.7992	0.65 (0.15 – 2.91)	0.5727	0.41 (0.14 – 1.15)	0.0900
≥ 50	0.56 (0.09 – 3.51)	0.5350	0.34 (0.09 – 1.36)	0.1274	0.38 (0.13 – 1.11)	0.0757
Gender at Birth						
Male (Ref)	1.00	-	1.00	-	1.00	-
Female	0.76 (0.31 – 1.86)	0.5382	0.77 (0.38 – 1.59)	0.4815	1.04 (0.59 – 1.84)	0.8959
Race/Ethnicity						
White, Non-Hispanic (Ref)	1.00	-	1.00	-	1.00	-
Black, Non-Hispanic	1.05 (0.34 – 3.18)	0.9362	1.65 (0.72 – 3.77)	0.2349	1.23 (0.60 – 2.52)	0.5756
Hispanic or Latino	2.17 (0.67 – 6.96)	0.1940	3.13 (1.21 – 8.13)	0.0191*	1.39 (0.65 – 2.97)	0.3940
Other	1.19 (0.17 – 8.12)	0.8594	0.96 (0.16 – 5.65)	0.9673	1.06 (0.24 – 4.77)	0.9404
Homeless [€]						
No (Ref)	1.00		1.00	-	1.00	-
Yes	0.20 (0.04 – 0.92)	0.0390*	0.38 (0.13 – 1.06)	0.0641	1.42 (0.45 – 4.45)	0.5508
Food Insecurity [€]						
No (Ref)	1.00	-	1.00	-	1.00	-
Yes	1.04 (0.45 – 2.41)	0.9216	1.23 (0.54 – 2.82)	0.6245	1.22 (0.64 – 2.32)	0.5464
Smoking Status [€]						
Never Smoker (Ref)	1.00	-	1.00	-	1.00	-
Former Smoker	0.23 (0.07 – 0.69)	0.0089**	0.44 (0.18 – 1.06)	0.0672	1.45 (0.64 – 3.29)	0.3693
Current Smoker	0.84 (0.34 – 2.10)	0.7102	0.91 (0.43 – 1.93)	0.8115	0.90 (0.51 – 1.59)	0.7141
Depression status [ƨ]						
No (Ref)	1.00	-	1.00	-	1.00	-
Yes	0.76 (0.32 – 1.81)	0.5330	1.06 (0.50 – 2.24)	0.8825	1.36 (0.75 – 2.49)	0.3113
Diabetes Mellitus						
No (Ref)	1.00	-	1.00	-	1.00	-
Yes	0.56 (0.18 – 1.74)	0.3144	1.27 (0.52 – 3.13)	0.5975	1.44 (0.69 – 3.03)	0.3314

Table 5 (continued)

Dyslipidemia						
No (Ref)	1.00	-	1.00	-	1.00	-
Yes	0.59 (0.25 – 1.38)	0.2232	0.60 (0.31 – 1.17)	0.1327	0.97 (0.56 – 1.70)	0.9245
Hypertension						
No (Ref)	1.00	-	1.00		1.00	
Yes	1.42 (0.62 – 3.26)	0.4026	1.16 (0.56 – 2.41)	0.6871	1.10 (0.62 – 1.95)	0.7543
Time since HIV Diagnosis (years)						
< 5 (*Ref)*	1.00	-	1.00	-	1.00	-
5 – 9	0.98 (0.3 – 3.10)	0.9770	3.64 (1.48 – 8.93)	0.0050**	3.46 (1.60 – 7.48)	0.0017**
≥ 10	1.58 (0.47 – 5.23)	0.4565	3.23 (1.42 – 7.33)	0.0052**	2.72 (1.32 – 5.62)	0.0068**
Lowest Nadir CD4 Count[π]						
0 - 49	0.67 (0.20 – 2.24)	0.5088	0.63 (0.23 – 1.73)	0.3673	1.44 (0.58 – 3.55)	0.4305
50 – 199	0.35 (0.12 – 1.02)	0.0551	0.39 (0.15 – 1.05)	0.0612	0.98 (0.46 – 2.10)	0.9543
200 – 349	0.79 (0.26 – 2.35)	0.6643	1.18 (0.48 – 2.91)	0.7226	1.19 (0.61 – 2.32)	0.6084
350 – 499 (Ref)	1.00	-	1.00	-	1.00	-
Durable Viral Suppression[π]						
Undetectable, < 200 copies/mL (Ref)	1.00	-	1.00	-	1.00	-
Detectable, ≥ 200 copied/mL	1.14 (0.43 – 3.03)	0.7907	1.31 (0.57 – 3.03)	0.5213	0.73 (0.38 – 1.42)	0.3598
INSTI						
No (Ref)	1.00	-	1.00	-	1.00	-
Yes	1.32 (0.57 – 3.08)	0.5182	0.88 (0.48 – 1.63)	0.6905	0.75 (0.45 – 1.47)	0.2799
NNRTI						
No (Ref)	1.00	--	1.00	-	1.00	-
Yes	15.78 (1.15 – 216.69)	0.0392*	4.79 (0.55 – 42.09)	0.1572	0.54 (0.22 – 1.28)	0.1587
Protease Inhibitors						
No (Ref)	1.00	-	1.00	-	1.00	-
Yes	0.97 (0.39 – 2.41)	0.9404	0.79 (0.38 – 1.64)	0.5189	0.83 (0.47 – 1.47)	0.5268

Notes.

[β] Model 1 = Mild (0) vs. Moderate (1); Model 2 = Mild (0) vs. Severe (1); Model 3 = Moderate (0) vs. Severe (1).

Model Fit statistics:

Model 1--Akaike Information Criterion (AIC) = 7,007.03; Schwartz Criterion (SC) = 7,013.62; Likelihood Ratio Test (LRT): Degree of Freedom (df) = 4,451.47, F-value = 1.67*.

Model 2--Akaike Information Criterion (AIC) = 9,736.91; Schwartz Criterion (SC) = 9,744.12; Likelihood Ratio Test (LRT): Degree of Freedom (df) = 8,197.80, F-value = 1.77*.

Model 3--Akaike Information Criterion (AIC) = 14,069.15; Schwartz Criterion (SC) = 14,076.15; Likelihood Ratio Test (LRT): Degree of Freedom (df) =9,471.05, F-value =1.19[ns] .

Significance based on 95% confidence interval: Significance level: *=p<0.05; **=p<0.01; ***=p<0.001; ****=p<0.0001; ns= Not significant (p > 0.05).

Abbreviations. aOR = Adjusted Odds Ratio; CI = Confidence Interval; Ref = Referent; HIV = Human Immunodeficiency Virus; CD4 = Cluster of Differentiation 4; INSTI = Integrase Strand Transfer Inhibitor; NNRTI = non-nucleoside reverse transcriptase inhibitors.

Table 6

Recursive Partition Model for NAFLD Among People Living with HIV – Houston Medical Monitoring Project, 2015-2019

Term	Number of Splits	G^2	Plot	Proportion (%)
Model 1 $^{\beta}$				
Smoking Status	4	442.807		42.20
Homelessness	3	355.025		33.90
Use of NNRTI	4	250.754		23.90
R^2 = 0.112				
Model 2 $^{\beta}$				
Race/Ethnicity	7	250.228		50.96
Time Since HIV Diagnosis	4	240.803		49.04
R^2 = 0.038				
Model 3 $^{\beta}$				
Age Group	8	322.878		67.48
Time Since HIV Diagnosis	3	155.567		32.52
R^2 = 0.025				

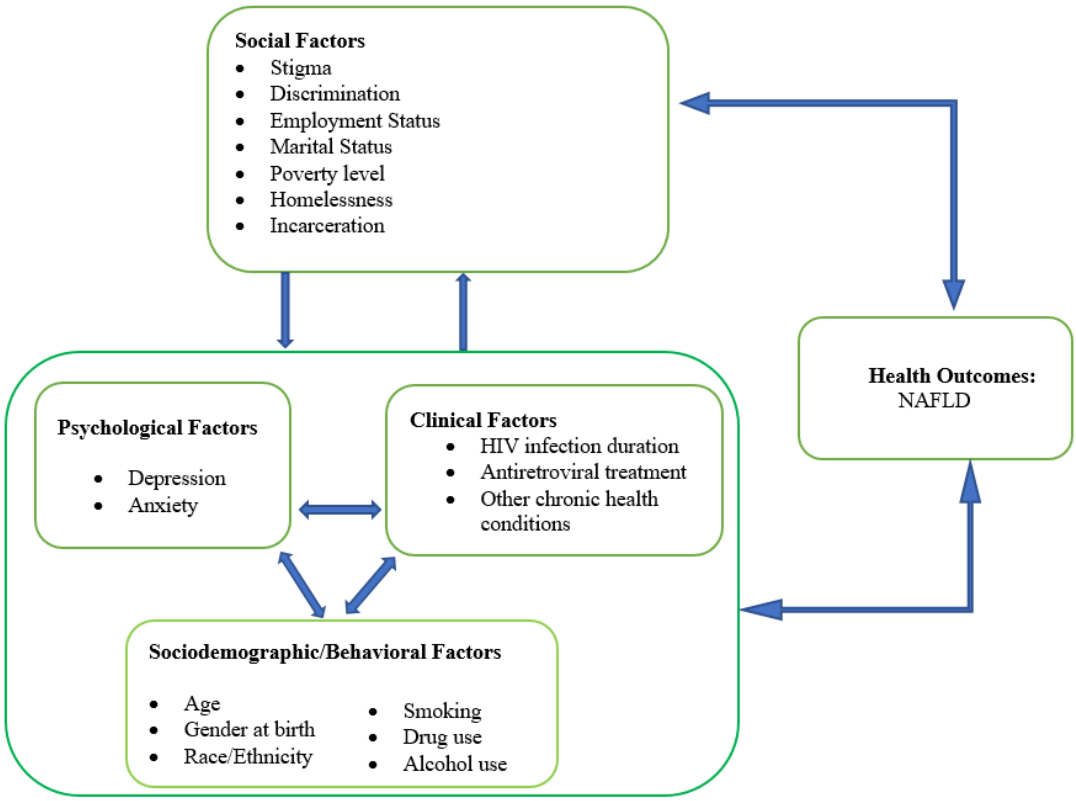
Notes.

$^{\beta}$Model 1 = Mild (0) vs. Moderate (1); Model 2 = Mild (0) vs. Severe (1); Model 3 = Moderate (0) vs. Severe (1).

Abbreviations. NNRTI = non-nucleoside reverse transcriptase inhibitors; HIV = human immunodeficiency virus. G^2 = The likelihood-ratio chi-square statistic. R^2 = Coefficient of determination.

Figure 1

Conceptual Framework of Factors Associated with Nonalcohoplic Fatty Liver Disease (NAFLD) in PLWH



Appendix E

Houston Health Department Data Use Agreement

Houston Health Department Data Use Agreement

CITY OF HOUSTON
Houston Health Department

Sylvester Turner
Mayor

Stephen L. Williams, M.Ed., MPA
Director
Houston Health Department
8000 N. Stadium Drive
Houston, Texas 77054-1823

T. 832-393-5169
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www.houstonhealth.org

May 17, 2021

Geraldine L. Wood, PhD, RN, FAAN
Director, PhD Program
UT Health Science Center at Houston
Cizik School of Nursing
Houston, Texas

RE: Permission to Use the Houston Health Department (HHD) Data for Dissertation Work

Dear Dr. Wood,

This letter is to confirm that permission has been granted to Ms. Essi Havor, a PhD candidate at the Cizik School of Nursing at the University of Texas Health Science Center at Houston, Texas to analyze the Medical Monitoring Project (MMP) data for the 2015-2019 cycles for her doctoral dissertation project entitled "*Psychological Factors Associated with Nonalcoholic Fatty Liver Disease Among People Living with HIV in Houston, Texas*".

Ms. Havor's proposed research work aims to estimate nonalcoholic fatty liver disease (NAFLD) risk, and to determine psychological predictors associated with NAFLD risk among people living with HIV (PLWH) in Houston, and Harris County, Texas. Despite the high prevalence of NAFLD among PLWH in the U.S., and worldwide, little is known about the burden of NAFLD and its associated risk factors among PLWH in Houston, and Harris County. Filling this gap will increase knowledge and understanding of various stakeholders and inform public health initiatives. The findings of Ms. Havor's project can help to identify high-risk groups and help improve the quality of care and health outcomes among PLWH in Houston/Harris County, Texas.

Ms. Havor will be permitted to have access to the Medical Monitoring Project data for 2015-2019 cycles. Prior to access, she will be required to receive Health Insurance Portability and Accountability Act (HIPAA) and HHD Privacy, Data Security, and Confidentiality trainings in compliance with federal, state and local guidelines. All data must be obtained and analyzed onsite at the HHD behind our institutional firewall on City of Houston-issued devices. Ms. Havor will be given access to the data only after completing necessary training and under the condition that all analysis of such data be completed in-person at the HHD and follows all guiding principles for ethical research conduct. Data that have

been properly de-identified may be released and analyzed outside the HHD on a case-by-case basis with prior, written approval from the Chief of Epidemiology.

Ms. Havor shall extend an offer to have at least one contributing author from the Houston Health Department on all manuscripts, articles, and other published material resulting from the data provided from the Houston Health Department. This offer shall be made through the Assistant Director of the Division of Disease Prevention and Control. The Assistant Director may designate the contributing author(s). The contributing author shall contribute to the published materials in a substantial way according to scientific and academic standards, including authoring beyond editing. The Houston Health Department and the funding sources shall be acknowledged in published materials that result from the data provided. These shall include the Houston Health Department and the grant(s) that the data was collected under.

We greatly look forward to the findings of Ms. Havor's dissertation research as they could allow us to better understand the impacts of psychological factors on the risk for NAFLD among PLWH in Houston/Harris County, Texas.

Please contact Kirstin Short at kirstin.short@houstontx.gov should you have any questions.

Sincerely,

Marlene McNeese
Assistant Director, HHD
Disease Prevention and Control Division

Kirstin Short, MPH
Chief, Epidemiology
Disease Prevention and Control Division

Appendix F

UT Health Science Center at Houston CPHS Approval of Proposal

UT Health Science Center at Houston CPHS Approval of Proposal

UTHealth
The University of Texas
Health Science Center at Houston

Committee for the Protection of Human Subjects

Essi M Havor, MSN, RN
UT-H - SN - Nursing Undergraduate Studies

February 21, 2022

HSC-SN-22-0138 - *Noninvasive Screening of Nonalcoholic Fatty Liver Disease Among People Living with HIV*

The above named project is determined to qualify for exempt status according to 45 CFR 46.104(d).

CATEGORY #4 : Secondary research uses of identifiable private information or identifiable biospecimens, if at least one of the following criteria is met:

a. *The identifiable private information of identifiable biospecimens are publicly available;*

b. ***Information, which may include information about biospecimens, is recorded by the investigator is such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects, the investigator does not contact the subjects, and the investigator will not re-identify the subjects;***

c. *The research involves only information collection and analysis involving the investigator's use of identifiable health information when that use is regulated under HIPAA regulations, for the purpose of "health care operations" or "research" or for "public health activities and purposes"; or,*

d. *Under this exemption, an investigator (with proper HIPAA Waiver or Alteration authorization) may inspect private, identifiable records, but may only record information in a non-identifiable manner.*

CHANGES: Should you choose to make any changes to the protocol that would involve the inclusion of human subjects or identified data from humans, please submit the change via iRIS to the Committee for the Protection of Human Subjects for review.

INFORMED CONSENT DETERMINATION:
Waiver of Consent Granted

HEALTH INSURANCE PORTABILITY and ACCOUNTABILITY ACT (HIPAA):
Exempt from HIPAA

STUDY CLOSURES: Upon completion of your project, submission of a study closure report is

required. The study closure report should be submitted once all data has been collected and analyzed.

Should you have any questions, please contact the Office of Research Support Committees at 713-500-7943.

CURRICULUM VITAE

Essi M. Havor, PhD (c), RN, PHNA-BC
EHavor@gmail.com

EDUCATION

Degree	Institution	Date
Ph.D.	UTHealth Science Center At Houston Cizik School of Nursing Houston, Texas Dissertation Title: Non-Invasive Screening of Nonalcoholic Fatty Liver Disease Among People Living with HIV. Dissertation Committee: Geri L. Wood PhD, RN; Stacey Crane, PhD, RN; Diane Santa Maria, DrPH, RN; Osaro Mgbere, PhD, MS, MPH.	May 2023 (Expected)
Master of Public Health (MPH)	UTHealth Science Center At Houston -School of Public Health Houston, Texas Major: Epidemiology Minor: Maternal and Child Health	May 2023
Master of Science in Nursing	Creighton University Omaha, NE Major: Global/Public Health	May 2016
Bachelor of Science In Nursing	Nebraska Wesleyan University Omaha, Nebraska	May 2010
Associate Degree In Nursing	Metropolitan Community College Omaha, NE	February 2009
Practical Certificate In Nursing (LPN)	Metropolitan Community College	November 2007
Associate Degree In Science	Metropolitan Community College Omaha, NE	May 2007
General Courses In Biology	Bellevue University Bellevue, NE	2005-2006

Courses in Banking & Finance	ESGIS Lomé, Togo	2002 - 2004

PROFESSIONAL POSITIONS:

Institution	**Position Title**	**Dates**
Health Resources & Services Administration Dallas, Texas	Public Health Analyst & Regional Maternal & Child Health Consultant	2022 - Present
Dallas County Health Department/ Cornerstone Medical, Dallas, Texas	Public Health Nurse Practitioner	2021
Houston Health Department Houston, Texas	Chief Nurse, RN Public Health Nurse IV	2014 – 2021 2013 – 2014
Douglas County Health Department Omaha, NE	Public Health Nurse	2010 – 2013
Charles Drew Community Health Center Omaha, NE	Nurse Educator/Pediatric Nurse	2009 – 12010
Brookstone Meadows, Inc. Elkhorn NE	Charge Nurse/ House Supervisor Licensed Practical Nurse/ Charge Nurse	2009 – 2011 2008 - 2009

PROFESSIONAL CREDENTIALS

License	**State**	**Dates**
Registered Nursing (RN) License # 850663 (Active)	Texas	2014 - Present
Minnesota RN (Inactive) (Inactive)	MN	2017- 2020
RN (Inactive)	NE	2009- 2014
Practical Nurse (Inactive)	NE	2007- 2009

BLS Certification	American Heart Association	Current
Advanced Public Health Nursing (PHNA-BC) Certification # 2017023628	ANCC	Certified 2017

OTHER EXPERIENCES

University of Texas at Health Science Center 2021 - 2023
Cizik School of Nursing
Houston, TX

Graduate Research Assistant
Project title: The Impact of COVID-19 Pandemic on People with HIV. Role: Co-Investigator. Principal Investigator: Dr. Diane Santa Maria

University of Texas Arlington 2022 - 2023
College of Nursing & Health Innovation
Arlington, Texas

Research Intern
Project title: Social and Structural Determinants of Cardiometabolic Health among Black Women. Role: Co-Investigator. Principal Investigator: Dr. Kyrah Brown

University of Texas at Health Science Center 2018 - 2022
Cizik School of Nursing
Houston, TX

Clinical Instructor of Nursing (Adjunct)
Undergraduate clinical course taught: N4521B (Community Public Health Nursing Clinical)

Grand Canyon University 2017 - 2018
College of Nursing and Healthcare Professions
Phoenix, AZ

Adjunct Faculty (Online)
Courses taught: Graduate- HLT-665 (Public Health Practicum) & Undergraduate NRS-427VN (Concepts in Community/Public Health).

Clinical/Preceptorship Experiences

Houston Health Department 12/2014- 09/2021

Douglas County Health Department 10/2010- 11/2013

COMMUNITY SERVICES & PROFESSIONAL MEMBERSHIP

Member of Association of Nurses in AIDS Care	2022- Present
Member of CDC immunization IQIP workgroup	2018 - 2021
Houston Endowment's Reducing Maternal Mortality Steering Committee	2017- 2021
Member of Sécretariat International Des Infirmières et Infirmiers de l'Espace Francophone (SIDIIF)	2017- Present
Member of Consortium Universities for Global Health (CUGH)	2017 - Present
Member of American Nurses Association & Texas District 9	2017- Present
Member of Coalition Against Hepatitis for People of African Origin (CHIPO)	2017 - Present
Committee Member of March of Dimes Maternal & Child Health	2016- 2021
Member of Texas Public Health Association,	2016-Present
Chair-Elect, Public Health Nursing Section	2017- 2018
Membership Committee Member	2017-2018
Chair, Public Health Nursing Section	2018-2019
Abstracts Reviewer	2017 - 2019
Member of Sigma Theta Tau International	2015 – Present
Member of Iota Tau Chapter	2015-2017
Member of Zeta Pi Chapter	2017- 2021
Member of Beta Alpha Chapter	2021 - Present
Member of Immunization Coalition of Greater Houston (ICOGH)	2015- 2021
Member of Houston Perinatal HIV Prevention Task Force	2015- 2021

HONORS & AWARDS

Sigma Theta Tau International (STTI) Zeta Pi Chapter, Cizik School of Nursing	2022
Preceptor of the Year Certificate Texas State University College of Pharmacy & Health Sciences	2018
Patricia L. Starck Scholarship UTHealth Science Center at Houston Cizik School of Nursing	2018 - 2021
NACCHO Model of Practice Award Recipient	2018
Carole Douglas Emerging Leader (CityMatCH)	2016-2017
Sigma Theta Tau International (STTI) Iota Tau Chapter, Creighton University	Inducted 2015

PRESENTATIONS

National

Havor, E. M. (2016, October 15). Eliminating a Global Health Threat: Mother-To-Child Transmission of Hepatitis B Virus. SEED Global Health & Global Nursing Caucus Conference, October14-15,2016. Boston, MA. Poster Presentation.

Havor, E. M. (2017, August 23). Increasing HPV Vaccine Coverage by Strengthening Adolescent AFIX Activities. 2017 CDC Immunization Awardee Meeting (IAM), August 23-25, 2017. Atlanta, GA. Oral Presentation.

Havor, E.M. (2017, December 7). Increasing HPV Vaccine Coverage by Strengthening Adolescent AFIX Activities. CDC Reverse Site Visit, December 6-7, Atlanta, GA. Oral Presentation.

Havor, E. M. (2019, May 1). Innovative Strategies to Increase Identification of Infants Born to Hepatitis B Positive Mothers. NACCHO Webinar Series "Exploring National and Local Approaches to Perinatal Hepatitis B Prevention". (Invited).

Havor, E. M. (2019, October 29). Increasing Immunization Coverage Rates Among Vulnerable Populations. APHA Webinar Series "Improving Vaccine Equity: How to Reach Vulnerable Populations". (Invited).

Regional/State

Havor, E.M. & Shirley, N. (2016, May5). Improving Care for Hepatitis B Infected Mothers and their Babies in Houston, Texas. Creighton College of Nursing, Iota Tau 27th Annual Nursing Research Day. Omaha, NE. Poster Presentation.

Havor, E. M. (2017, March28). Underreporting of Hepatitis B Infections: A Threat to the Elimination of Perinatal Hepatitis B Transmission. Texas Public Health Association, 93rd Annual Conference, March 27-29, 2017. Fort Worth, TX. Oral Presentation.

Nash, D.& Havor, E. (2017). Assessing PVST completion rates of infants born to hepatitis B-infected mothers. Texas Public Health Association, 93rd Annual Conference, March 27-29, 2017. Fort Worth, TX. Poster Presentation.

Havor, E.M.& Hinckson-Callis. (2017, August2). Immunization Updates. TSNO, Region IV, 39thAnnual Belle Blackwell Conference. Humble, TX. Oral Presentation.

Havor, E. M. (2018, January 31). "Implementation of influenza screening, testing and vaccination clinics in two shelters following Hurricane Harvey". TACCHO'S 2018 Premier Public Health Conference. Horseshoe Bay, TX. Oral Presentation.

Havor, E. M. (2018, March 6). Effective Implementation of AFIX Model to Improve HPV Vaccination Rates. Texas Public Health Association 94th Annual Education Conference. Waco, TX. Oral Presentation.

Local

Havor, E. M. (2013, April 4). Togo Health Profile. Creighton University Global Health Event "Health as Human Right". Omaha, NE. Oral Presentation.

Havor, E. M. (2015, April 29). Preparing for the Annual VFC Compliance Visit. Houston Health Department 2015 VFC Summit. Houston, TX. Oral Presentation.

Havor, E.M. (2016, March 22). You are the Key to HPV Cancer Prevention: Overview of HPV Facts and Guidelines. Houston Health Department & NACCHO HPV Vaccination Strategic Action Planning Meeting. Houston, TX. Oral Presentation.

Raju, A., Havor, E., Assefa, A., Yang, B., Arafat, R. & Salgado, O. (2016). Utilizing A Web-Based Disease Surveillance System to Improve Case Management and Reporting Timeliness for Hepatitis B Cases in Pregnant Women. Texas Public Health Association Conference. Galveston, TX. Poster Presentation.

Havor, E.M. (2016, June 2). "Overview of Perinatal Hepatitis B in Harris County". Texas Perinatal HIV Prevention Task Force. Houston, TX. Oral Presentation.

Havor, E.M. (2016, June16). Epidemiology of Pertussis. "Preventing Pertussis: Current and Needed Strategies". Texas Immunization Partnership, Houston, TX. Webinar, Oral Presentation.

Havor, E. M. (2016, September 6). Immunization Screening For School Nurses,2016-2017.Houston Independent School District Annual Training. Houston, TX. Oral Presentation.

Havor, E. M. (2016, September 29). What are your immunization coverage indicators? VFC providers' Training, Houston Health Department. Houston, TX. Oral Presentation.

Havor, E. M. (2016, October 5). "The HPV Vaccine is said to prevent Cancer-So why don't some people like it". CW39-NEWSFIX. Houston, TX. Media Interview.

Havor, E. M. (2017, March 2). "Challenges of Immunizing Population". Multicultural Dinner Panel Discussion. Houston Global Health Collaborative, UTHealth Science Center at Houston-School of Public Health. (Invited).

Havor, E.M. (2018, April 4). Effective Implementation of AFIX Model to Improve HPV Vaccination Rates. Texas Immunization Grantees Leadership Meeting. Houston, TX. Oral Presentation.

Havor, E.M. (2019, April 30). Immunization Schedule & Vaccine Updates- 2019. The Immunization Partnership, 2019 School Nurses Immunization Forum. Houston, TX.