

ORIGINAL ARTICLE

# Prevalence and risk factors of non-alcoholic fatty liver disease in Bangladesh

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**Key words**

Bangladesh, fatty liver, non-alcoholic fatty liver disease, obesity, ultrasonography.

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**Abstract**

**Background and Aim:** Non-alcoholic fatty liver disease (NAFLD) is a significant cause of hepatic dysfunction and liver-related mortality. As there is a lack of population-based prevalence data in a representative sample of general population, we aimed to estimate the prevalence and risk factors of NAFLD in Bangladesh.

**Methods:** A cross-sectional study was conducted both in urban and rural areas of Bangladesh from December 2015 to January 2017. Data were collected using a pre-tested structured questionnaire followed by ultrasonography of hepatobiliary system for screening of NAFLD. Multivariate logistic regression was used to estimate the risk factors of NAFLD.

**Results:** A total of 2782 (1694 men and 1088 women) participants were included in the study, with a mean age of 34.21 ( $\pm 12.66$ ) years. The overall prevalence of NAFLD was 33.86% (95% confidence interval [CI]: 32.12, 35.64). Females living in the rural areas and midlife adults (45–54 years) had the highest prevalence of NAFLD ( $P < 0.05$ ). Multivariable logistic regression model demonstrated that increasing age, diabetes, elevated body mass index, and married individuals are significantly associated with NAFLD. Individuals with diabetes (adjusted odds ratio: 2.71, 95% CI: 1.85, 3.97) and hypertension were at a higher risk of having NAFLD. The odds of having NAFLD were 4.51 (95% CI: 3.47, 5.86) and 10.71 (95% CI: 7.80, 14.70) times higher among overweight and obese participants, respectively, as compared to normal-weight participants.

**Conclusions:** About one-third of the population of Bangladesh is affected by NAFLD. Individuals with higher body mass index (overweight and obese), diabetics, midlife adults, married individuals, and rural women were more at risk of having NAFLD than others.

**Introduction**

Non-alcoholic fatty liver disease (NAFLD) ranges from simple steatosis to non-alcoholic steatohepatitis (NASH) and cirrhosis.<sup>1,2</sup> It is a significant cause of liver-related mortality, associated with severe insulin resistance and increased risk of cardiovascular diseases.<sup>3–5</sup> A large proportion of individuals with type 2 diabetes mellitus and a metabolic syndrome develop NAFLD,<sup>6,7</sup> and it may also progress to malignancy.<sup>3,8</sup> Currently, NAFLD is the most common cause of hepatic dysfunction in developed countries and is predicted to be the same for developing countries within the next few decades.<sup>9,10</sup> The prevalence of NAFLD ranges from 20% to 30% in Western countries.<sup>9,11</sup> Prevalence in the Middle East, Japan, and China is almost the same as the Western world, with a prevalence rate of 15–30%. In Asian countries, the prevalence of NAFLD varies in different regions. However, in the Indian subcontinent, prevalence of NAFLD is

recorded to be 16–32% in urban population and approximately 9–16% in rural areas.<sup>9,11,12</sup>

Bangladesh is also experiencing an increasing trend of NAFLD due to changing dietary patterns and sedentary lifestyles.<sup>13–15</sup> The World Health Organization (WHO) has been documented in May 2014 stating that 2.82% of total deaths in Bangladesh are due to liver diseases. It is the eighth most common cause of death in Bangladesh, and the age-adjusted death rate is 19.26 per 100 000 populations.<sup>13–16</sup> Chronic liver diseases (CLDs) are responsible for 37–69% of liver diseases in Bangladesh, and NAFLD is a significant contributor to the burden of chronic liver diseases.<sup>15</sup> However, data on the burden of NAFLD are very limited in Bangladesh. The few studies that have been conducted included hospitalized patients,<sup>17,18</sup> and little information is available on the community-based estimation of NAFLD burden. In low-income countries like Bangladesh,

hospital-based prevalence estimates may underestimate the true burden of disease as many patients with NAFLD may never seek medical care as a result of being asymptomatic, having limited access to healthcare services, and being in fear of significant economic burden.<sup>19–22</sup>

Population-based prevalence data may help better define the risk groups and provide evidence that can be used to develop effective intervention strategies for the control and prevention of NAFLD. Identification of potential risk factors may lead to the earlier detection of the burden and may help deal with it effectively. Because the implications of NAFLD for health care are substantial, we sought to measure the prevalence and identify the associated risk factors of NAFLD in the general adult population in Bangladesh. This article provides the most recent population-based prevalence and risk estimates of NAFLD and provides an overview of the evidence of the strength of these risk factors.

## Methods

**Study design and sample.** A cross-sectional study was conducted between December 2015 and January 2017 in Dhaka City, the capital of Bangladesh, along with four district towns and four subdistrict towns (small administrative unit) in Bangladesh. The locations were selected purposively. A multi-stage sampling method was followed in order to represent the general population of Bangladesh irrespective of urban and rural areas. Of the 11 city corporations, Dhaka City was selected. The district and subdistrict towns were selected from the larger four divisions of the country. The district towns of Feni, Mymensingh, Bogra, and Patuakhali are located in urban areas, and the subdistrict areas of Pabna sadar upazilla, Chatkhil, Bheramara, and Keraniganj represent the rural areas. The study population comprises healthy individuals who were informed of a free medical camp through an extensive media campaign and through text messages, leaflets, banners, posters, and hand-mike announcing. Participants who attended the medical camp and provided informed consent to participate were enrolled in the study. Higher education group was defined as participants who attained a bachelor degree or above, and those who had a monthly income of more than BDT (Bangladeshi Taka) 15 000 were considered higher income participants.

**Data collection.** Informed written consent was obtained from each individual participant, and data were collected using a pretested questionnaire through interview followed by physical examination and screening tests for hepatitis B and hepatitis C. A trained physician collected data and performed the physical examination. The questionnaire included demographic characteristics such as age; gender; family history of liver disease; any current medication that may elicit liver disease; medical history; anthropometric measurement; and other comorbid conditions like diabetes (Random Blood Sugar (RBS) > 11.1 mmol/L or known case of diabetes), hypertension (known case of hypertension and receiving treatment), previous history of surgery, and previous dental procedure. Any previously diagnosed cases of liver disease were excluded from the study.

**Physical examination and biochemical tests.** Physical examination was performed by physicians to detect any

signs of jaundice, abdominal mass, or any other symptoms related to liver diseases. Screening tests for the serum markers of hepatitis B (HBsAg) and hepatitis C (anti-HCV) viruses were also carried out using the rapid strip test. Height was measured by standard stadiometer, and weight was measured using a standard bathroom scale. Anthropometric measurements were cross checked to ensure the interrater reliability. Body mass index (BMI) was calculated using height in cm and weight in kg. We used a WHO-approved BMI scale for Asian populations: underweight (<18.5 kg/m<sup>2</sup>), normal weight (18.5 to <23.0 kg/m<sup>2</sup>), overweight (23.0 to <27.50 kg/m<sup>2</sup>), and obese (≥27.50 kg/m<sup>2</sup>).<sup>23–25</sup>

**Detection of fatty liver.** Ultrasonography (USG) of the hepatobiliary system was used to diagnose the presence or absence of NAFLD. USG is considered an easily available, cost-effective, and essentially noninvasive method for the detection of NAFLD.<sup>26–29</sup> A postgraduate-trained sonographer performed USG of the hepatobiliary system for each subject. The physicians scanned the liver, biliary tract, spleen, and the kidney using a sonographic machine equipped with 3.5 MHz transducers. Fatty liver was diagnosed by the sonographic findings of the echogenicity of the liver, which is greater than that of the renal cortex; intrahepatic vessels are not well depicted; the ultrasound beam is attenuated posteriorly; and the diaphragm is poorly delineated. As cirrhotic liver may also present bright echogenicity, it was excluded by medical history, physical examinations, and sonographic findings like the coarse echo texture of liver.<sup>27,30–32</sup>

**Statistical analysis.** We summarized the data using frequency and percentages. We used multivariable logistic regression to identify covariates of NAFLD. An arbitrary *P*-value of <0.20 was used as a criterion to include the variables in the multivariable logistic regression model to control for confounding effects, and the results were considered statistically significant at a *P*-value of ≤0.05. Using the logistic regression procedure, we estimated the odds ratio (OR) and 95% confidence interval (CI) for each covariate to identify risk factors of NAFLD. We considered forward, backward, and stepwise model selection procedures in the analysis. To select the best model, the values of –2Log Likelihood ratio test, the Akaike information criterion (AIC), and the area under the receiver operating characteristic (ROC) curve were examined. The lower values of –2Log Likelihood ratio test and AIC represent the better model. Before entering the independent variables into the multivariable models, we checked the variation inflation factor (VIF) to avoid the problem of multicollinearity. All statistical procedures were performed using the StataMP software (Version 13.0; StataCorp, College Station, TX, USA).

## Results

The distribution of sociodemographic, anthropometric, and clinical characteristics of the study participants is presented in Table 1 according to whether they had NAFLD. A total of 2782 (1694 men and 1088 women) participants were included in the study. Mean age was 34.21 years (±12.66), ranging from 18 to 85 years. Among the participants, 1694 (60.86%) were male, 2118 (76.13%) were from urban areas, and one-fourth (713) of

**Table 1** Characteristics of the subjects with and without NAFLD in Bangladesh, 2017<sup>‡</sup>

	No NAFLD	NAFLD	Total	P-value <sup>†</sup>
Age (years), mean (SD)	31.38 (12.19)	39.73 (11.71)	34.21 (12.66)	<0.0001
Gender, <i>n</i> (%)				0.961
Male	1121 (66.2)	573 (33.8)	1694 (100)	
Female	719 (66.1)	369 (33.9)	1088 (100)	
Place of residence, <i>n</i> (%)				0.088
Urban	1419 (77.12)	699 (74.2)	2118 (76.13)	
Rural	421 (22.88)	243 (25.8)	664 (23.87)	
Marital status, <i>n</i> (%)				<0.0001
Married	1159 (62.99)	743 (89.49)	2002 (71.96)	
Not married	681 (37.01)	99 (10.51)	780 (28.04)	
Income, <i>n</i> (%)				<0.0001
Low	84 (8.39)	38 (6.5)	122 (7.69)	
Medium	597 (59.64)	222 (37.95)	819 (51.64)	
High	320 (31.97)	325 (55.56)	645 (40.67)	
Education, <i>n</i> (%)				0.152
No education	221 (12.01)	121 (12.85)	342 (12.29)	
Primary	500 (27.17)	246 (26.11)	746 (26.82)	
Secondary	331 (17.99)	178 (18.9)	509 (18.3)	
Higher secondary	333 (18.1)	139 (14.76)	472 (16.97)	
Higher	455 (24.73)	258 (27.39)	713 (25.63)	
BMI, mean (SD)	22.48 (3.93)	26.61 (4.07)	23.87 (4.43)	<0.0001
SBP (mmHg) (mean, SD)	113.18 (9.5)	118.94 (9.66)	115.13 (9.93)	<0.0001
DBP (mmHg) (mean, SD)	69.53 (7.31)	72.76 (7.11)	70.62 (7.4)	<0.0001
Hypertension, <i>n</i> (%)				<0.0001
Yes	61 (4.54)	103 (13.29)	164 (7.74)	
No	1282 (95.46)	672 (86.71)	1954 (92.26)	
Diabetes, <i>n</i> (%)				<0.0001
Yes	51 (3.79)	126 (16.26)	177 (8.35)	
No	1294 (96.21)	649 (83.74)	1943 (91.65)	
Blood transfusion				0.002
Yes	79 (5.88)	74 (9.57)	153 (7.23)	
No	1265 (94.12)	699 (90.43)	1964 (92.77)	
Hepatitis B, <i>n</i> (%)				0.575
Positive	97 (5.27)	45 (4.78)	142 (5.1)	
Negative	1743 (94.73)	897 (95.22)	2640 (94.9)	
Family history of liver disease				0.006
Yes	183 (9.95)	126 (13.38)	309 (11.11)	
No	1657 (90.05)	816 (86.62)	2473 (88.89)	

<sup>†</sup>P-values were calculated using the Student's *t*-test or chi-square test.

<sup>‡</sup>Data are presented as mean (SD) or number (%) for continuous and categorical variables.

BMI, body mass index; DBP, Diastolic Blood Pressure; NAFLD, non-alcoholic fatty liver disease; SBP, Systolic Blood Pressure.

the study participants had higher education. The mean BMI, Systolic Blood Pressure (SBP), and Diastolic Blood Pressure (DBP) of the study participants were 23.82 kg/m<sup>2</sup> ( $\pm$ 4.43), 115.13 mmHg ( $\pm$ 9.93), and 70.62 mmHg ( $\pm$ 7.4), respectively.

**Prevalence of NAFLD.** The prevalence of NAFLD is presented in Table 2 according to the characteristics of the individuals in the study population and their demographic and clinical covariates. The overall prevalence of NAFLD in the study population was 33.86% (95% CI: 32.12 – 35.64), and there was no significant difference between the genders ( $P = 0.961$ ). Individuals from rural areas had a higher prevalence—36.95% (95% CI: 33.01 – 40.33)—of NAFLD than the individuals from urban areas—33.00% (95% CI: 31.03 – 39.93). High-income individuals had more than 1.5 times higher prevalence (50.38%, 95%

CI: 46.52 – 54.24) of NAFLD than low-income individuals (31.14%, 95% CI: 23.53 – 39.93). Interestingly, the prevalence rate of NAFLD was similar among the respondents irrespective of educational attainment. The prevalence ranged between 29% and 36%. NAFLD prevalence was 71.18%, 62.8%, and 40.77% among diabetic, hypertensive, and individuals with family history of liver disease, respectively. Respondents with high BMI (overweight and obesity) have a higher prevalence of NAFLD.

The prevalence of NAFLD by age group and place of residence is presented in Figure 1. We observed that the prevalence of NAFLD increases with increase of age. With the exception of the 35–44 years age group, rural individuals from all other (younger and older) age groups had a higher prevalence of NAFLD than urban individuals. Rural study participants aged 45–54 years had the highest prevalence (58.43%) followed by

**Table 2** Prevalence of NAFLD among adults in Bangladesh by characteristics, Bangladesh 2017

	NAFLD prevalence, % (95% CI)
Gender	
Male	33.82 (31.6 – 36.11)
Female	33.91 (31.15 – 36.78)
Age group	
≤24	9.25 (7.33 – 11.61)
25–34	30.91 (27.95 – 34.04)
35–44	48.72 (44.56 – 52.9)
45–54	55.38 (50.4 – 60.25)
55+	48.37 (42.17 – 54.62)
Place of residence	
Urban	33.00 (31.03 – 35.03)
Rural	36.59 (33.01 – 40.33)
Income	
Low	31.14 (23.53 – 39.93)
Medium	27.1 (24.16 – 30.25)
High	50.38 (46.52 – 54.24)
Education	
No education	35.38 (30.48 – 40.6)
Primary	32.97 (29.69 – 36.43)
Secondary	34.97 (30.94 – 39.22)
Higher secondary	29.44 (25.5 – 33.72)
Higher	36.18 (32.73 – 39.78)
Hypertension	
Yes	62.8 (55.13 – 69.88)
No	34.39 (32.31 – 36.52)
Diabetes	
Yes	71.18 (64.06 – 77.39)
No	33.4 (31.33 – 35.53)
Blood transfusion	
Yes	48.36 (40.52 – 56.28)
No	35.59 (33.5 – 37.73)
Hepatitis B	
Positive	31.69 (24.54 – 39.81)
Negative	33.97 (32.19 – 35.8)
Family history of liver disease	
Yes	40.77 (35.42 – 46.36)
No	32.99 (31.16 – 34.87)
BMI	
Underweight	5.42 (3.34 – 8.67)
Normal	14.47 (12.34 – 16.88)
Overweight	44.05 (41.03 – 47.11)
Obese	63.55 (59.37 – 67.52)

BMI, body mass index; CI, confidence interval; NAFLD, non-alcoholic fatty liver disease.

the 35–44 years (48.46%) and 25–34 years (35.35%) age groups. In subgroup analysis by place of residence, gender, and age group, rural women had a higher prevalence of NAFLD in almost all age groups than any other study participants (Table S1, Supporting information). The prevalence ranged from 16.9% (<24 years) to 69.05% (45–54) years. Figure 2 shows the prevalence of NAFLD by categories of BMI and place of residence. A very sharp increase in NAFLD prevalence was observed with increase of BMI. Overall, overweight and obese individuals had a prevalence of NAFLD of 44.05% and 63.55%, respectively. Underweight subjects also had NAFLD, although

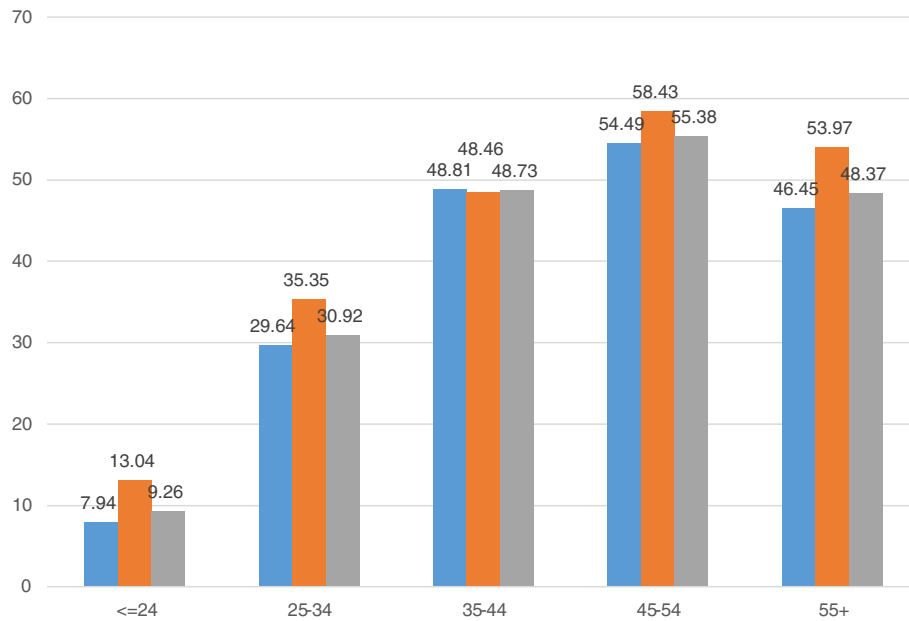
the percentage is very low (5.42%). NAFLD was observed among 14.47% subjects with normal BMI. Similar to the finding regarding age groups, rural women had a higher prevalence of NAFLD than any other BMI categories. We observed the highest prevalence (73.21%) among rural obese women than any other BMI classifications (Table S1).

**Risk factors.** The individuals with NAFLD had significantly higher BMI, SBP, and DBP ( $P < 0.001$ ). Individuals with NAFLD were more likely to have hypertension and diabetes, had a previous blood transfusion, and had a family history of liver disease. Study participants with higher income (55.56% vs 31.97%) and higher education (27.39% vs 24.73%) had a higher likelihood of having NAFLD; however, the level of education was not significant for NAFLD and non-NAFLD groups.

Table 3 shows the risk factors associated with NAFLD from the multivariable logistic regression analysis, with adjusted ORs (AORs) and 95% CIs. Study participants with increasing age, with diabetes and higher BMI (overweight and obesity), and who were married were more likely to have NAFLD. The risk of NAFLD was significantly higher among individuals aged 35–44 years (AOR = 3.00, 95% CI: 1.94–4.63) and those aged 45–54 years (AOR = 4.14, 95% CI: 2.63 – 6.53) compared to individuals younger than 24 years. For individuals with diabetes, the odds of having NAFLD were 2.71 (95% CI: 1.85 – 3.97) times higher than the individuals without diabetes. The odds of having NAFLD was 4.51 (95% CI: 3.47 – 5.86) and 10.71 (95% CI: 7.80 – 14.70) times higher among overweight and obese study participants, respectively, as compared to normal-weight study participants. The analysis also indicated that individuals who were underweight were less prone (AOR = 0.48, 95% CI: 0.27 – 0.85) to have NAFLD compared to normal-weight study participants. In addition, married study participants had a 67% (AOR: 1.67, 95% CI: 1.17 – 2.37) higher chance of having NAFLD as compared to the study participants who were not married. In this study, we used Hosmer and Lemeshow's (H–L) goodness-of-fit test and area under the curve (AUC) using ROC curve to assess our final model. The Hosmer and Lemeshow statistic had a significance of 0.6102, meaning that it was not statistically significant, and therefore, our model is a good fit. In addition, the area under curve of the ROC was found to be 0.82 (Fig. S1), which also indicates a very good prediction of the outcome.

## Discussion

Our study results demonstrated that one in every three individuals in Bangladesh had NAFLD. This result delineates the serious epidemic of NAFLD in the country and highlights the further risk of increasing liver-related morbidity and mortality. The prevalence that we have estimated in this study is higher than that of neighboring countries and the previous reports from Bangladesh.<sup>9,12,23</sup> This is in accordance with the increasing trend of fatty liver globally and also strengthens the existing evidence of increasing NAFLD prevalence in this region.<sup>9,10</sup> However, the neighboring state of West Bengal in India has demonstrated a prevalence to be about 8–9% in a previous study,<sup>12</sup> despite having a similar sociocultural background. Our study explored a higher prevalence of NAFLD that could be explained by the

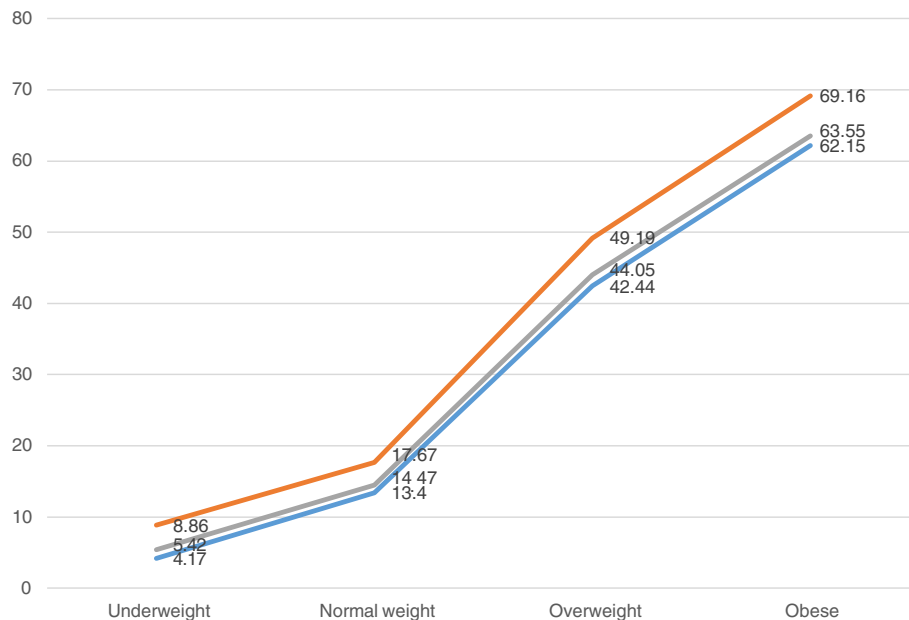


**Figure 1** Prevalence of non-alcoholic fatty liver disease by age group and place of residence. ■, Urban; ■, rural; ■, overall.

global trend of higher prevalence, increasing awareness for sonographic detection for NAFLD, recent economic growth with life-style change, and the religious conservative attitude of rural Bangladeshi women.

Several risk factors for NAFLD have been identified in this study. Individuals with NAFLD were more likely to have hypertension, diabetes, previous blood transfusion, higher income, be married, and have family history of liver disease. We

found that increasing age is a strong and independent risk factor for NAFLD. NAFLD is perceived to be a disease that mainly affects the middle and older age group.<sup>33</sup> But, in our population, an age older than 24 years was an independent predictor of having fatty liver. Prevalence among the 25–34 years age group was 30.91% (95% CI: 27.95 – 34.04), which increases with age. Studies have shown that fatty changes in liver increase with age.<sup>34</sup> We have observed the same trend of amplified prevalence



**Figure 2** Prevalence of non-alcoholic fatty liver disease by body mass index category and place of residence. —, Urban; —, rural; —, overall.

**Table 3** Logistic regression model for fatty liver disease in Bangladesh, 2017

	OR	95% CI	P-value
Age groups			
≤24	Reference		
25–34	2.00	1.35 – 2.94	<0.0001
35–44	3.00	1.94 – 4.63	<0.0001
45–54	4.14	2.63 – 6.53	<0.0001
55+	3.77	2.29 – 6.21	<0.0001
Marital status			
Not married	Reference		
Married	1.67	1.17 – 2.37	0.004
Diabetes			
No	Reference		
Yes	2.71	1.85 – 3.97	<0.0001
BMI			
Underweight	0.48	0.27 – 0.85	0.012
Normal	Reference		
Overweight	4.51	3.47 – 5.86	<0.0001
Obese	10.71	7.80 – 14.70	<0.0001

BMI, body mass index; CI, confidence interval; OR, odds ratio.

with increasing age. Young people aged less than 24 years were much less affected, and the risk increases in each decade of life from 25 to 54 years. Midlife adults aged between 45 and 54 years demonstrated the highest prevalence (55.38%), and the risk decreased among individuals older than 55 years. Previous studies have documented that the average age for NASH is 40–50 years.<sup>17</sup> Prevalence of NAFLD is highest among adults aged 40–60 years in India,<sup>33</sup> and liver-related mortality is the fourth leading cause of death among adults aged 45–54 years in USA.<sup>34</sup> Our findings are also in accordance with those demonstrating that the highest prevalence occurs in adults of 45–54 years. However, this is contrary to the findings of many studies which demonstrated that older individuals are more vulnerable of developing fatty liver disease and its associated complications.<sup>35</sup> However, in our series, prevalence was found to be lower (12.63%) among elderly individuals.

Findings from previous studies confirmed that NAFLD has a profound association with diabetes mellitus and higher BMI (overweight and obesity).<sup>36,37</sup> NAFLD is known as the hepatic component of metabolic syndrome, and stronger evidence demonstrates its association with diabetes mellitus.<sup>38</sup> We have found diabetes to be an independent predictor of having NAFLD (OR: 2.71, 95% CI: 1.85 – 3.97,  $P < 0.0001$ ). In our study, 71.18% of NAFLD cases were observed in subjects with diabetes. This finding confirmed the strong association of diabetes with fatty changes in liver, showing accordance with the previous studies.<sup>36–39</sup>

Patients with NAFLD are typically found to be overweight or obese.<sup>40,41</sup> Our data suggested that subjects with NAFLD are more likely to be overweight and obese, confirming that BMI is an independent predictor of NAFLD.<sup>39</sup> Mean BMI of the participants recruited in our study was 23.87 kg/m<sup>2</sup>, but the participants with NAFLD had a much higher mean BMI (26.61 kg/m<sup>2</sup>). Obese individuals had more than four times higher prevalence (14.47% vs 63.55%) than normal-weight individuals. Logistic regression model showed that ORs for obese groups were

significantly higher (OR: 10.71, 95% CI: 7.80 – 14.70,  $P < 0.0001$ ), indicating obesity to be an independent risk factor for NAFLD. Being overweight is also a significant factor associated with NAFLD. The odds of developing a fatty liver among overweight subjects were 4.51 times higher than normal individuals. Because it was evident that fatty liver is predominant among subjects with elevated BMI, it was believed that underweight subjects are not affected by NAFLD, but our study result revealed that underweight subjects also developed NAFLD, although the percentage is very low (5.42%). NAFLD was even observed among 14.47% subjects with normal BMI. There is emerging but limited evidence that NAFLD may affect lean or normal individuals, especially Asians. In Asian countries, such as South Korea, Japan, and India, the prevalence of NAFLD among lean individuals ranges from 12% to 20%, and our findings are also in accordance with this.<sup>42</sup>

Furthermore, the study results indicated that NAFLD prevalence was 62.8% among hypertensive subjects, although it was not found to be an independent predictor in multivariable analysis. We have identified that women living in the rural areas are at a greater risk of developing NAFLD. Data from various studies suggested that men have a higher predilection for developing NAFLD than women.<sup>43</sup> In our study, overall, both males and females were equally affected ( $P = 0.961$ ) by the fatty changes in liver. However, in rural areas, women were almost 10% more (1.27 times more) prone to developing NAFLD than men. Several hospital-based studies from Bangladesh reported female preponderance of fatty liver in the country.<sup>14,15,17,18</sup> In rural areas, women usually stay at home due to social conservativeness, which causes them to lead a sedentary lifestyle. This might be a cause of female preponderance of NAFLD in rural areas.<sup>17</sup>

Among the three grades of NAFLD, the prevalence of Grade I (26.10%) was higher in Bangladesh. Although this condition is benign, there may be significant changes in liver, to NASH or cirrhosis, if Grade I progresses to further stages.<sup>44,45</sup> Finally, it was demonstrated in the present study that married individuals are at greater risk of developing NAFLD. ORs were found to be significantly higher among those who were married (OR: 1.67, 95% CI: 1.17 – 2.37,  $P < 0.0001$ ), but there is no evidence supporting this finding, and that is why we could not elucidate any justification. It could be explained as follows: in south Asian populations, marriage is usually associated with 'settling down in life', having a job, and having a living with a regular source of income. The cultural practice in south Asians is usually to get married when they have a regular source of income, and this may be one reason for a lifestyle where they have access to excess calorie intake and lower physical activity, leading to a higher prevalence in married individuals. Blood transfusion was not associated with HCV infection in this series. So, it could not explain the association of NAFLD with blood transfusion.

The strength of this study includes the large sample size, which included both the urban and rural population of Bangladesh. Our study has several limitations as well. We have diagnosed NAFLD on the basis of ultrasonographic findings, which were not confirmed by liver biopsy, the gold standard for diagnosing NAFLD. However, USG is noninvasive and is certainly the most common method for diagnosing NAFLD in clinical practice. It has very high sensitivity and specificity for detecting hepatic steatosis, which may vary from 60% to 94%

and 88% to 95%, respectively.<sup>46</sup> Several studies have suggested that, due to the obvious sensitivity and specificity of simple ultrasound, liver biopsy is hardly ever required to diagnose NAFLD.<sup>47,48</sup>

In conclusion, the results of this study demonstrate that about one-third population of Bangladesh is affected by NAFLD, and the prevalence is higher than neighboring countries, putting this population at an increased risk of liver-related morbidity and mortality. Early to midlife adults; diabetic, overweight, and obese individuals; rural women; and married individuals are at a greater risk of developing NAFLD than others. Young and nonobese individuals are not also spared by NAFLD. Modifiable risk factors identified in this study might help to develop feasible interventions for the early detection and management of NAFLD. In addition, it will lead to the development and implementation of national programs to prevent NAFLD and control its associated risk factors.

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## Supporting information

Additional supporting information may be found in the online version of this article at the publisher's website:

**Table S1.** Prevalence of non-alcoholic fatty liver disease by gender and place of residence, Bangladesh 2017.

**Figure S1.** Receiver operating characteristic curve.