Nonalcoholic fatty liver disease prevalence and severity in Asian Americans from the national health and nutrition examination surveys 2017–2018

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Abstract
Studies have examined nonalcoholic fatty liver disease (NAFLD) prevalence and severity in Asians; however, this is not well understood in Asian Americans (both East and South Asian Americans) as few studies have analyzed this population. We aimed to describe characteristics, prevalence of NAFLD, and its severity in Asian Americans in the National Health and Nutrition Examination Surveys (NHANES) from 2017 to 2018. Respondents 18 years and older with interview, laboratory testing, and transient elastography data were included. Other causes of liver disease were excluded. Controlled attenuation parameter (CAP) cutoff ≥ 274 dB/m, as published in the literature, defined NAFLD. Sensitivity analysis for CAP cutoffs ≥ 248 and ≥ 302 dB/m were performed. We found that 450 out of 3639 respondents were Asian Americans, and prevalence using CAP ≥ 274 dB/m was 43.23%. Using sensitivity analysis cutoffs of CAP ≥ 248 dB/m and CAP ≥ 302 dB/m, the prevalence was 57.38% and 28.03%, respectively. Compared with non-Asian Americans with NAFLD, Asian Americans with NAFLD had significantly lower body mass index (BMI) and less prevalent smoking history. Comorbidities, such as prediabetes, diabetes, and hypertension, were not significantly different between Asian and non-Asian Americans with NAFLD. Compared to non-Asian Americans with NAFLD, Asian Americans with NAFLD exhibited higher aminotransferases and triglycerides. Fibrosis assessed by transient elastography was not significantly different between Asian and non-Asian Americans with NAFLD. Despite decreased prevalence of BMI ≥ 30 kg/m², Asian Americans experienced similar NAFLD prevalence with increased hepatocellular injury.
INTRODUCTION

Nonalcoholic liver disease (NAFLD) is the leading cause of chronic liver disease worldwide.\(^1,2\) Cardiometabolic risk factors associated with metabolic syndrome, such as obesity, diabetes, hypertension, and hyperlipidemia, increase the risk of NAFLD and disease progression to nonalcoholic steatohepatitis (NASH), fibrosis, and even cirrhosis.\(^3\) Despite these cardiometabolic risk factors, NAFLD develops in 10%–20% of Americans without obesity (body mass index [BMI]< 30 kg/m\(^2\) in non-Asians, <25 kg/m\(^2\) in Asians) or Americans who are lean (BMI < 25 kg/m\(^2\) in non-Asians, <23 kg/m\(^2\) in Asians).\(^4\) Compared to those with non-lean NAFLD, those with lean NAFLD exhibit lower rates of cirrhosis, diabetes, dyslipidemia, and hypertension.\(^5\)

In Asia, the overall prevalence of NAFLD is 29.62%, and this has increased over time.\(^6\) Approximately 8%–19% of Asians who are not obese or are lean have NAFLD, and Asians with nonobese/lean NAFLD exhibit less severe metabolic features compared to Asians with obese NAFLD.\(^7\) Although Asian Americans comprise one of the most rapidly growing ethnic minorities in the United States, with Asian Americans accounting for nearly half of individuals with nonobese/lean NAFLD, the prevalence of NAFLD and its severity among Asian Americans remain poorly characterized, especially in a large real-world cohort across the United States.\(^5,8\) Studies investigating NAFLD have frequently lumped Asians or Asian Americans into overall analyses of nonobese/lean NAFLD cohorts; yet, assessing NAFLD in Asian Americans separately remains important due to possibly distinct genetic signatures and lifestyle factors, including diet and cultural influences, among Asian Americans. In a cross-sectional National Health and Examination Nutrition Survey (NHANES) study using ultrasound combined with fatty liver index from the 2011 to 2016 cycle to compare non-Hispanic Whites with NAFLD (prevalence, 28.4%) to Asian Americans with NAFLD (prevalence, 18.3%), Asian Americans with NAFLD were found to have a lower BMI and waist circumference and lower likelihood of coexisting metabolic syndrome or cardiovascular disease.\(^9\) Presence of type 2 diabetes was independently associated with advanced fibrosis (defined by at least one of the following noninvasive tests: aminotransferase-to-platelet ratio >1.0, fibrosis-4 index >2.67, or NAFLD fibrosis score >0.676) in Asian Americans with NAFLD.\(^9\) However, this study was limited in that various degrees of fibrosis staging were not readily available by liver biopsy or more accurate noninvasive test assessment.\(^9\) Overall, the prevalence and severity of NAFLD is not well understood in Asian Americans as this population is usually combined with other subjects with nonobese/lean NAFLD in analyses. A recent study that used NHANES 2017–2018 and vibration controlled transient elastography (VCTE) to assess the prevalence of NAFLD did not focus on Asian Americans. Therefore, the prevalence of NAFLD in Asian Americans remains unclear.\(^10\)

In this study, we aimed to determine the prevalence and characterization of NAFLD, its severity, and its comorbidities among Asian Americans by using controlled attenuation parameter (CAP) and liver stiffness measurements (LSMs) on VCTE in the most recent cycle of the NHANES data from 2017 to 2018 and to compare these characteristics to those among non-Asian Americans.\(^10\) As transient elastography is more accurate than ultrasound used in prior studies in assessing steatosis and degree of fibrosis, we developed highly accurate estimations of NAFLD disease prevalence and severity. To our knowledge, this cross-sectional study comprises the largest nationally representative population of Asian Americans to date with access to VCTE assessments that empower accurate classification of steatosis and fibrosis by CAP and LSM, respectively. We hypothesized that risk factors, prevalence of NAFLD, severity of NAFLD, and comorbidities varied among Asian Americans compared to non-Asian Americans, independent of BMI.

MATERIALS AND METHODS

Data source

The National Center for Health Statistics at the Centers for Disease Control and Prevention conducts NHANES, a nationally representative, cross-sectional, multistage study of the nonmilitary and noninstitutionalized population of the United States and releases the NHANES data once every 2 years. NHANES data incorporate self-reported interviews and clinical examinations from survey subjects. Each survey subject chosen at random undergoes interviews on demographics, socioeconomic background, diet, and health-related information followed by physical examination at a mobile examination center that includes laboratory blood testing and VCTE (FibroScan) assessments.\(^11\)
Patient selection

We analyzed pooled data from the NHANES cycle conducted from 2017 to 2018. Subjects ≥18 years old were included, whereas subjects with excessive alcohol use (seven or more drinks per week for men, 14 or more drinks per week for men), as determined using alcohol questionnaires, or with human immunodeficiency virus (HIV) or viral hepatitis B, C, D, or E infection were excluded. Those who did not undergo FibroScan were also excluded. The demographic and clinical characteristics among participants and nonparticipants of VCTE examinations are detailed in Table S1. Asian Americans included those who considered themselves to be Asian Indian, Bangladeshi, Bengalese, Bharat, Bhutanese, Burmese, Cambodian, Cantonesse, Chinese, Dravidian, East Indian, Filipino, Goanese, Hmong, Indochinese, Indonesian, Iwo Jiman, Japanese, Korean, Laohmong, Laotian, Madagascar/Malagasy, Malaysian, Maldivian, Mong, Nepalese, Nipponese, Okinawan, Pakistani, Siamese, Singaporean, Sri Lankan, Taiwanese, Thai, or Vietnamese. Non-Asian Americans included those who considered themselves to be Hispanic, American Indian or Alaska Native, African American, Native Hawaiian or Pacific Islander, White, or other.

Definition

VCTE (FibroScan) assessments were included, and CAP and LSM data were collected. Subjects were determined to have NAFLD based on CAP ≥ 274 dB/m (based on a 90% sensitivity cutoff),[12] and sensitivity analyses were performed for additional cutoffs of CAP ≥ 248 dB/m (based on a meta-analysis from 19 studies[13]) and CAP ≥ 302 dB/m (based on the Youden's cutoff from Eddowes et al.'s study[12]). Subjects were also divided into fibrosis stages based on LSM as follows: stage 1 fibrosis or less (LSM < 8.2 kPa), stage 2 fibrosis and above (LSM ≥ 8.2 kPa), stage 3 fibrosis and above (LSM ≥ 9.7 kPa), and stage 4 fibrosis (LSM ≥ 13.6 kPa) based on Youden's index published by Eddowes et al.[12] Using a combination of CAP and LSM by VCTE with aspartate aminotransferase (AST), the FibroScan AST (FAST) score identifies those with fibrotic nonalcoholic steatohepatitis (NASH) with a NAFLD activity score ≥ 4 and significant fibrosis (F2 or higher).[14]

To assess disease severity, we assessed the proportion of patients with clinically meaningful fibrosis stages (F2 or higher, F3 or higher, F4 or higher) and with NASH + NAS ≥ 4+ ≥ F2, assessed by the FAST score using the rule-in cutoff ≥ 0.67, as published by Newsome et al.[14]

Covariates, such as age, sex, and lifestyle factors, were self-reported. Diabetes was determined based on a combination of self-report and/or glycohemoglobin ≥ 6.5%. Prediabetes was determined based on glycohemoglobin ≥ 5.7%. The smoking metric was used to characterize smoking status into past smoking history or current smoking. Clinically measured information obtained during mobile examination was used to calculate BMI. Subjects were further characterized into ideal and normal weight (BMI, 18.5– 22.9 kg/m² for Asian Americans; BMI, 18.5– 24.9 kg/m² for non-Asian Americans), overweight (BMI, 23– 27.4 kg/m² for Asian Americans; BMI, 25– 29.9 kg/m² for non-Asian Americans), obese (BMI, 27.5– 32.4 kg/m² for Asian Americans; BMI, 30– 34.9 kg/m² for non-Asian Americans), and morbidly obese (BMI, ≥ 32.5 kg/m² for Asian Americans; BMI ≥ 35 kg/m² for non-Asian Americans) categories based on World Health Organization (WHO) BMI cut-off points and proposed BMI cut-off points for public health action in Asians[15].

During the mobile examination, up to four blood pressure measurements were performed. Blood pressure was categorized as ideal (blood pressure < 140/<90 mmHg) or high (systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg). Blood samples were collected from each subject and measured for total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and triglycerides.

The prevalence of demographic, metabolic, and biochemical characteristics, including sex, diabetes, prediabetes, obesity, past smoking history, current smoking, high blood pressure, total cholesterol ≥ 200 mg/dL, HDL < 40 mg/dL, LDL ≥ 160 mg/dL, triglycerides ≥ 200 mg/dL, and fibrosis stage were analyzed among Asian Americans and non-Asian Americans.[12,13]

Statistical analysis

The 2-year NHANES survey weights from 2017 to 2018 were used to compute population estimates. Descriptive statistics were reported as proportion (95% confidence interval [CI]) for categorical variables and mean (±SD) for continuous variables. To compare between two categories, Rao-Scott chi-squared test was used for categorical variables and the weighted Student t test was used for continuous variables. Potential risk factors for NAFLD, defined as CAP ≥ 274 dB/m, were estimated using univariable and multivariable logistic regression. Variables on the multivariable regression model were selected based on clinical experience. Two-sided p ≤ 0.05 was significant. Analyses were carried out using survey procedures and testing in SAS version 9.4 (SAS Institute, Cary, NC) and R. Figures were generated using Microsoft Excel.

RESULTS

We included 8704 respondents from the 2017–2018 NHANES cycle who completed both the interview
and mobile examination. After stepwise exclusions for lack of a transient elastography examination \((n = 3210)\), age < 18 years \((n = 748)\), viral hepatitis \((n = 7)\), and excessive alcohol use \((n = 287)\), 3639 subjects were included for final analyses (Figure S1).

Of 3639 participants, 450 (12.37%) were Asian Americans and 3189 (87.63%) were non-Asian Americans (Table S2). A comparison of demographic and clinical variables between Asian Americans and non-Asian Americans with NAFLD, defined as CAP ≥ 274 dB/m, is shown in Table 1.

Compared with non-Asian Americans with NAFLD, Asian Americans with NAFLD were younger and had lower BMI, decreased waist circumference, and decreased previous smoking history. Sex, current smoking, and comorbidities, such as obesity, prediabetes, diabetes, and hypertension, were not significantly different between Asian Americans and non-Asian Americans with NAFLD. Distribution of BMI categories in Asian Americans and non-Asian Americans with NAFLD are shown in Figure 1. The prevalence of nonobese NAFLD in Asian Americans remained significantly higher than that in non-Asian Americans (Asian Americans, 14.05%; 95% CI, 11.2%–16.9%; non-Asian Americans, 7.9%; 95% CI, 5.4%–10.5%; \(p < 0.001\)). There was no significant difference in other BMI categories. Compared to non-Asian Americans with NAFLD, Asian Americans with NAFLD exhibited lower alkaline phosphatase (ALP) and higher albumin, alanine transaminase (ALT), AST, and triglycerides.

The prevalence of NAFLD in Asian Americans was 43.23%, using CAP ≥ 274 dB/m, with 10.01% with F2 or higher, 7.32% with F3 or higher, and 2.48% with F4. In addition, 3.43% of Asian Americans with NAFLD had a FAST score ≥ 0.67, consistent with NASH with significant fibrosis. The prevalence of these clinically significant fibrosis stages and NASH with significant fibrosis was not significantly different between Asian Americans and non-Asian Americans with NAFLD (Table 1).

### Risk factors of fibrotic NASH and advanced fibrosis in Asian Americans with NAFLD

Unadjusted ORs of characteristics among Asian Americans with fibrotic NASH and advanced fibrosis, together defined as CAP ≥ 274 dB/m and LSM ≥ 9.7 kPa, are illustrated in Table 3.

Fibrotic NASH and advanced fibrosis in Asian Americans with NAFLD were significantly associated with diabetes (OR, 27.018; 95% CI, 7.990–91.354), hypertension (OR, 14.153; 95% CI, 3.440–58.231), previous smoking history (OR, 4.033; 95% CI, 1.066–15.261), decreased platelets (OR, 0.989; 95% CI, 0.982–0.995), and increased levels of ALT by 10 U/L (OR, 1.434; 95% CI, 1.212–1697), ALP by 10 U/L (OR, 1.366; 95% CI, 1.017–1.834), and AST per 20 U/L (OR, 3.111; 95% CI, 1.220–7.935).

### Sensitivity analysis using CAP cutoffs

A comparison of demographic and clinical variables between Asian Americans and non-Asian Americans with NAFLD, defined as CAP ≥ 248 and ≥ 302 dB/m, for sensitivity analysis is shown in Table S4.

The prevalence of NAFLD in Asian Americans was 57.38%, using CAP ≥ 248 dB/m, with 8.20% with F2 or higher, 5.98% with F3 or higher, and 2.40% with F4, whereas the prevalence of NAFLD in Asian Americans was 28.03%, using CAP ≥ 302 dB/m, with 14.14% with F2 or higher, 9.74% with F3 or higher, and 3.38% with F4. The prevalence of NAFLD with FAST score ≥ 0.67 (NASH with significant fibrosis) was 2.50% and 5.78% in Asian Americans for CAP ≥ 248 and ≥ 302 dB/m, respectively. The prevalence of these clinically significant fibrosis stages and NASH with significant fibrosis was not significantly different between Asian Americans and non-Asian Americans with NAFLD for either CAP ≥ 248 or ≥ 302 dB/m.

### DISCUSSION

Among individuals with NAFLD, Asian Americans were younger, had a less prevalent smoking history, and had lower BMI and waist circumference but had a significantly higher prevalence of prediabetes and numerically higher prevalence of type 2 diabetes compared to non-Asian Americans. As Asian Americans with NAFLD are younger, have a lower BMI and waist circumference, and have a decreased previous smoking history compared to non-Asian Americans with NAFLD, this suggests that Asian Americans may be vulnerable to developing NAFLD; this would likely be secondary to a combination of genetics, cultural influence, and dietary choices. The vulnerability of Asian Americans to
NAFLD is alarming as studies have demonstrated that less than 5% of non-Hispanic Asians with NAFLD are aware of having liver disease. Educational programs to enhance awareness and development of guidelines for NAFLD screening among susceptible individuals are essential for early detection and management.

In this large nationally representative study with VCTE-proven NAFLD, Asian Americans had a NAFLD prevalence that was overall comparable to that of non-Asian Americans; however, Asian Americans had a higher prevalence for NAFLD than non-Asian Americans in the lean/normal BMI and morbidly obese.

### Table 1: Demographic and Clinical Characteristics Among Asian Americans versus Non-Asian Americans with NAFLD Using CAP Cutoff ≥ 274 dB/m

|                           | Asian Americana | Non-Asian Americab | p value |
|---------------------------|-----------------|--------------------|---------|
| **Demographics**          |                 |                    |         |
| Age (years)               | 45.83 (43.47–48.19) | 49.84 (48.72–50.96) | 0.009   |
| Female                    | 42.38 (34.57–50.19) | 44.94 (41.26–48.63) | 0.532   |
| BMI (kg/m²)               | 29.35 (28.83–29.86) | 34.18 (33.45–34.92) | <0.001  |
| Waist circumference (cm)  | 98.33 (96.46–100.19) | 111.87 (109.98–113.75) | <0.0001 |
| Any smoking history       | 23.46 (16.12–32.05) | 41.81 (37.62–46.09) | <0.001  |
| Current smoking           | 9.87 (4.45–18.00) | 13.13 (10.36–16.29) | 0.398   |
| **Comorbidities**         |                 |                    |         |
| Obesity                   | 58.54 (50.89–66.19) | 70.35 (64.91–75.78) | 0.0168  |
| Prediabetes               | 58.84 (48.46–68.72) | 54.97 (50.94–58.97) | 0.466   |
| Diabetes                  | 25.47 (19.06–32.67) | 22.62 (19.16–26.34) | 0.459   |
| Hypertension              | 41.15 (33.51–49.09) | 44.03 (38.13–50.05) | 0.526   |
| WBC (1000 cells/μL)       | 7.77 (7.40–8.15) | 7.82 (7.61–8.02) | 0.846   |
| Hemoglobin (g/dL)         | 14.24 (13.92–14.56) | 14.43 (14.29–14.58) | 0.300   |
| Platelets (1000 cells/μL) | 252.03 (238.67–265.39) | 251.35 (244.38–258.31) | 0.918   |
| Albumin (g/L)             | 41.66 (41.11–42.22) | 40.59 (40.19–41.00) | 0.003   |
| ALP (IU/L)                | 77.34 (74.79–79.77) | 80.24 (78.12–82.35) | 0.032   |
| ALT (IU/L)                | 29.56 (26.31–32.81) | 26.48 (25.27–27.68) | 0.050   |
| AST (U/L)                 | 24.15 (22.05–26.25) | 22.12 (21.3–22.93) | 0.045   |
| Total bilirubin (mg/dL)   | 0.45 (0.40–0.51) | 0.45 (0.43–0.48) | 0.995   |
| Total cholesterol ≥ 200 mg/dL | 42.17 (34.11–50.51) | 39.30 (32.91–45.94) | 0.495   |
| HDL <40 mg/dL             | 27.05 (17.96–37.66) | 26.47 (21.39–32.01) | 0.903   |
| LDL ≥ 160 mg/dL           | 13.84 (6.87–23.63) | 10.64 (7.47–14.48) | 0.334   |
| Triglycerides ≥ 200 mg/dL | 29.5 (17.16–44.29) | 16.23 (11.75–21.49) | 0.028   |
| HbA1c (%)                 | 6.02 (5.85–6.20) | 5.97 (5.90–6.05) | 0.659   |
| Median CAP (IQR)          | 310.92 (292; 344.02) | 314.70 (292.83; 347.41) | 0.5735c |
| Median LSM (IQR)          | 5.18 (4.30; 6.10) | 5.38 (4.30; 6.81) | 0.1146c |
| ≥F2                      | 10.01 (5.67–15.89) | 15.46 (11.54–20.01) | 0.103   |
| ≥F3                      | 7.32 (3.65–12.66) | 10.07 (7.55–13.05) | 0.344   |
| F4                        | 2.48 (0.64–6.24) | 5.02 (3.35–7.12) | 0.184   |
| FAST score                | 0.18 (0.15–0.21) | 0.17 (0.16–0.18) | 0.390   |
| FAST score ≥ 0.67         | 3.43 (0.03; 6.83) | 2.93 (2.02; 3.83) | 0.7591  |

Note: Values show mean or percentage (95% CI). NAFLD is defined using CAP ≥ 274 dB/m. ≥ F2, ≥ F3, and F4 were defined by liver stiffness measurements ≥ 8.2, ≥ 9.7, and ≥ 13.6, respectively. Obesity is defined as BMI ≥ 27.5 kg/m² for Asian Americans or BMI ≥ 30 kg/m² for non-Asian Americans. Abbreviations: ALT, alanine aminotransferase; AST, aspartate aminotransferase; BMI, body mass index; CAP, controlled attenuation parameter; CI, confidence interval; FAST, FibroScan aspartate aminotransferase; F2, stage 2 fibrosis; F3, stage 3 fibrosis; F4, stage 4 fibrosis; HbA1c, hemoglobin A1c; HDL, high-density lipoprotein; IQR, interquartile range; LDL, low-density lipoprotein; LSM, liver stiffness measurement; NAFLD, nonalcoholic fatty liver disease; WBC, white blood count.

aUnweighted count, n = 183; weighted count, n = 3,426,780.
bUnweighted count, n = 1390; weighted count, n = 66,451,377.
cThis comparison was conducted using Wilcoxon test.
NAFLD PREVALENCE AND SEVERITY IN ASIAN AMERICANS

The cutoff for NAFLD was defined as CAP ≥ 274 dB/m. Based on WHO BMI cut-off points and proposed BMI cut-off points for public health action in Asians, BMI categories were defined as ideal and normal weight (BMI < 23 kg/m² Asian Americans, BMI < 25 kg/m² non-Asian Americans), overweight (BMI 23–27.4 kg/m² Asian Americans, BMI 25–29.9 kg/m² non-Asian Americans), obese (BMI 27.5–32.4 kg/m² Asian Americans, BMI 30–34.9 kg/m² non-Asian Americans), and morbidly obese (BMI ≥ 32.5 kg/m² Asian Americans, BMI ≥ 35 kg/m² non-Asian Americans). Prevalence was weighted to compute population estimate. BMI, body mass index; CAP, controlled attenuation parameter; NAFLD, nonalcoholic fatty liver disease; WHO, World Health Organization.

TABLE 2  Independent predictors of NAFLD (CAP ≥ 274) among Asian Americans

| Variables                  | Univariable | Multivariable |
|----------------------------|-------------|---------------|
|                            | OR          | 95% CI        | p value | aOR         | 95% CI        | p value |
| Age (every 10 years)       | 1.230       | 1.079–1.402   | 0.0042  | 1.144       | 0.910–1.439   | 0.2300 |
| Sex                       |             |               |         |             |               |         |
| Female                    | Reference   |               |         |             |               |         |
| Male                      | 1.882       | 1.418–2.498   | 0.0003  | 2.017       | 1.203–3.383   | 0.0111 |
| BMI < 27.5 kg/m²           | Reference   |               |         |             |               |         |
| ≥ 27.5 kg/m²              | 6.536       | 4.115–10.417  | <0.0001 | 6.507       | 4.143–10.221  | <0.0001 |
| Diabetes                   |             |               |         |             |               |         |
| No                        | Reference   |               |         |             |               |         |
| Yes                       | 4.760       | 0.122–0.363   | <0.0001 | 4.110       | 1.544–10.937  | 0.0077 |
| Hypertension               |             |               |         |             |               |         |
| No                        | Reference   |               |         |             |               |         |
| Yes                       | 0.347       | 0.199–0.606   | 0.0011  | 2.101       | 1.177–3.751   | 0.0155 |
| Platelets (every 1000 cells/μL) | 1.002    | 1.000–1.004   | 0.2188  | 1.002       | 0.999–1.004   | 0.2188 |
| ALT (every 10 U/L)        | 1.563       | 1.163–2.102   | 0.0058  | 1.304       | 1.016–1.674   | 0.0388 |

Note: NAFLD defined as CAP ≥ 274 dB/m.
Abbreviations: ALT, alanine aminotransferase; aOR, adjusted odds ratio; BMI, body mass index; CAP, controlled attenuation parameter; CI, confidence interval; NAFLD, nonalcoholic fatty liver disease; OR, odds ratio.

FIGURE 1  Distribution of prevalence of NAFLD across different BMI categories among Asian Americans versus non-Asian Americans. The cutoff for NAFLD was defined as CAP ≥ 274 dB/m. Based on WHO BMI cut-off points and proposed BMI cut-off points for public health action in Asians, BMI categories were defined as ideal and normal weight (BMI < 23 kg/m² Asian Americans, BMI < 25 kg/m² non-Asian Americans), overweight (BMI 23–27.4 kg/m² Asian Americans, BMI 25–29.9 kg/m² non-Asian Americans), obese (BMI 27.5–32.4 kg/m² Asian Americans, BMI 30–34.9 kg/m² non-Asian Americans), and morbidly obese (BMI ≥ 32.5 kg/m² Asian Americans, BMI ≥ 35 kg/m² non-Asian Americans). Prevalence was weighted to compute population estimate. BMI, body mass index; CAP, controlled attenuation parameter; NAFLD, nonalcoholic fatty liver disease; WHO, World Health Organization.

Metabolic abnormalities and diabetes are known risk factors associated with NAFLD. In this study, the
prevalence of type 2 diabetes and prediabetes was higher overall in Asian Americans. Additionally, factors significantly associated with a higher risk of NAFLD in Asian Americans were male sex, diabetes, hypertension, and increased ALT, whereas risk factors of fibrotic NASH in Asian Americans with NAFLD included diabetes, hypertension, previous smoking history, decreased platelets, and increased levels of ALT, AST, and ALP. This suggests that Asian Americans may be predisposed to increased liver injury from metabolic abnormalities compared to non-Asian Americans and that considerable effort should be made to control metabolic abnormalities or diseases in Asian Americans. The reasons why these factors increase risk are not completely understood. However, genetic or, more importantly, dietary factors, such as a carbohydrate-enriched diet (e.g., rice), can contribute to this risk.[19]

Indeed, because studies have shown that Asian populations experience increased risk of obesity-related comorbidities, including diabetes, hypertension, and cardiovascular disease, at lower BMI cutoffs, WHO has proposed lower BMI cut-off thresholds for public health information but not fibrosis, although this study was limited to a small sample size.[24] Overall, our findings indicate that neither NASH with F2 or higher (as reflected by LSM) nor clinically significant stages of fibrosis (F2 or higher, nor 0.77) after adjusting for sex, age, and center type and site.[8] However, staging by liver biopsy was not available for all patients.[8] In contrast, a study that included biopsy-proven NAFLD showed that Asian Americans had a trend toward more severe steatosis and inflammation but not fibrosis, although this study was limited by a small sample size.[24] Overall, our findings indicate that neither NASH with F2 or higher (as reflected by a FAST score and prevalence of a FAST score ≥ 0.67) nor clinically significant stages of fibrosis (F2 or higher, F3 or higher, or F4 as reflected by LSM) are less prevalent in Asian Americans compared to non-Asian Americans. This is plausible given that the prevalence of prediabetes and type 2 diabetes was not less in the Asian American population.

This study has limitations. First, the NHANES measures of smoking were based on self-reported data, which may be subject to recall bias. Nevertheless, self-assessments of smoking status have been shown to be accurate and valid.[25] Second, the NHANES surveys lack genetic information that would allow improved differentiation among Asian Americans. Given the small sample sizes of Asian Americans, the assessment of NAFLD, its comorbidities, and its disease severity among individual Asian subgroups (such as the Chinese, Japanese, and Vietnamese populations), was

### TABLE 3

| Variable                        | OR     | 95% CI          | p value |
|---------------------------------|--------|-----------------|---------|
| Age by 10 years                 | 1.45   | 0.97–2.16       | 0.0659  |
| Sex (male/female)               | 2.258  | 0.497–10.261    | 0.2694  |
| BMI≥27.5 kg/m²                  | 5.314  | 0.734–38.492    | 0.0923  |
| Diabetes                        | 27.018 | 7.990–91.354    | <0.0001 |
| Hypertension                    | 14.153 | 3.440–58.231    | 0.0012  |
| Previous smoking history        | 4.033  | 1.066–15.261    | 0.0412  |
| Platelets (cells/μL)            | 0.989  | 0.982–0.995     | 0.0011  |
| ALT per 10 U/L                  | 1.434  | 1.212–1.697     | 0.0004  |
| ALP per 20 U/L                  | 3.111  | 1.220–7.935     | 0.0208  |
| Triglycerides per 10 mg/dL      | 1.055  | 0.984–1.131     | 0.1225  |

Note: Fibrotic NASH and advanced fibrosis is defined as CAP≥274 dB/m and LSM≥9.7 kPa, respectively.

Abbreviations: ALP, alkaline phosphatase; ALT, alanine aminotransferase; AST, aspartate aminotransferase; BMI, body mass index; CAP, controlled attenuation parameter; CI, confidence interval; LSM, liver stiffness measurement; NASH, nonalcoholic steatohepatitis; OR, odds ratio.
not possible. However, to our knowledge, this cross-sectional study encompasses the largest nationally representative population of Asian Americans to date with access to VCTE assessments that allow for accurate measurements of steatosis by CAP and fibrosis by LSM. As this study cohort is nationally representative, our study holds increased generalizability and applicability in the clinical setting.

In conclusion, the prevalence of NAFLD may vary based on the CAP score cutoff used in the Asian American population. Despite younger age, lower BMI cutoffs, and decreased prevalence of obesity, Asian Americans with NAFLD demonstrate similar disease prevalence with comparable severity of disease as evidenced by the FAST score, prevalence of FAST score ≥0.67, and LSM on VCTE compared to non-Asian Americans with NAFLD. Given the diversity of cultures in the United States, culturally responsive health care specific to individual populations is necessary for diagnosis, evaluation, and treatment of NAFLD.

CONFLICTS OF INTEREST
Mazen Noureddin has been on the advisory board for 89BIO, Gilead, Intercept, Pfizer, Novartis, Novo Nordisk, Allergan, Blade, EchoSens, Fractyl, Terns, OWL, Siemens, Roche Diagnostic, and Abbott; he has received research support from Allergan, BMS, Gilead, Galmed, Galectin, Genfit, Conatus, Enanta, Madrigal, Novartis, Shire, Viking, and Zydu; he is a minor shareholder or has stock in Anaetos and Viking. Naim Alkhouri has been on the advisory board for Gilead and Allergan; he is on the speaker’s bureau for Intercept and Gilead. Vinay Sundaram is on the speaker’s bureau for Gilead, AbbVie, and Intercept and is a consultant for Sael Therapeutics. Vincent Wong has served as an advisory board member or consultant for 3V-BIO, AbbVie, Allergan, Boehringer Ingelheim, Echosens, Gilead Sciences, Inventiva, Merck, Novartis, Novo Nordisk, Pfizer, ProSciento, Sagmet Biosciences, TARGET PharmaSolutions, and Terns and is on the speaker’s bureau for Abbott, AbbVie, Echosens, Gilead Sciences, and Novo Nordisk; he has received a grant from Gilead Sciences for fatty liver research and is a co-founder of Illuminatio Medical Technology Limited. The other authors have nothing to report.

AUTHOR CONTRIBUTIONS
Emily Truong and Yee Hui Yeo participated in the design of the study, interpreted the data, and drafted the manuscript. Galen Cook-Wiens performed the statistical analysis. Mark Muthiah, Ju Dong Yang, Vinay Sundaram, Devon Chang, Tsuyoshi Todo, Irene K. Kim, Shelly C. Lu, Veronica Wendy Setiawan, Vincent W. S. Wong, Stephen A Harrison, and Naim Alkhouri interpreted the data and critically revised the manuscript for important intellectual content. Mazen Noureddin participated in the design of the study, supervised the study, interpreted the data, and approved the final manuscript.

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REFERENCES
1. Younossi Z, Anstee QM, Marietti M, Hardy T, Henry L, Eslam M, et al. Global burden of NAFLD and NASH: trends, predictions, risk factors and prevention. Nat Rev Gastroenterol Hepatol. 2018;15:11–20.
2. Setiawan VW, Stram DO, Porcel J, Lu SC, Le Marchand L, Noureddin M. Prevalence of chronic liver disease and cirrhosis by underlying cause in understudied ethnic groups: the multi-ethnic cohort. Hepatology. 2018;64:1969–77.
3. Dietrich P, Hellerbrand C. Non-alcoholic fatty liver disease, obesity and the metabolic syndrome. Best Pract Res Clin Gastroenterol. 2014;28:637–53.
4. Younes R, Bugianesi E. NASH in lean individuals. Semin Liver Dis. 2019;39:86–95.
5. Weinberg EM, Trinh HN, Firpi RJ, Bhamidimarri KR, Klein S, Durlam J, et al. Lean Americans with nonalcoholic fatty liver disease have lower rates of cirrhosis and comorbid diseases. Clin Gastroenterol Hepatol. 2021;19:996–1008.e6.
6. Li J, Zou B, Yeo YH, Feng Y, Xie X, Lee DH, et al. Prevalence, incidence, and outcome of non-alcoholic fatty liver disease in Asia, 1999–2019: a systematic review and meta-analysis. Lancet Gastroenterol Hepatol. 2019;4:389–98.
7. Ye Q, Zou B, Yeo YH, Li J, Huang DQ, Wu Y, et al. Global prevalence, incidence, and outcomes of non-obese or lean non-alcoholic fatty liver disease: a systematic review and meta-analysis. Lancet Gastroenterol Hepatol. 2020;5:739–52.
8. Budiman A, Ruiz N. Key facts about Asian Americans, a diverse and growing population. Washington, DC: Pew Research Center; 2021. [cited 2021 December]. https://www.pewresearch.org/fact-tank/2021/04/29/key-facts-about-asian-americans/.
9. Golabi P, Paik J, Hwang JP, Wang S, Lee HM, Younossi ZM. Prevalence and outcomes of non-alcoholic fatty liver disease (NAFLD) among Asian American adults in the United States. Liver Int. 2019;39:748–57.
10. Zhang X, Heredia NI, Balakrishnan M, Thrift AP. Prevalence and factors associated with NAFLD detected by vibration controlled transient elastography among US adults: Results from NHANES 2017–2018. PLoS One. 2021;16:e0252164.
11. Paulose-Ram R, Burt V, Broitman L, Ahluwalia N. Overview of Asian American data collection, release, and analysis: National Health and Nutrition Examination Survey 2011–2018. Am J Public Health. 2017;107:916–21.
12. Eddowes PJ, Sasso M, Allison M, Tsotchatzis E, Anstee QM, Sheridan D, et al. Accuracy of FibroScan controlled attenuation parameter and liver stiffness measurement in assessing steatosis and fibrosis in patients with nonalcoholic fatty liver disease. Gastroenterology. 2019;156:1717–30.
13. Karlas T, Petroff D, Sasso M, Fan JG, Mi YQ, de Lédinghen V, et al. Individual patient data meta-analysis of controlled attenuation parameter (CAP) technology for assessing steatosis. J Hepatol. 2017;66:1022–30.

14. Newsome PN, Sasso M, Deeks JJ, Paredes A, Boursier J, Chan WK, et al. FibroScan-AST (FAST) score for the non-invasive identification of patients with non-alcoholic steatohepatitis with significant activity and fibrosis: a prospective derivation and global validation study. Lancet Gastroenterol Hepatol. 2020;5:362–73. Erratum in: Lancet Gastroenterol Hepatol. 2020;5:e83.

15. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;363:157–63. Erratum in: Lancet. 2004;363:902.

16. Le MH, Yeo YH, Cheung R, Wong VWS, Nguyen MH. Ethnic influence on nonalcoholic fatty liver disease prevalence and lack of disease awareness in the United States, 2011–2016. J Intern Med. 2020;287:711–22.

17. Harrison SA, Gawrieh S, Roberts K, Lisanti CJ, Schwope RB, Cebe KM, et al. Prospective evaluation of the prevalence of non-alcoholic fatty liver disease and steatohepatitis in a large middle-aged US cohort. J Hepatol. 2021;75:284–91.

18. Ruhl CE, Everhart JE. Fatty liver indices in the multiethnic United States National Health and Nutrition Examination Survey. Aliment Pharmacol Ther. 2015;41:65–76.

19. Tajima R, Kimura T, Enomoto A, Yanoshita K, Saito A, Kobayahi S, et al. Association between rice, bread, and noodle intake and the prevalence of non-alcoholic fatty liver disease in Japanese middle-aged men and women. Clin Nutr. 2017;36:1601–8.

20. Pan WH, Flegal KM, Chang HY, Yeh WT, Yeh CJ, Lee WC. Body mass index and obesity-related metabolic disorders in Taiwanese and US whites and blacks: implications for definitions of overweight and obesity for Asians. Am J Clin Nutr. Vol 79; Oxford: Oxford University Press; 2004. p. 31–9.

21. Shai I, Jiang R, Manson JAE, Stampfer MJ, Willett WC, Colditz GA, et al. Ethnicity, obesity, and risk of type 2 diabetes in women: a 20-year follow-up study. Diabetes Care. 2006;29:1585–90.

22. Wen CP, Cheng TYD, Tsai SP, Chan HT, Hsu HL, Hsu CC, et al. Are Asians at greater mortality risks for being overweight than Caucasians? Redefining obesity for Asians. Public Health Nutr. 2009;12:497–506.

23. Gawrieh S, Wilson LA, Cummings OW, Clark JM, Loomba R, Hameed B, et al. Histologic findings of advanced fibrosis and cirrhosis in patients with nonalcoholic fatty liver disease who have normal aminotransferase levels. Am J Gastroenterol. 2019;114:1626–35.

24. Tabibian JH, Lazo M, Durazo FA, Yeh HC, Tong MJ, Clark JM. Nonalcoholic fatty liver disease across ethno-racial groups: do Asian-American adults represent a new at-risk population? J Gastroenterol Hepatol. 2011;26:501–9.

25. Patrick DL, Cheadle A, Thompson DC, Diehr P, Koepsell T, Kinne S. The validity of self-reported smoking: a review and meta-analysis. Am J Public Health. 1994;84:1086–93.

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