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Original Article

To Study on Non-Alcoholic Fatty Liver Disease and Its Association with Obesity among Adult Coal Miners Aged 18 Years and Above in Jharkhand: A Cross-Sectional Study

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ABSTRACT

Background: Non-alcoholic fatty liver disease (NAFLD) is now the commonest chronic liver disorder worldwide and is closely linked with obesity, diabetes and metabolic syndrome. Coal miners work under heavy physical load, shift duty and dust exposure, yet very little is known about their liver health. This study estimated the prevalence of NAFLD and examined its association with obesity among adult coal miners of Jharkhand. **Methods**: A hospital-and-field based cross-sectional study was conducted among 172 coal miners aged 18 years and above over six months. The sample size was calculated using the formula $n = Z^2pq/d^2$. A two-stage random sampling method was used. Data were collected through a structured questionnaire, anthropometric measurements, blood pressure recording, fasting blood tests and ultrasonography of the abdomen. Obesity was defined as body mass index (BMI) of 25 kg/m² or more using Asian-Indian criteria. Persons with significant alcohol intake, viral hepatitis or hepatotoxic drug use were excluded. Data were analysed using SPSS; chi-square test and odds ratio (OR) with 95% confidence interval (CI) were applied, and $p<0.05$ was considered significant. **Results**: The mean age of participants was 38.9 ± 10.4 years and 91.9% were men. The prevalence of NAFLD was 36.0% (95% CI 28.9–43.2). Prevalence rose from 15.8% in the 18–29 year group to 50.0% in those aged 50 years and above ($p = 0.004$). NAFLD was present in 59.4% of obese miners and 22.2% of non-obese miners. Obesity was strongly associated with NAFLD (OR 5.12; 95% CI 2.61–10.04; $p<0.001$). Central obesity, diabetes, dyslipidaemia, sedentary lifestyle, hypertension, age of 40 years or more and service of 10 years or more were also significantly associated. Among NAFLD cases, 50.0% had metabolic syndrome and 3.2% had suspected cirrhosis. **Conclusion**: More than one in three coal miners had NAFLD, and obesity was the strongest modifiable risk factor. Periodic liver screening, weight control and lifestyle counselling should be built into occupational health programmes for miners.

Keywords: NAFLD, fatty liver, obesity, coal miners, Jharkhand, prevalence, odds ratio.

INTRODUCTION

Non-alcoholic fatty liver disease (NAFLD) is defined by excess fat accumulation in more than 5% of hepatocytes in a person who does not consume harmful amounts of alcohol and has no other cause of liver fat [1,4]. It covers a wide spectrum, from simple steatosis to non-alcoholic steatohepatitis (NASH), fibrosis, cirrhosis and hepatocellular carcinoma. Recently, an international expert panel has proposed the term metabolic dysfunction-associated fatty liver disease to highlight the metabolic origin of the condition [3].

The global burden is large. A meta-analysis estimated that about one quarter of the world's adult population has NAFLD, with the highest rates in the Middle East and South America [1]. The disease is expected to increase further as obesity and type 2 diabetes continue to rise [2]. Asian countries are no exception; the epidemic of obesity in Asia has pushed the

prevalence of fatty liver to levels seen in Western nations, even though the average body mass index (BMI) in Asia is lower [10].

In India, the prevalence of NAFLD in the general population has been reported between 9% and 53%, depending on the study population and the method of diagnosis [5,9]. Community-based studies from Mumbai, coastal Odisha and rural Haryana have reported prevalence of roughly 16% to 32% [6,7,8]. Indian patients develop fatty liver at lower BMI and smaller waist circumference than Western patients, because of greater visceral fat and insulin resistance [5,9]. For this reason, lower BMI cut-offs are recommended for Asians, with 23 kg/m² indicating overweight and 25 kg/m² indicating obesity [20,21].

NAFLD is not a harmless condition. Although most patients have simple steatosis, a proportion progresses to steatohepatitis and fibrosis [11,12]. NAFLD is closely tied to the metabolic syndrome [13], and it increases the risk of cardiovascular disease [14] and type 2 diabetes [15]. Fibrosis stage is the strongest predictor of liver-related and overall mortality [16,17]. Obesity is the most important factor behind NAFLD. Excess body fat, especially visceral fat, leads to insulin resistance, increased free fatty acid flux to the liver and chronic low-grade inflammation, all of which favour fat deposition and liver injury [10,13]. A large share of patients with NAFLD are overweight or obese, and the risk increases steadily with rising BMI.

Occupational factors may add to this risk. Exposure to certain industrial toxicants, heavy metals and solvents has been linked with fatty liver and toxicant-associated steatohepatitis [18,19]. Coal mining is a physically demanding occupation, but it also involves long shift work, irregular meals, limited recreational exercise and exposure to coal dust and metals. Many miners also move to sedentary routines or high-calorie diets once they are on stable salaries. Jharkhand is one of India's major coal-producing states, and a large workforce depends on this industry. Despite this, hardly any study has examined fatty liver among coal miners. Occupational health services in mines concentrate on respiratory diseases, injuries and hearing loss, while metabolic liver disease remains largely unnoticed.

Therefore, this study was undertaken to estimate the prevalence of NAFLD among adult coal miners in Jharkhand and to find out its association with obesity and other risk factors.

OBJECTIVES

2.1 Primary objectives

- To estimate the prevalence of non-alcoholic fatty liver disease (NAFLD) among coal miners aged 18 years and above in Jharkhand.
- To determine the association between obesity and NAFLD in the study population.

2.2 Secondary objectives

- To describe the sociodemographic profile of the participants.
- To assess the age-wise distribution of NAFLD.
- To identify other risk factors and associated complications of NAFLD.
- To suggest suitable management and preventive measures for affected miners.

METHODOLOGY

3.1 Study design, setting and period

This was a cross-sectional, observational study carried out among coal miners working in selected mining areas of Jharkhand. The study was conducted over six months, including participant enrolment, clinical examination, laboratory testing and ultrasonography.

3.2 Study population

All male and female coal mine workers aged 18 years and above, with at least one year of service, who gave written informed consent, were eligible for inclusion. Workers with alcohol intake above 30 g/day for men or 20 g/day for women, positive hepatitis B surface antigen or anti-HCV antibody, history of drugs known to cause fatty liver (such as steroids, methotrexate, tamoxifen and amiodarone), known chronic liver disease, or pregnancy were excluded.

3.3 Sample size calculation

The sample size was calculated by the formula for a single proportion in a cross-sectional study:

$$\mathbf{n = Z^2 \times p \times q / d^2}$$

where Z = 1.96 (standard normal deviate at 95% confidence level), p = expected prevalence of NAFLD, q = 1 − p, and d = absolute precision. Taking the expected prevalence as 30% (based on Indian studies in adult populations), and absolute precision of 7%:

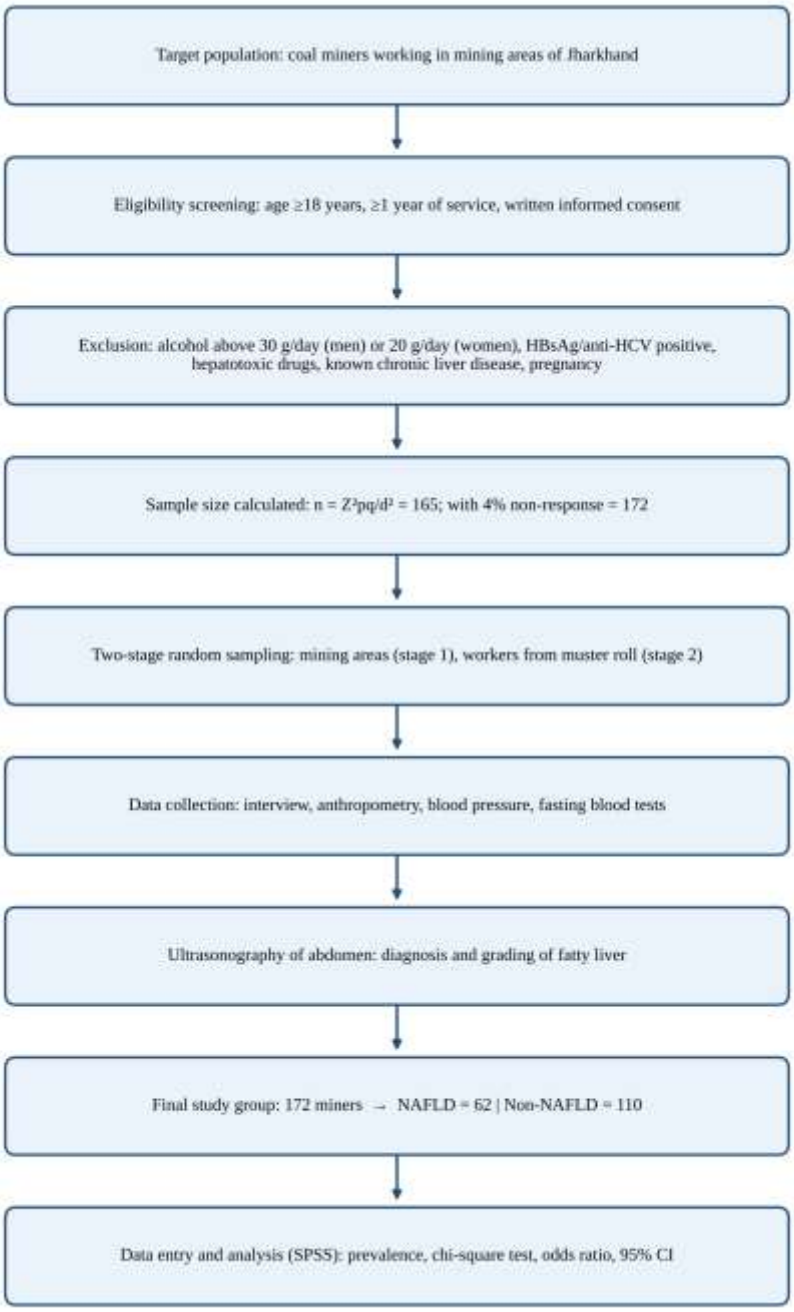
$$n = (1.96)^2 \times 0.30 \times 0.70 / (0.07)^2 = 3.8416 \times 0.21 / 0.0049 = 164.6 \approx 165$$

After allowing for a 4% non-response or incomplete data, the adjusted sample size was 165 / (1 − 0.04) = 171.9, which was rounded off to 172. Thus, a final sample of 172 coal miners was studied.

3.4 Method of sampling

A two-stage random sampling technique was followed. In the first stage, the coal mining areas of Jharkhand were listed, and the required number of mining units was selected by simple random sampling (lottery method). In the second stage, a list of eligible workers was prepared from the muster roll of each selected unit, and the participants were chosen by simple random sampling using a computer-generated random number table. The number of workers from each unit was fixed by proportionate allocation to the size of its workforce. If a selected worker was absent or unwilling, the next number on the random list was taken. The steps of the study are shown in Figure 1.

Figure 1. Flow chart showing the methodology of the study



3.5 Data collection

A pre-tested, structured questionnaire was used to obtain information on age, sex, education, marital status, type of mining work, years of service, tobacco and alcohol use, dietary habits, physical activity and history of diabetes, hypertension or other illness. Physical activity was classified as sedentary if the worker did not engage in at least 150 minutes of moderate activity per week outside work duties.

Height was measured with a stadiometer to the nearest 0.1 cm and weight with a calibrated digital scale to the nearest 0.1 kg. BMI was calculated as weight in kilograms divided by height in metres squared. Obesity was defined as BMI of 25 kg/m² or more, and overweight as 23.0 to 24.9 kg/m², following Asian-Indian criteria. Waist circumference was measured at the midpoint between the lower rib margin and iliac crest, and central obesity was taken as more than 90 cm in men and more than 80 cm in women. Blood pressure was recorded twice after five minutes of rest, and the average was used.

After overnight fasting of 8 to 12 hours, venous blood was collected for fasting plasma glucose, lipid profile, liver enzymes (ALT, AST), platelet count, HBsAg and anti-HCV. Diabetes or impaired fasting glucose was defined as fasting glucose of 100 mg/dL or more or a known history of diabetes. Dyslipidaemia was defined as triglycerides of 150 mg/dL or more, or low HDL cholesterol. Metabolic syndrome was diagnosed using the criteria modified for Asian Indians.

3.6 Diagnosis of NAFLD

Ultrasonography of the abdomen was done by a trained radiologist, who was unaware of the BMI and laboratory results of the participant. NAFLD was diagnosed when there was a bright hepatic echo pattern, greater echogenicity compared with the kidney, vascular blurring or deep attenuation of the ultrasound beam, after excluding other causes of fatty liver. Steatosis was graded as mild (grade 1), moderate (grade 2) or severe (grade 3). Fibrosis risk was estimated by the FIB-4 index, calculated from age, AST, ALT and platelet count.

3.7 Statistical analysis

Data were entered in Microsoft Excel and analysed with SPSS software. Categorical variables were expressed as numbers and percentages, and continuous variables as mean ± standard deviation. Prevalence was reported with 95% confidence interval. The chi-square test was used to compare proportions. The association between NAFLD and each risk factor was measured by the odds ratio with 95% CI. A p value below 0.05 was considered statistically significant.

3.8 Ethical considerations

The study was started after approval from the Institutional Ethics Committee and permission from the mine management. The purpose of the study was explained in simple Hindi, and written informed consent was obtained from every participant. Confidentiality of data was maintained, and all participants found to have fatty liver or other abnormalities were counselled and referred for further care free of cost.

RESULTS

A total of 172 coal miners participated, with a response rate of 100% after replacement of the absentees as described. The mean age was 38.9 ± 10.4 years, and the mean BMI was 23.8 ± 3.9 kg/m².

4.1 Sociodemographic profile

Table 1 presents the sociodemographic profile. The largest age group was 30–39 years (30.2%), and most participants were male (91.9%) and married (81.4%). About 37% had secondary education, and 16.3% were illiterate. Underground work was reported by 43.0% of miners, and nearly half (48.8%) had served for ten years or more.

Table 1. Sociodemographic characteristics of the participants and prevalence of NAFLD (n = 172)

Variable	Total n	%	NAFLD n	NAFLD prevalence (%)
Age group (years)				
18–29	38	22.1	6	15.8
30–39	52	30.2	16	30.8
40–49	46	26.7	22	47.8
≥50	36	20.9	18	50.0
Sex				
Male	158	91.9	58	36.7
Female	14	8.1	4	28.6
Educational status				
Illiterate	28	16.3	12	42.9
Primary	52	30.2	22	42.3
Secondary	64	37.2	22	34.4
Graduate and above	28	16.3	6	21.4

Variable	Total n	%	NAFLD n	NAFLD prevalence (%)
Marital status				
Married	140	81.4	54	38.6
Unmarried	28	16.3	6	21.4
Widowed/separated	4	2.3	2	50.0
Type of mine work				
Underground	74	43.0	30	40.5
Opencast	68	39.5	24	35.3
Surface/other duties	30	17.4	8	26.7
Years of service				
<5	42	24.4	8	19.0
5–9	46	26.7	16	34.8
10–19	50	29.1	22	44.0
≥20	34	19.8	16	47.1

Prevalence is calculated within each category.

4.2 Prevalence of NAFLD

Of 172 miners, 62 had NAFLD on ultrasonography, giving an overall prevalence of 36.0% (95% CI 28.9–43.2). The remaining 110 miners (64.0%) did not have fatty liver. Prevalence was slightly higher among men (36.7%) than women (28.6%), but this difference was not statistically significant. It was highest among underground workers (40.5%) and among those with 10 or more years of service (45.2%).

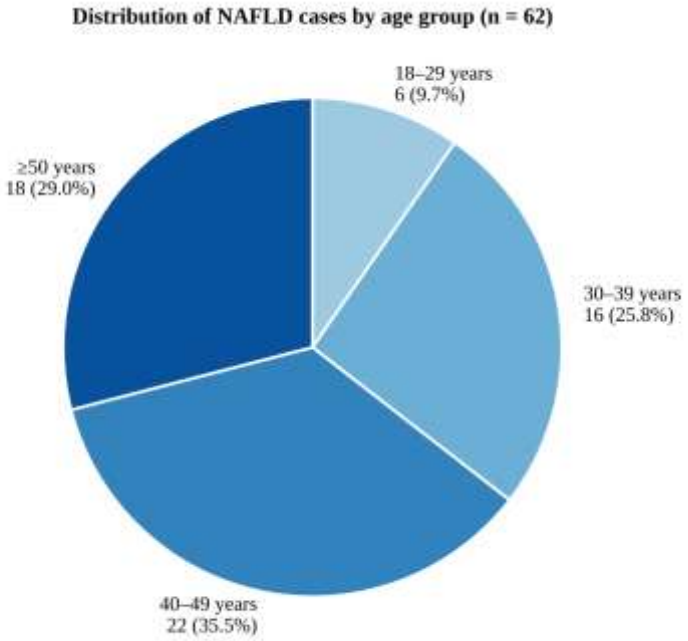
4.3 Prevalence of NAFLD according to age group

Prevalence of NAFLD increased with advancing age, from 15.8% in the youngest group to 50.0% among miners aged 50 years and above ($\chi^2 = 13.1$, df = 3, p = 0.004), as shown in Table 2. Figure 2 shows the share of each age group among the 62 NAFLD cases. The 40–49 year group contributed the largest share (35.5%), followed by those aged 50 years and above (29.0%) and the 30–39 year group (25.8%). Only 9.7% of cases were below 30 years of age.

Table 2. Age-wise prevalence of NAFLD

Age group (years)	Examined (n)	NAFLD cases (n)	Prevalence (%)
18–29	38	6	15.8
30–39	52	16	30.8
40–49	46	22	47.8
≥50	36	18	50.0
Total	172	62	36.0

Figure 2. Pie chart showing age-wise distribution of NAFLD cases



4.4 Body mass index and obesity

According to Asian-Indian cut-offs, 64 miners (37.2%) were obese and 32 (18.6%) were overweight, while 64 (37.2%) had normal BMI and 12 (7.0%) were underweight. The prevalence of NAFLD showed a clear gradient with BMI, rising from 12.5% in the normal weight group to 46.9% in the overweight group and 59.4% in the obese group (Table 3).

Table 3. Distribution of NAFLD according to BMI category

BMI category (Asian-Indian cut-offs)	Total n (%)	NAFLD n (row %)	Non-NAFLD n
Underweight (<18.5 kg/m²)	12 (7.0)	1 (8.3)	11
Normal (18.5–22.9)	64 (37.2)	8 (12.5)	56
Overweight (23.0–24.9)	32 (18.6)	15 (46.9)	17
Obese (≥25.0)	64 (37.2)	38 (59.4)	26

4.5 Risk factors

Table 4 compares the common risk factors between miners with and without NAFLD. Obesity, central obesity, sedentary lifestyle, diabetes or impaired fasting glucose, dyslipidaemia and hypertension were all more frequent among the NAFLD group. For example, 58.1% of NAFLD cases had a sedentary lifestyle against 30.9% of non-cases, and 71.0% of cases had central obesity against 30.9% of non-cases. Tobacco use was reported by 58.1% of cases and 47.3% of non-cases.

Table 4. Risk factors among miners with and without NAFLD

Risk factor	NAFLD (n = 62) n (%)	Non-NAFLD (n = 110) n (%)
Obesity (BMI ≥25 kg/m²)	38 (61.3)	26 (23.6)
Age ≥40 years	40 (64.5)	42 (38.2)
Central obesity	44 (71.0)	34 (30.9)
Sedentary lifestyle	36 (58.1)	34 (30.9)
Type 2 diabetes/impaired fasting glucose	22 (35.5)	12 (10.9)
Dyslipidaemia (high TG/low HDL)	34 (54.8)	24 (21.8)
Hypertension	26 (41.9)	20 (18.2)
Tobacco use	36 (58.1)	52 (47.3)

Risk factor	NAFLD (n = 62) n (%)	Non-NAFLD (n = 110) n (%)
Service ≥10 years	38 (61.3)	46 (41.8)

4.6 Complications and associated conditions

On ultrasonography, 34 of the 62 cases (54.8%) had grade 1, 20 (32.3%) had grade 2 and 8 (12.9%) had grade 3 fatty liver. Raised liver enzymes were found in 46.8% of cases. Half of the cases fulfilled the criteria for metabolic syndrome. Dyslipidaemia (54.8%), hypertension (41.9%) and diabetes or impaired fasting glucose (35.5%) were common. A FIB-4 score of 1.3 or more, suggesting a risk of significant fibrosis, was seen in 22.6% of cases, and two patients (3.2%) were suspected to have early cirrhosis on imaging and were referred to a gastroenterologist. No case of hepatocellular carcinoma was detected (Table 5).

Table 5. Severity, complications and associated conditions among NAFLD cases (n = 62)

Complication/associated condition	NAFLD cases n	Percentage (%)
Grade 1 steatosis (mild)	34	54.8
Grade 2 steatosis (moderate)	20	32.3
Grade 3 steatosis (severe)	8	12.9
Raised ALT and/or AST	29	46.8
Metabolic syndrome	31	50.0
Dyslipidaemia	34	54.8
Type 2 diabetes/impaired fasting glucose	22	35.5
Hypertension	26	41.9
FIB-4 score ≥1.3 (risk of significant fibrosis)	14	22.6
Gallstones on ultrasonography	5	8.1
Suspected cirrhosis	2	3.2
Hepatocellular carcinoma	0	0.0

Categories are not mutually exclusive, except the three grades of steatosis.

4.7 Association between obesity and NAFLD

Obesity showed the strongest association with NAFLD. The calculation from the 2 × 2 table (Table 6) is simple: the odds of NAFLD among obese miners were 38/26 = 1.46, and among non-obese miners 24/84 = 0.29. The odds ratio is therefore 1.46 / 0.29 = 5.12 (95% CI 2.61–10.04; $p<0.001$). In other words, obese miners had about five times higher odds of having fatty liver than non-obese miners.

Table 6. Two-by-two table for obesity and NAFLD

Obesity status	NAFLD present	NAFLD absent	Total
Obese (BMI ≥25)	38	26	64
Non-obese (BMI <25)	24	84	108
Total	62	110	172

Table 7 shows the odds ratios of all the studied factors. Besides obesity, central obesity (OR 5.46), diabetes or impaired fasting glucose (OR 4.49), dyslipidaemia (OR 4.35), hypertension (OR 3.25), sedentary lifestyle (OR 3.10), age of 40 years or more (OR 2.94) and service of 10 years or more (OR 2.20) were significantly associated with NAFLD. Tobacco use was not significantly associated (OR 1.54; 95% CI 0.82–2.89).

Table 7. Odds ratio analysis of risk factors for NAFLD

Variable	Exposed NAFLD/Total	Unexposed NAFLD/Total	OR	95% CI	p value
Obesity (BMI ≥25 kg/m²)	38/64	24/108	5.12	2.61–10.04	<0.001
Age ≥40 years	40/82	22/90	2.94	1.54–5.62	0.001
Central obesity	44/78	18/94	5.46	2.76–10.80	<0.001

Variable	Exposed NAFLD/Total	Unexposed NAFLD/Total	OR	95% CI	p value
Sedentary lifestyle	36/70	26/102	3.10	1.62–5.91	0.001
Type 2 diabetes/IFG	22/34	40/138	4.49	2.03–9.93	<0.001
Dyslipidaemia	34/58	28/114	4.35	2.22–8.54	<0.001
Hypertension	26/46	36/126	3.25	1.61–6.54	0.001
Tobacco use	36/88	26/84	1.54	0.82–2.89	0.18
Service ≥10 years	38/84	24/88	2.20	1.17–4.16	0.015

OR = odds ratio; CI = confidence interval; IFG = impaired fasting glucose. An OR above 1 with a CI that does not include 1 indicates a significant association.

4.8 Management of NAFLD

All 62 miners with NAFLD received counselling and a management plan. At present, the cornerstone of treatment is lifestyle modification, and drug therapy is limited to selected patients. The plan followed is described below.

- **Weight reduction.** Gradual loss of 7% to 10% of body weight is the most effective measure, as it reduces liver fat, inflammation and, in many patients, even fibrosis. A loss of about 0.5 to 1 kg per week was advised. Rapid weight loss was discouraged because it can worsen liver injury.
- **Dietary advice.** Patients were advised a low-calorie, balanced diet, with a daily deficit of 500 to 1000 kcal. Intake of sugar-sweetened drinks, sweets, fried snacks, refined flour and processed food was to be reduced. Whole grains, pulses, vegetables, fruits, nuts and locally available foods cooked in limited mustard or other vegetable oil were encouraged. Regular meal timing, even during night shifts, and avoidance of heavy late-night meals were stressed.
- **Physical activity.** At least 150 to 300 minutes of moderate exercise per week, such as brisk walking, cycling or yoga, was advised, together with two sessions of resistance exercise. Exercise reduces liver fat even without weight loss. Miners with sedentary surface duties were advised short walking breaks.
- **Avoidance of alcohol and tobacco.** Complete abstinence from alcohol was recommended because even moderate intake may accelerate fibrosis. Tobacco cessation support was provided.
- **Treatment of associated conditions.** Diabetes, hypertension and dyslipidaemia were treated according to standard guidelines. Statins are safe in fatty liver and were used where indicated for cardiovascular protection. Drugs with potential liver toxicity were reviewed.
- **Pharmacotherapy.** No drug was given merely for steatosis. In patients with biopsy-proven or highly suspected steatohepatitis, vitamin E (800 IU/day) may be considered in those without diabetes, and pioglitazone in those with diabetes, under specialist supervision. Newer agents such as GLP-1 receptor agonists may help patients with obesity and diabetes, and are decided by the treating physician.
- **Bariatric surgery.** This was reserved for patients with severe obesity who failed to respond to lifestyle measures, as per specialist advice.
- **Monitoring and referral.** Patients with raised FIB-4 score or suspected cirrhosis were referred for elastography and gastroenterology consultation. Others were advised repeat liver enzymes, glucose and lipid tests and ultrasonography every 6 to 12 months. Cirrhosis patients need endoscopy for varices and six-monthly ultrasound surveillance for liver cancer.
- **Preventive measures.** Hepatitis A and B vaccination was advised for non-immune patients, and workplace measures such as healthy canteen food, exercise facilities and periodic health check-ups were suggested to the mine management.

DISCUSSION

This study evaluated the prevalence of NAFLD and its link with obesity among 172 adult coal miners in Jharkhand. The overall prevalence was 36.0%, which means that more than one in three miners had fatty liver. This is higher than the global estimate of about 25% [1] and is also above the pooled prevalence of about 30% reported for Asia [10], though within the wide range of 9% to 53% described for India [5,9]. Community studies in India have found lower values of 16% to 32% [6,7,8]. The higher figure in the present study may be related to the occupational setting, with long shift work, irregular diet and low leisure-time activity, and to the use of ultrasonography as a sensitive screening tool. It should be noted that miners are often thought to be physically fit because of heavy manual work; our findings show that this assumption does not protect them from metabolic liver disease.

The prevalence of NAFLD increased significantly with age, from 15.8% in the 18–29 year group to 50.0% among those aged 50 years and above. Similar age-related trends were reported in Italian and American population studies [23,24] and in rural Haryana [8]. Ageing is accompanied by accumulation of visceral fat, decline in muscle mass, and increasing insulin resistance, which explain this pattern [25]. However, a notable finding is that one in six young miners (15.8%) already had

fatty liver, and nearly 10% of all cases were below 30 years. This shows that screening should not be confined to middle-aged workers.

Obesity was strongly associated with NAFLD in this study. The odds of fatty liver were more than five times higher in obese than non-obese miners, and the prevalence showed a graded rise from 12.5% in normal weight to 59.4% in the obese. This is consistent with the observations of Bellentani and colleagues, who found that hepatic steatosis was present in a majority of obese individuals [23], and with Asian data showing that obesity is the main driver of the NAFLD epidemic [10,22]. The mechanism is believed to involve insulin resistance, increased lipolysis in visceral fat and delivery of free fatty acids to the liver [13,25]. Our finding that central obesity had a slightly higher odds ratio than BMI-defined obesity supports the view that visceral fat is more harmful than total body weight, especially in Asian Indians [5,21]. It also emphasises the value of measuring waist circumference during routine check-ups. Notably, 12.5% of miners with normal BMI also had fatty liver, which reminds us of the concept of lean NAFLD in Asians [22].

Other metabolic factors were also significantly associated with NAFLD, namely diabetes or impaired fasting glucose, dyslipidaemia and hypertension. This agrees with the well-known association of NAFLD with the metabolic syndrome [13,25], and with evidence that diabetes is both a risk factor for and a consequence of fatty liver [15,36]. Half of our NAFLD cases had metabolic syndrome. Because NAFLD also increases cardiovascular risk [14], these miners need attention to their heart health along with liver care. A sedentary lifestyle was associated with a threefold increase in the odds of NAFLD. Poor physical activity and unhealthy dietary patterns are known contributors [26,27], and they may be relevant even in miners, since modern mining relies on machines and many workers have surface or supervisory duties.

Years of service of ten or more and underground work were linked with a higher prevalence. Age may partly explain the first relationship, but occupational exposures could also play a role. Environmental toxicants, including metals and organic pollutants, have been related to liver fat accumulation and steatohepatitis [18,19]. The present study design cannot separate these effects, and further studies measuring exposure are needed. Tobacco use was not significantly associated, in keeping with the limited and inconsistent evidence on smoking and fatty liver.

Regarding severity and complications, most cases had mild steatosis, but 12.9% had severe steatosis, and nearly one in four had a FIB-4 score suggesting a risk of significant fibrosis. The severity of ultrasound findings is known to reflect the degree of metabolic syndrome and visceral fat [32]. The identification of two miners with suspected cirrhosis is clinically important, because fibrosis stage is the strongest predictor of liver-related death in NAFLD [16,17]. These findings show that a subset of affected workers may already be at risk of advanced disease, while remaining without symptoms.

The management strategy applied in this study is in line with current guidelines, which recommend lifestyle intervention and weight loss as first-line treatment [4,22]. Weight loss of 7% to 10% has been shown to improve steatohepatitis and fibrosis [28,29], and exercise reduces liver fat independent of weight change [27]. Vitamin E and pioglitazone have shown histological benefit in selected patients [30], while bariatric surgery has improved liver histology in morbidly obese patients [31]. For a working population like miners, interventions have to be practical and integrated with workplace routines, which is why employer involvement is vital.

Strengths and limitations

The strengths of this study include random sampling, an adequately calculated sample size, use of Asian-specific BMI criteria and exclusion of alcohol and viral causes of liver disease. Being the first study on this occupational group in Jharkhand, it fills a gap in literature. There are some limitations. The cross-sectional design does not establish the temporal order between obesity and NAFLD. Ultrasonography is less sensitive when liver fat is below 20% to 30% [33], so some mild cases may have been missed, whereas liver biopsy, the gold standard, was not feasible [35]. FIB-4 is only a non-invasive estimate of fibrosis [34]. Alcohol intake was self-reported and may be underestimated, and dietary intake was not quantified. The small number of women limits conclusions about sex differences, and the results may not apply to all mining regions of India.

CONCLUSION

About 36% of adult coal miners in this study had NAFLD, and its prevalence rose steadily with age. Obesity, particularly central obesity, was the strongest factor linked with fatty liver, with obese miners having over five times higher odds than non-obese miners. Diabetes, dyslipidaemia, hypertension, sedentary lifestyle and longer service were additional risk factors. A sizeable number of cases had metabolic syndrome or signs of possible fibrosis. NAFLD should therefore be recognised as an important occupational health problem among miners, and simple, early measures can prevent progression to advanced liver disease.

RECOMMENDATIONS

Periodic health check-ups of miners should include BMI, waist circumference, blood pressure, blood glucose, lipid profile and liver enzymes, with ultrasonography for those at high risk. Miners with obesity, diabetes or metabolic syndrome should be screened for NAFLD and fibrosis using FIB-4 and referred for elastography if the score is raised. Mine managements

should arrange health education, nutritious canteen meals, yoga and exercise facilities, and shift schedules that permit regular meals and rest. Weight reduction of 7% to 10% through diet and exercise should be promoted as the first-line approach, with follow-up by the occupational health physician. Tobacco and alcohol cessation programmes should be included in workplace health services. Large multicentric cohort studies with fibro scan or biopsy confirmation and measurement of occupational exposures are recommended to establish causality.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest regarding the conduct or publication of this study.

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SUBMISSION DECLARATION

We declare that this work is original, has not been published previously, and is not under consideration for publication elsewhere. Its publication is approved by all authors and by the responsible authorities where the work was carried out. The manuscript is written in the authors' own words, and all sources have been duly acknowledged. Informed consent was obtained from all participants, and ethical clearance was obtained from the Institutional Ethics Committee before the start of the study. If accepted, the article will not be published elsewhere in the same form, in English or in any other language, without the written consent of the copyright holder.

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