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# The association between non-alcoholic fatty liver disease and urinary incontinence among adult females in the United States

Xinyuan Li[1], Weiwei Zhou[1*] and Guangsheng Hu[1*]

## Abstract

**Background and objectives** Non-alcoholic fatty liver disease (NAFLD) and urinary incontinence (UI) are both highly prevalent and age-related diseases. Nevertheless, the link between NAFLD and UI is unclear. Hence, the study was designed to evaluate the association between the NAFLD and UI (including UI types) in a nationally representative sample of United States (US) female adults.

**Methods** We conducted this study used data from U.S. female adults in the National Health and Nutrition Examination Survey (NHANES) 2017-March 2020 (pre-pandemic) cycles. The diagnosis of NAFLD is based on Vibration controlled transient elastography (VCTE) and absence of know liver diseases and significant alcohol consumption. The diagnosis and types of UI were assessment using a self-report questionnaire. Multivariable logistic regression models were used to analyze the association between NALFD and UI. Stratified analyses based on age, obesity, race, educational level, married status, PIR, and smoking status were conducted.

**Results** Of the 2149 participants, the mean (95% CI) age was 53.9 (52.7–55.0), 686 (61.1%) were Non-Hispanic White. UI was significantly more common in participants with NAFLD [490 (64.7%)] than those without NAFLD [552 (44.9%)]. Adjusted for age, race/ethnicity, marital status, educational level, family poverty income ratio (PIR) status, alanine aminotransferase (ALT), aspartate aminotransferase (AST), smoking status, obesity, type 2 diabetes mellitus (T2DM), hypertension and insulin resistance (IR) in a multivariable logistic regression model, NALFD were associated with UI [OR: 1.93, 95%CI 1.23–3.02, $P=0.01$] and urge UI [OR: 1.55, 95%CI 1.03–2.33, $P=0.03$], while patients with NAFLD did not show an increased odds in stress UI and mixed UI when compared with those without NAFLD subject ($P>0.05$). In the subgroup analyses, NAFLD remained significantly associated with UI, particularly among those participants without obesity (OR: 2.69, 95% CI 1.84-4.00) and aged ≥ 60 years (OR: 2.20, 95% CI 1.38–3.51).

**Conclusions** Among US female adults, NAFLD has a strong positive correlation with UI. Given that NAFLD is a modifiable disease, these results may help clinicians to target female patients with NAFLD for treatments and interventions that may help prevent the occurrence of UI and reduce the symptoms of UI.

**Keywords** Urinary incontinence, NAFLD, NHANES, Cross-sectional, United States

*Correspondence:
Weiwei Zhou
zw137543@163.com
Guangsheng Hu
360680725@qq.com
[1]Department of Gastroenterology, The First Affiliated Hospital of University of South China, Hengyang, Hunan 421001, People's Republic of China

## Introduction

Non-alcoholic fatty liver disease (NAFLD) is a clinicopathologic syndrome characterized by diffuse bulla fat of hepatocytes (the presence of more than 5% of hepatic steatosis), with the exception of considerable alcohol consumption and other well-defined liver damage factors such as drugs, autoimmune, viral hepatitis, and other causes [1]. NAFLD is the most common chronic liver disease, affecting an estimated 32.4% of adult population and approximately 25.9% of adolescents worldwide [2, 3]. At the same time, its global prevalence is increasing at an alarming rate and is in line with the growing global trend of obesity and type 2 diabetes mellitus (T2DM) [2]. Fueled by the increasing diagnosis of NAFLD, the direct medical costs caused by NAFLD in the United States (US) have exceeded $100 billion annually [4]. As to the treatment of NAFLD, in addition to drug treatment, intensive lifestyle intervention has been proven to be effective in the remission of NAFLD [5, 6].

Urinary incontinence (UI), a common chronic condition that causes psychological distress and worsening quality of life [7]. UI can be divided into three types: stress UI (SUI), urge UI (UUI) and mixed UI (MUI) [8]. The prevalence of UI has increased over the past few decades, affecting approximately 19.3% US male and 45.9%% US female [9, 10]. The main risk factors for UI are include modifiable risks (such as obesity, metabolic syndrome (MetS), T2DM, hypertension, smoking status, the level of physical exercise, etc.) and unmodifiable risk factors (such as advanced age, neurological disease, history of surgery, etc.) [7, 11–13]. Identifying and intervening the modifiable risk factors of UI is an economical and effective scheme to prevent UI, reduce symptoms of UI and reduce adverse events related to UI.

Considering that NAFLD is closely related with obesity and MetS, we hypothesize that the existence of NAFLD may be related to urinary incontinence [14, 15].

Therefore, our objective was to assess the association between NAFLD and UI in a large, nationally representative sample of adult female in the US.

## Methods

### Date sources

NHANES is a cross-sectional research program conducted by the Centers for Disease Control (CDC) and National Center for Health Statistics (NCHS) to assess the health and nutrition status of adults and children in the US. The NHANES program began in the early 1960s and was conducted as a series of surveys focusing on different population groups or health topics. A nationally representative sample of around five thousand people is surveyed annually, and because it oversamples specific age and racial groups, NHANES provides comprehensive data that is representative of the civilian and noninstitutionalized population in the US. The participants provided their written informed consent to participate in this study and their personal information was de-identified in the NHANES database.

### Study design and population

Data collected from participants in the 2017-March 2020 (pre-pandemic) NHANES cycle are used in our analysis. The data included demographic data, examination data, laboratory data, and questionnaire data for the presented analysis. In NHANES 2017-March 2020 (pre-pandemic) cycle, the overall sample included 9232 people over 20 years of age. We excluded those individuals with one of the following conditions: (I) males ($n$=4479); (II) missing or incomplete VCTE test data ($n$=1014); (III) evidence of considerable alcohol consumption (more than 14 drinks per week ($n$=1330); (IV) evidence of viral hepatitis (serum hepatitis B surface antigen positive or serum hepatitis C antibody positive) ($n$=40); (V) missing the data of UI ($n$=220). In the end, our study included 2149 participants. The screening process flowchart was shown in Fig. 1.

### Diagnosis of NAFLD

Despite the fact that liver tissue biopsy evaluation is recommended by clinical guidelines as the golden standard for diagnosing hepatic disease, it is impractical to perform liver biopsy examination to evaluate liver disease status (such as hepatic steatosis) for large populations, given the current global prevalence of patients with NAFLD [1, 16, 17]. Vibration controlled transient elastography (VCTE) is a widely used non-invasive and convenient method to identify hepatic steatosis through the value of controlled attenuation parameter (CAP) [18, 19]. In the NHANES 2017-March 2020 (pre-pandemic) cycle, the VCTE was carried out in the Mobile Examination Center using an ultrasound machine (FibroScan®502 V2 Touch instrument). The elastography exam was performed by NHANES health technicians (HTs), who were trained and certified by NHANES staff, Westat and the equipment manufacturer (Echosens™ North America). In the presented study, individuals were diagnosed with hepatic steatosis by CAP≥274 dB/m, as this threshold highly showed accuracy in identifying hepatic steatosis [20, 21]. If the average alcoholic drink per week is more than 14 drinks per week, it was considered considerable alcohol consumption [1]. Viral hepatitis was defined as either viral hepatitis B (positive for serum hepatitis B surface antigen test) or hepatitis C (positive for serum hepatitis C antibody test).

### Diagnosis of UI

The information on urinary incontinence in NHANES was collected from kidney conditions only for people

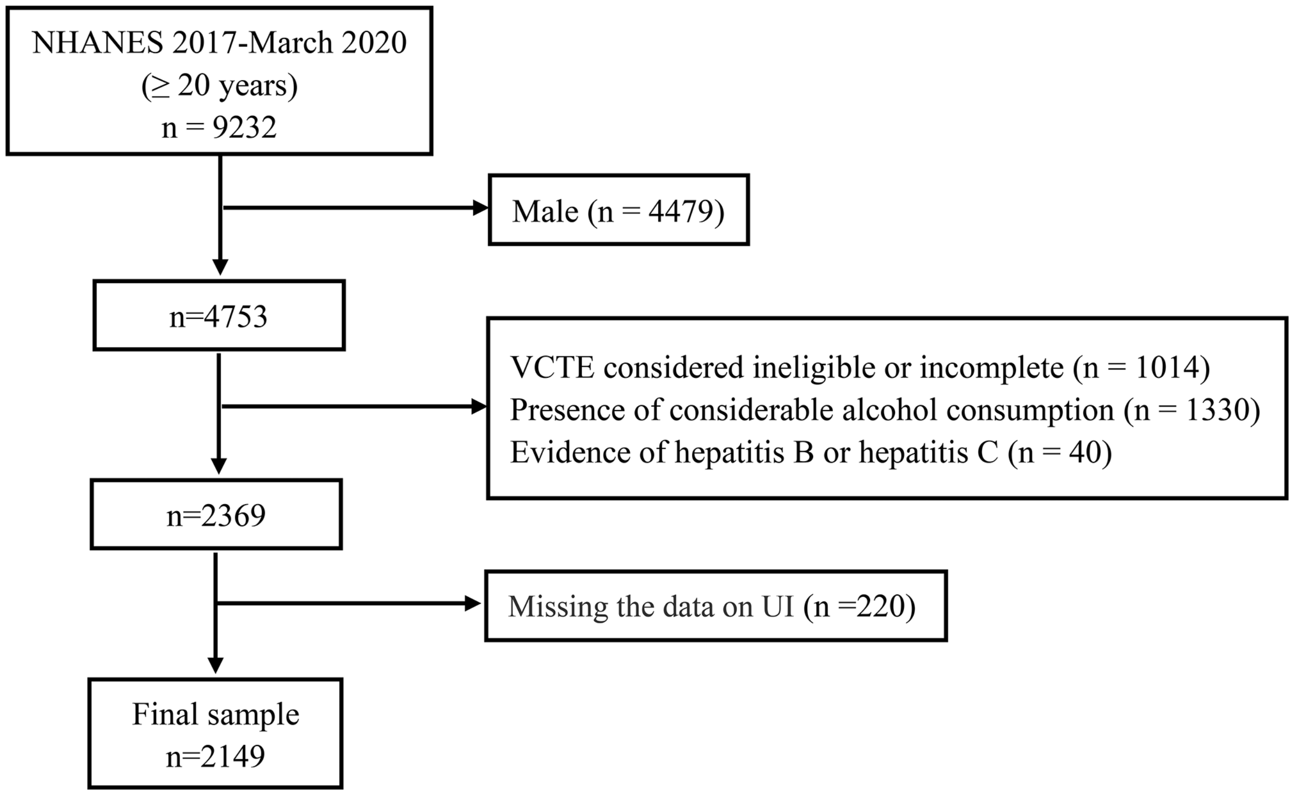


**Fig. 1** Flowchart showing the selection of eligible participants

over 20 years of age. If participants answered "never" to this question "How often have urinary leakage?", they were defined as UI [22].

Answering "yes" to the following question was defined as the SUI: "During the past 12 months, have you leaked or lost control of even a small amount of urine with activity like coughing, lifting, or exercise?". Answering "yes" to the following question was defined as the UUI: "During the past 12 months, have you leaked or lost control of even a small amount of urine with an urge or pressure to urinate and you couldn't get to the toilet fast enough?". Those who were diagnosed with both SUI and UUI were defined as MUI.

### Covariates

On basis of the literature, the potential confounders included age, ethnicity, marital status, educational level, family poverty income ratio (PIR) status, alanine aminotransferase (ALT), aspartate aminotransferase (AST), smoking status (never, current, or former), obesity (yes or no), T2DM (yes or no), hypertension (yes or no), insulin resistance (IR) (yes or no). The smoking status was categorized as current smoker (had smoked ≥ 100 cigarettes in their lifetime and smoking everyday/somedays), former smoker (had smoked ≥ 100 cigarettes in their lifetime but not smoking now), and never smoker (had smoked < 100 cigarettes in their lifetime). The PIR status divided into 3 levels: low income (≤1.3), medium income (≥1.3 to 3.5), and high income (>3.5) [23]. The body mass index (BMI) cut-off 30 kg/m$^2$ was used to define obesity. According to the American Diabetes Association criteria, participants were diagnosed with (T2DM) if they met any of the following conditions: (I) a self-reported history of diagnosis; (II) use of antidiabetic drugs (consists of oral antidiabetic drugs or insulin); (III) glycated hemoglobin A1c (HbA1c) level ≥ 6.5%; (IV) fasting plasma glucose ≥ 7.0 mmol/L [24]. Hypertension was diagnosed when participants had a systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg or had a self-reported history of hypertension, or self-reported current use of antihypertensive drugs [25]. IR was assessed by using HOMA-IR model, which was calculated as [(fasting insulin (μU/mL) × fasting glucose (mmol/L) ]/22.5 [26].

### Statistical analysis

All statistical analyses were performed using R software (version 4.2.0). *P* value < 0.05 was considered statistically significant. We selected appropriate weights for each analysis in this study, as recommended by the NCHS. Baseline characteristics were described as mean (95% confidence intervals) for continuous variables and numbers (percentages) for categorical variables. Student-t tests was used to compare continuous data and χ2 test was used to compare categorical data. Logistic regression models were used to estimate the odd ratios (ORs) and 95% confidence intervals (CIs) for the association of NAFLD with UI. In the multivariable models, age (continuous), race/ethnicity (Mexican American, other Hispanic, non-Hispanic white, non-Hispanic black, or others), marital status (married/living with partner, widowed/divorced/separated, or never married), educational level (high school and below, or some college and above) and PIR status (≤1.3, ≥ 1.3 to 3.5, or ≥3.5) were adjusted in model II. In model III, we further adjusted for ALT (continuous), AST (continuous), smoking status (never, current, or former), obesity (yes or no), T2DM (yes or no), hypertension (yes or no), IR (yes or no). The subgroup analyses were performed by the following covariates: age (<40 years, ≥ 40 to 60 years, ≥ 60 years), obesity (yes, no), race/ethnicity, marital status, educational level and PIR status (≤1.3, ≥ 1.3 to 3.5, ≥ 3.5) and smoking status (never, current, former).

## Results

### Characteristics of participants in this study

The baseline characteristics of subjects excluded and included are summarized in Table 1. Of the 2149 participants, the mean (95% CI) age was 53.9 (95%CI 52.7–55.0), 686 (61.1%) were Non-Hispanic White. Of these, 884 (47.3%) participants were diagnosed NAFLD and 1042 (52.7%) have UI. Overall, the prevalence of UI was significantly higher among participants with NAFLD [490 (64.7%)] than among participants without NAFLD [552 (44.9%)]. Besides, the age was higher in participants with NAFLD (mean age, 57.2 years; 95% CI 55.6–58.8 years) than in those without (mean age, 51.7 years; 95%CI 50.4–53.0 years). Participants with NAFLD were more likely to have an educational level of some college and above [397 (41.9%) vs. 492 (34.5%)], to be Mexican American individuals [131 (10.1%) vs. 101 (5.1%)], to have diabetes [321 (32.4%) vs. 149 (7.7%)], to have hypertension [532 (57.6%) vs. 536 (35.1%)] and to have insulin resistance [342 (78.5%) vs. 220 (35.3%)]. Furthermore, compared with the participants with NAFLD, participants without NAFLD had significantly higher levels of BMI, waist circumference, ALT, AST, uric acid, triglycerides, total cholesterol, low-density lipoprotein-cholesterol (LDL-c) and had lower levels of high-density lipoprotein-cholesterol (HDL-c).

### Association between NAFLD and different types of UI

Multivariable logistic regression analysis was then constructed to investigate the relationship between NAFLD and different types of UI (as shown in Table 2). For individuals with NAFLD vs. those without NAFLD, the crude OR was 2.25 (95% CI, 1.59–3.18) for UI, 2.08 (95% CI, 1.43–3.01) for SUI, 1.81 (95% CI, 1.38–2.38) for UUI and 2.16 (95% CI, 1.53–3.07) for MUI. In the multivariable logistic adjusted models (model III) illustrated that patient with NAFLD had 93% and 55% higher odds of UI and UUI than those without NAFLD subjects [UI, OR: 1.93, 95%CI 1.23–3.02, $P=0.01$; UUI, OR: 1.55, 95%CI 1.03–2.33, $P=0.03$], while patients with NAFLD did not show an increased odds in SUI and MUI when compared with those without NAFLD subject ($P>0.05$).

### Subgroup analysis

To further investigate the association between NAFLD and UI, subgroup analyses were performed stratified by age, obesity, race/ethnicity, education level, marital status, PIR status and smoking status (As presented in Table 3). NAFLD was still significantly associated with UI, especially among those who without obesity (OR: 2.69, 95% CI 1.84-4.00), were older than 60 years (OR: 2.20, 95% CI 1.38–3.51), were non-Hispanic white (OR: 2.27, 95% CI 1.38–3.73), high school and below (OR: 2.30, 95% CI 1.56–3.05), married or living with partner (OR: 2.06, 95% CI 1.37–3.04) and never smoked participants (OR: 2.22, 95% CI 1.44–3.42).

## Discussion

The presented study investigated the relationship between NAFLD and different types of UI in a large U.S. population by analyzing the date of female participants over 20 years of age in 2017-March 2020 (pre-pandemic) NHANES cycles. We found that those who had been diagnosed with NAFLD had higher odds of UI and UUI than those without NAFLD. To further confirm the founding, age, race/ethnicity, marital status, educational level, PIR status, ALT, AST, smoking status, obesity, T2DM, hypertension and IR were adjusted in the multivariate logistic regression models. The results indicated that compared with those individuals without NAFLD, NAFLD patients were significantly associated with both UI (OR: 1.93, 95%CI 1.23–3.02, $P=0.01$) and UUI (OR: 1.55, 95%CI 1.03–2.33, $P=0.03$), but not with SUI and MUI.

There is no denying that excess weight and obesity are important risk factors for urinary incontinence in female [27, 28]. Besides, evidence in the literature supports the notion that MetS is a risk factor for UI [29, 30]. A cross-sectional study performed on 518 female with T2DM (aged 50–75 years) suggests that Mets specifically affects UI in diabetic female, probably by compounding the effect of peripheral neuropathy [31]. Its means that the association between Mets and UI is complex and not just affected by weight.

**Table 1** Base characteristics of participants with and without NAFLD in the NHANES 2017-march 2020 (pre-pandemic) cycles

| Characteristic | Total (*n* = 2149) | Without NAFLD (*n* = 1265) | With NAFLD (*n* = 884) | *P* value |
|---|---|---|---|---|
| Age, years | 53.9 (52.7–55.0) | 51.7 (50.4–53.0) | 57.2 (55.6–58.8) | < 0.01 |
| Race/ethnicity | | | | < 0.01 |
| Mexican American | 232 (7.1) | 101 (5.1) | 131 (10.1) | |
| Other Hispanic | 230 (7.4) | 143 (7.8) | 87 (6.8) | |
| Non-Hispanic White | 686 (61.1) | 399 (61.7) | 287 (60.3) | |
| Non-Hispanic Black | 575 (12.4) | 350 (13.0) | 225 (11.4) | |
| Other Race | 426 (12.0) | 272 (12.5) | 154 (11.4) | |
| Educational level | | | | < 0.01 |
| High school and below | 1256 (62.6) | 772 (65.5) | 484 (58.1) | |
| Some college and above | 889 (37.4) | 492 (34.5) | 397 (41.9) | |
| Marital status | | | | 0.24 |
| Married/ living with partner | 1157 (58.6) | 670 (57.6) | 487 (60.2) | |
| Widowed/divorced/separated | 651 (27.3) | 376 (26.9) | 275 (27.9) | |
| Never married | 335 (14.1) | 216 (15.5) | 119 (12.0) | |
| PIR | | | | 0.33 |
| ≤ 1.3 | 540 (20.0) | 304 (19.0) | 236 (21.5) | |
| ≥ 1.3 to 3.5 | 729 (37.6) | 414 (36.6) | 315 (39.2) | |
| ≥ 3.5 | 595 (42.4) | 369 (44.4) | 226 (39.4) | |
| BMI, kg/m$^2$ | 29.8 (29.1–30.5) | 26.8 (26.1–27.5) | 34.5 (33.5–35.5) | < 0.01 |
| Waist circumstance, cm | 98.5 (96.8-100.2) | 91.2 (89.4–92.9) | 109.9 (107.9-111.9) | < 0.01 |
| ALT, U/L | 17.9 (17.5–18.4) | 15.6 (15.1–16.1) | 21.4 (20.2–22.5) | < 0.01 |
| AST, U/L | 19.3 (18.9–19.6) | 18.5 (18.2–18.8) | 20.4 (19.6–21.2) | < 0.01 |
| Uric acid, μmol/L | 285.9 (280.3-291.5) | 267.1 (260.4-273.9) | 314.3 (308.3-320.3) | < 0.01 |
| Triglycerides, mmol/L | 1.17 (1.12–1.22) | 0.96 (0.91–1.01) | 1.46 (1.36–1.56) | < 0.01 |
| Total cholesterol, mmol/L | 5.00 (4.92–5.08) | 4.98 (4.89–5.07) | 5.03 (4.92–5.13) | 0.34 |
| LDL cholesterol, mmol/L | 2.92 (2.84-3.00) | 2.91 (2.81-3.00) | 2.94 (2.80–3.08) | 0.66 |
| HDL cholesterol, mmol/L | 1.50 (1.47–1.53) | 1.59 (1.56–1.62) | 1.37 (1.34–1.41) | < 0.01 |
| Smoking status | | | | 0.66 |
| Never | 1584 (71.0) | 945 (72.0) | 639 (69.6) | |
| Current | 197 (9.8) | 118 (9.8) | 79 (9.8) | |
| Former | 367 (19.2) | 201 (18.3) | 166 (20.6) | |
| Diabetes | 470 (17.4) | 149 (7.7) | 321 (32.4) | < 0.01 |
| Hypertension | 1068 (44.0) | 536 (35.1) | 532 (57.6) | < 0.01 |
| Insulin resistance | 562 (53.0) | 220 (35.3) | 342 (78.5) | < 0.01 |
| UI | 1042 (52.7) | 552 (44.9) | 490 (64.7) | < 0.01 |
| SUI | 920 (45.7) | 459 (38.6) | 461 (56.6) | < 0.01 |
| UUI | 754 (31.7) | 386 (26.6) | 368 (39.6) | < 0.01 |
| MUI | 429 (58.3) | 192 (14.3) | 237 (26.5) | < 0.01 |

Characteristics of participants are described as means (95% CIs) for continuous variables and unweighted numbers (weighted percentages) for categorical variables

Abbreviation: PIR: family poverty income ratio; BMI, body mass index; ALT, alanine aminotransferase; AST, aspartate aminotransferase. LDL, low-density lipoprotein; HDL, high-density lipoprotein

The findings of the presented study demonstrated that NAFLD is significantly correlated with UUI, and its potential mechanism needs to be further explored. We hypothesized that endothelial dysfunction, IR and the commodities might support this positive correlation. In a multivariable logistic regression model, some covariates including BMI were adjusted, and the results still illustrated that NAFLD was independently associated with the increased odds of UI and UUI. This suggested that the influence of NAFLD on UI, especially UUI, were independent of BMI itself. Considering that NAFLD patients were often characterized by IR, dyslipidemia, and glucose tolerance, these factors together constitute vascular injury and endothelial dysfunction [32, 33]. The changes of vascular mechanism might be involved in the pathophysiological process of UUI [34]. Furthermore, some comorbidities such as T2DM, prediabetes and dyslipidemia might also contribute to the pathophysiological process of both NAFLD and UUI [35, 36].

UUI is a subtype of UI, compared to SUI, UUI has a greater impact on patients' physical and mental health.

**Table 2** Association of NAFLD with different types of UI among participants in the NHANES 2017-march 2020 (pre-pandemic) cycles

| Types of UI | OR | 95% CI | *P* value |
|---|---|---|---|
| UI | | | |
| Model I | 2.25 | 1.59–3.18 | 0.00 |
| Model II | 2.15 | 1.46–3.17 | 0.00 |
| Model III | 1.93 | 1.23–3.02 | 0.01 |
| SUI | | | |
| Model I | 2.08 | 1.43–3.01 | 0.00 |
| Model II | 2.09 | 1.38–3.16 | 0.00 |
| Model III | 1.41 | 0.62–3.21 | 0.33 |
| UUI | | | |
| Model I | 1.81 | 1.38–2.38 | 0.00 |
| Model II | 1.63 | 1.16–2.28 | 0.01 |
| Model III | 1.55 | 1.03–2.33 | 0.03 |
| MUI | | | |
| Model I | 2.16 | 1.53–3.07 | 0.00 |
| Model II | 2.03 | 1.31–3.13 | 0.00 |
| Model III | 2.01 | 0.91–4.44 | 0.07 |

Abbreviations: OR: odds ratio; CI: confidence interval; UI: urinary incontinence; SUI: stress urinary incontinence; UUI: urge urinary incontinence

Model I: adjusted for none

Model II: adjusted for age, race/ethnicity, marital status, educational level and PIR status (≤ 1.3, ≥ 1.3 to 3.5, or ≥ 3.5)

Model III: adjusted for age, race/ethnicity, marital status, educational level and PIR status (≤ 1.3, ≥ 1.3 to 3.5, or ≥ 3.5), ALT, AST, smoking status (never, current, or former), obesity (yes or no), T2DM (yes or no), hypertension (yes or no), IR (yes or no)

psychological distress and worsening quality of life [7, 37]. At the same time, the incidence of UUI is higher in female than in male, so further understanding of the pathogenic factors for female UUI may help to take effective preventive measures and formulate treatment strategies [38]. NAFLD is a clinical syndrome that coexists with obesity, hypertension, hyperglycemia (impaired glucose tolerance, impaired fasting glucose or diabetes), dyslipidemia and a combination of metabolic risk factors as one of the controllable and modifiable factors. Its pathogenesis mainly includes central obesity, IR, atherosclerosis and endothelial dysfunction [1, 16].

In subgroup analysis, NAFLD was still significantly associated with UI especially among those participants who were without obesity (OR: 2.69, 95% CI 1.84-4.00). Accumulating growing prospective cohort evidence that the increase of BMI is associated with various types of UI, as elevated BMI tends to increase intra-abdominal and intra-bladder pressure in patients with UI [27, 39, 40]. Therefore, combined with our results, we concluded that the influence on UI with or without NAFLD may not be significant for those patients with obesity. However, as for non-obese patients, the contribution of BMI to UI was relatively high. At this time, those lean-NAFLD patients may develop IR, vascular endothelial dysfunction and some complications, which together increase the incidence of UI [41].

Several limitations of the present study are worth mentioning. Firstly, due to the cross-sectional nature of this study, we cannot determine any causal association between NAFLD and UI. Further cohort studies may be warranted in the future. Secondly, the diagnose of NAFLD is based on VCTE, a non-invasive method, rather than liver biopsy. Nevertheless, VCTE is very suitable for large-scale population evaluation and show good test efficiency. Thirdly, although we have adjusted for many confounders and performed stratified analyses in the multivariable regression model, it is undeniable that there are still several potential confounders that are not considered. Fourthly, the diagnosis of UI is based on self-reported data, which may result in inaccurate results due to recall bias.

The results of the presented cross-sectional study indicate a positive association between NAFLD and UI in the U.S. female adults. Considering that NAFLD is a treatable and modifiable disease, active treatment of NAFLD may contribute to the treatment and management of UI.

**Table 3** Stratified analyses of the associations between NAFLD and UI

| Subgroups | Participants[a] Without NAFLD | With NAFLD | Adjusted OR (95% CI) | *P* value |
|---|---|---|---|---|
| **Overall** | 552/1265 (43.6%) | 490/884 (55.4%) | 1.93 (1.23–3.02) | 0.01 |
| **Age, years** | | | | |
| < 40 | 90/357 (25.2%) | 53/123 (43.1%) | 1.16 (0.28–4.84) | 0.81 |
| ≥ 40 to 60 | 153/398 (38.4%) | 173/327 (52.9%) | 1.99 (0.75–5.31) | 0.13 |
| ≥ 60 | 309/510 (60.6%) | 264/434 (60.8%) | 2.20 (1.38–3.51) | 0.01 |
| **Obesity** | | | | |
| No | 337/888 (38.0%) | 143/285 (50.2%) | 2.69 (1.81-4.00) | 0.01 |
| Yes | 208/369 (56.4%) | 344/593 (58.0%) | 1.43 (0.81–2.52) | 0.28 |
| **Race/ethnicity** | | | | |
| Mexican American | 41/101 (40.6%) | 71/131 (54.2%) | 1.55 (0.65–3.66) | 0.43 |
| Other Hispanic | 54/143 (37.8%) | 43/87 (49.4%) | 2.25 (0.89–5.72) | 0.23 |
| Non-Hispanic White | 228/542 (42.1%) | 211/287 (73.5%) | 2.27 (1.38–3.73) | 0.08 |
| Non-Hispanic Black | 136/350 (38.9%) | 106/225 (47.1%) | 1.38 (0.36–5.35) | 0.68 |
| Other Race | 93/272 (34.2%) | 59/154 (38.3%) | 1.38 (0.52–3.70) | 0.58 |
| **Educational level** | | | | |
| High school and below | 334/772 (43.3%) | 292/484 (60.3%) | 2.30 (1.56–3.38) | 0.01 |
| Some college and above | 217/492 (44.1%) | 198/397 (24.7%) | 1.51 (0.75–3.05) | 0.30 |
| **Marital status** | | | | |
| Married/ living with partner | 270/670 (40.3%) | 272/487 (55.9%) | 2.06 (1.37–3.10) | 0.03 |
| Widowed/divorced/separated | 216/376 (57.5%) | 160/275 (58.2%) | 1.32 (0.57–3.04) | 0.55 |
| Never married | 63/216 (29.2%) | 57/119 (47.9%) | 4.31 (1.20–15.50) | 0.09 |
| **PIR** | | | | |
| ≤ 1.3 | 116/304 (38.2%) | 122/236 (51.7%) | 2.01 (0.70–5.72) | 0.26 |
| ≥ 1.3 to 3.5 | 221/414 (53.4%) | 190/315 (60.3%) | 1.09 (0.58–2.07) | 0.80 |
| ≥ 3.5 | 150/369 (40.7%) | 131/226 (58.0%) | 3.46 (1.82–6.58) | 0.02 |
| **Smoking status** | | | | |
| Never | 392/945 (41.5%) | 331/639 (51.8%) | 2.22 (1.44–3.42) | 0.02 |
| Current | 54/118 (45.8%) | 51/79 (64.6%) | 1.86 (0.54–6.46) | 0.38 |
| Former | 106/201 (52.7%) | 108/166 (65.1%) | 1.25 (0.62–2.53) | 0.57 |

[a] Data are presented as unweighted patients number/total number (unweighted percentage)

Each stratification was adjusted for age, race/ethnicity, marital status, educational level and PIR status (≤ 1.3, ≥ 1.3 to 3.5, or ≥ 3.5), ALT, AST, smoking status (never, current, or former), obesity (yes or no), T2DM (yes or no), hypertension (yes or no), IR (yes or no) except the stratification factor itself

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**Author contributions**
GSH and XYL made substantial contributions to the conception and design of the study. XYL and WWZ drafted the manuscript and analyzed the data. All the authors assisted in the acquisition and interpretation of data, contributed to the critical revision of the manuscript for important intellectual content and approved the final version.

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**Data availability**
Publicly available datasets were analyzed in this study. This data can be found here: The National Health and Nutrition Examination Survey dataset at https://www.cdc.gov/nchs/nhanes/index.htm.

## Declarations

**Ethics approval and consent to participate**
The NCHS Ethics Review Board examined and approved this study. In order to take part in this study, the patients/participants gave their written informed permission.

**Consent for publication**
Not applicable.

**Competing interests**
No potential conflicts of interest related to this article were reported.

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## Publisher's Note