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Prevalence of Type 2 Diabetes Mellitus among Coal Miners in Jharkhand, Its Most Important Complications and Clinical Management: A Cross-Sectional Study

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ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) is increasing rapidly in India, but occupational groups are rarely studied. Coal miners work in dust-laden environments, follow rotating shifts and are often exposed to irregular meals and growing mechanisation. Jharkhand has one of the largest coal-mining workforces in the country, yet local data on diabetes in miners are scanty. Objectives: To estimate the prevalence of T2DM among coal miners of Jharkhand, to identify associated risk factors, to document the commonest complications and to describe the clinical management of the affected miners. **Methods**: A cross-sectional study was carried out among 188 serving coal miners aged 20 years and above, selected by multistage random sampling from collieries of four coal-bearing districts. The sample size was calculated using the formula $n = Z^2pq/d^2$. Data were collected through a pre-tested questionnaire, anthropometry, blood pressure measurement, fasting and post-prandial plasma glucose, HbA1c and screening for complications. Diabetes was defined by American Diabetes Association criteria. Chi-square test and odds ratios with 95% confidence intervals were used for analysis. **Results**: The mean age of the miners was 41.3 ± 9.6 years and 91.0% were men. T2DM was present in 31 of 188 miners, giving a prevalence of 16.5% (95% CI 11.2–21.8%); 38.7% of these cases were newly detected. Age 40 years or above, family history, overweight/obesity, hypertension, sedentary lifestyle and more than 10 years of service were significantly associated with T2DM. Among diabetic miners, 67.7% had at least one complication; peripheral neuropathy (35.5%) was the commonest, followed by retinopathy (22.6%), nephropathy (19.4%) and recurrent infections (19.4%). **Conclusion**: Nearly one in six coal miners had T2DM, and two-thirds of them already had complications. Workplace-based screening, structured lifestyle counselling and regular complication surveillance should be built into occupational health services of coal companies.

Keywords: Type 2 diabetes mellitus; coal miners; Jharkhand; prevalence; complications; clinical management; occupational health.

INTRODUCTION

Diabetes mellitus has become one of the fastest-growing non-communicable diseases of this century. The International Diabetes Federation estimated that around 463 million adults were living with diabetes in 2019, and this number rose to about 537 million in 2021 [1,2]. The majority of them have type 2 diabetes mellitus (T2DM), and the steepest rise is expected in low- and middle-income countries, particularly in Asia [3,4].

India carries a very large share of this burden. The ICMR-INDIAB study estimated that about 101 million Indians had diabetes and 136 million had prediabetes in 2021 [5]. The earlier phase of the same study showed wide differences between states, with lower prevalence in less urbanised and economically weaker states, including Jharkhand, than in the more developed ones [6]. Rapid urbanisation, changing diet, falling physical activity and a strong genetic predisposition of Asian Indians are the usual explanations for this epidemic [7,8,9].

Occupation is an important but under-studied determinant of metabolic health. Jharkhand holds a large share of the country's coal reserves, and districts such as Dhanbad, Bokaro, Ramgarh and Hazaribagh depend heavily on mining. Coal miners are exposed to dust, noise, heat and vibration, and they work in long and rotating shifts, often with irregular meals. Coal dust is best known for causing pneumoconiosis [10], but fine particulate matter is also linked with cardiovascular disease and with an increased risk of diabetes [11,12,13]. Night and rotating shift work disturbs the circadian rhythm and has been associated with a higher risk of T2DM [14,15]. At the same time, mechanisation of mines has reduced manual labour, so that many workers now spend long hours in sedentary tasks such as operating machines and driving heavy vehicles.

The complications of diabetes decide the outcome of the disease. Retinopathy, neuropathy, nephropathy, coronary artery disease and diabetic foot disease account for most of the disability and cost related to diabetes, and good control of glucose and blood pressure reduces these risks significantly [16,17,18]. In a mining environment, neuropathy and foot problems can cause falls and injuries, poor vision endangers the worker and his colleagues, and hypoglycaemia during a shift can be dangerous. Early detection and proper management are therefore important for the worker as well as for workplace safety. Despite this, very few studies from the coal belt of Jharkhand have described how common diabetes is among miners, what complications they already have and how well they are managed. The present study was planned to fill this gap.

OBJECTIVES

2.1 General objective

To study the prevalence of type 2 diabetes mellitus among coal miners in Jharkhand, its most important complications and its clinical management.

2.2 Specific objectives

1. To estimate the prevalence of type 2 diabetes mellitus among coal miners.
2. To describe the sociodemographic and occupational profile of the study participants.
3. To identify risk factors associated with type 2 diabetes mellitus and measure the strength of association by odds ratio.
4. To determine the pattern and frequency of diabetic complications among diabetic miners.
5. To describe the clinical management, glycaemic control and follow-up status of the diabetic miners.

METHODOLOGY

3.1 Study design and setting

This was a descriptive, institution- and workplace-based cross-sectional study conducted over twelve months, from June 2020 to June 2021, among serving coal miners working in collieries of four coal-bearing districts of Jharkhand, namely Dhanbad, Bokaro, Ramgarh and Hazaribagh. Clinical examination and laboratory investigations were carried out in the colliery hospitals and dispensaries with the permission of the respective management.

3.2 Study population

The study population consisted of male and female coal miners aged 20 years and above with at least one year of service. Miners who were seriously ill, pregnant women, those with known type 1 diabetes or secondary diabetes (for example, pancreatic disease), persons taking long-term corticosteroids and those who did not give consent were excluded.

3.3 Sample size calculation

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

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

where Z = 1.96 (standard normal deviate at 95% confidence level), p = anticipated prevalence, q = 1 − p, and d = absolute precision. The anticipated prevalence was taken as 14.2% (p = 0.142) on the basis of a pilot screening and available reports on Indian industrial workers, and the absolute precision was fixed at 5% (d = 0.05).

$$n = (1.96)^2 \times 0.142 \times 0.858 / (0.05)^2$$

$$n = 3.8416 \times 0.121836 / 0.0025 = 0.46805 / 0.0025 = 187.2 \approx 188$$

Therefore, a minimum sample of 188 miners was required. Miners who refused or were absent were replaced by the next randomly selected eligible worker, so that the final sample remained 188.

3.4 Method of sampling

Multistage random sampling was used. In the first stage, six collieries were chosen by lottery method from the list of operational collieries of the four districts. In the second stage, the sample was divided among these collieries by proportional allocation, according to the number of miners on their muster rolls. In the third stage, the required number of miners from each colliery was selected by simple random sampling, using computer-generated random numbers applied to the muster roll, which served as the sampling frame. Underground, open-cast and surface workers were all represented in this process. The steps are shown in Figure 1.

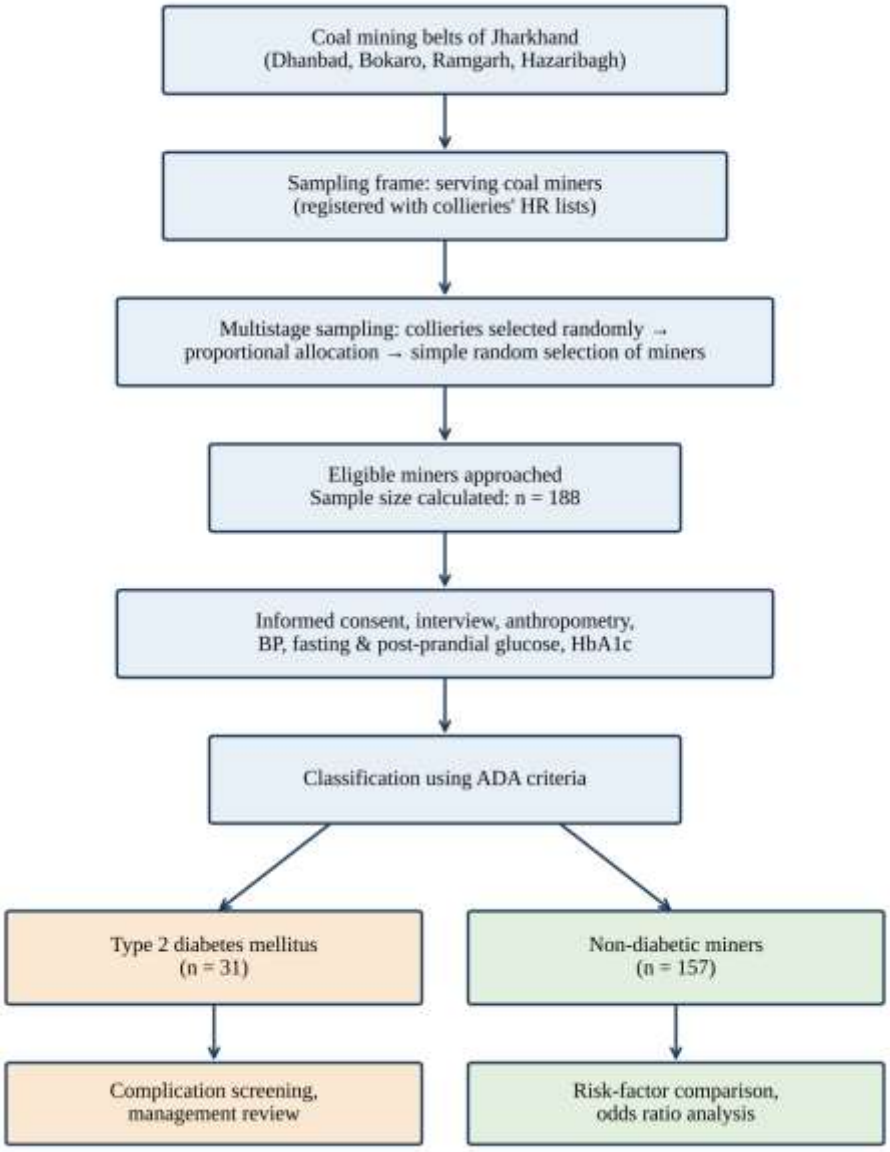


Figure 1. Flow chart of the study design and sampling procedure

3.5 Data collection and measurements

A pre-tested, semi-structured questionnaire, administered in Hindi by trained interviewers, collected information on age, sex, education, marital status, residence, type of work, years of service, shift pattern, family history of diabetes, tobacco and alcohol use, and physical activity. Height and weight were measured with a calibrated stadiometer and weighing scale, and body mass index (BMI) was calculated. Blood pressure was recorded twice after five minutes of rest, using a standard sphygmomanometer. Venous samples were taken for fasting plasma glucose, two-hour post-glucose plasma glucose (after 75 g oral glucose, in those without known diabetes), HbA1c, serum creatinine and lipid profile. A spot urine sample was tested for albumin-creatinine ratio.

3.6 Operational definitions

- Type 2 diabetes mellitus: fasting plasma glucose ≥126 mg/dL, two-hour plasma glucose ≥200 mg/dL, HbA1c ≥6.5%, or a known case on anti-diabetic treatment, as per the American Diabetes Association criteria.
- Overweight/obesity: BMI ≥23 kg/m², using the Asian cut-off. Hypertension: blood pressure ≥140/90 mmHg or use of antihypertensive drugs. Sedentary lifestyle: less than 150 minutes of moderate physical activity per week outside work. Tobacco and alcohol use: current use during the last 12 months.
- Complications: peripheral neuropathy by 10-g monofilament and 128-Hz tuning-fork testing; retinopathy by dilated fundus examination by an ophthalmologist; nephropathy by urine albumin-creatinine ratio ≥30 mg/g or eGFR <60 mL/min/1.73 m²; cardiovascular disease by history, examination and resting ECG; diabetic foot by

examination of ulcer, deformity or infection; and recurrent infections by two or more episodes of skin, urinary or respiratory infection in the previous year.

3.7 Statistical analysis

Data were entered in Microsoft Excel and analysed with SPSS version 26. Categorical variables are shown as numbers and percentages, and continuous variables as mean ± standard deviation. The prevalence is presented with a 95% confidence interval. Association between risk factors and T2DM was tested by the chi-square test, and the strength of association was expressed as a crude odds ratio (OR) with 95% confidence interval (CI). A p value below 0.05 was considered statistically significant.

3.8 Ethical considerations

Approval was obtained from the Institutional Ethics Committee, and permission was taken from the colliery managements. Written informed consent was obtained from every participant.

RESULTS

4.1 Sociodemographic and occupational profile

A total of 188 coal miners participated, with a response rate of 100% after replacement. Their mean age was 41.3 ± 9.6 years, and the largest group (32.4%) was between 40 and 49 years. Men formed 91.0% of the sample. About one-third had completed secondary education, and 15.4% were illiterate. Most were married (83.0%) and lived in colliery townships (64.4%). Open-cast miners were the largest group (44.1%), followed by underground (39.4%) and surface workers (16.5%), and 63.3% had served for more than 10 years (Table 1).

Table 1. Sociodemographic and occupational characteristics of coal miners (n = 188)

Characteristic	Number	Percentage (%)
Age group (years)		
20–29	31	16.5
30–39	52	27.7
40–49	61	32.4
≥50	44	23.4
Sex		
Male	171	91.0
Female	17	9.0
Education		
Illiterate	29	15.4
Primary	58	30.9
Secondary	67	35.6
Graduate and above	34	18.1
Marital status		
Married	156	83.0
Unmarried	32	17.0
Residence		
Colliery township	121	64.4
Nearby village	67	35.6
Type of work		
Underground	74	39.4
Open-cast	83	44.1
Surface	31	16.5
Years of service		
<10 years	69	36.7

Characteristic	Number	Percentage (%)
10–20 years	74	39.4
>20 years	45	23.9

4.2 Prevalence of type 2 diabetes mellitus

Out of 188 miners, 31 were diagnosed with T2DM, so the overall prevalence was 16.5% (95% CI 11.2–21.8%). Of these 31 miners, 19 (61.3%) were already known cases and 12 (38.7%) were detected for the first time during the study, which shows a considerable hidden burden.

Prevalence increased with age: 6.5% in the 20–29 years group, 9.6% at 30–39 years, 21.3% at 40–49 years and 25.0% in those aged 50 years and above. It was 17.0% in men and 11.8% in women, and it was 14.9% among underground, 16.9% among open-cast and 19.4% among surface workers.

4.3 Risk factors

Table 2 compares the distribution of risk factors between diabetic and non-diabetic miners. The commonest risk factors in the whole sample were service of more than 10 years (63.3%), age of 40 years or above (55.9%), tobacco use (52.1%) and night or rotating shift work (49.5%). Overweight or obesity was present in 42.0%, sedentary lifestyle in 38.3%, alcohol use in 32.4%, hypertension in 25.5% and family history of diabetes in 24.5%. Every risk factor was more frequent among the diabetic miners. Figure 2 shows the prevalence of these risk factors in the form of a pie chart.

Table 2. Risk factors among diabetic and non-diabetic coal miners, n (%)

Risk factor	Total (n = 188)	T2DM (n = 31)	No T2DM (n = 157)
Age ≥40 years	105 (55.9)	24 (77.4)	81 (51.6)
Family history of diabetes	46 (24.5)	14 (45.2)	32 (20.4)
Overweight/obesity (BMI ≥23)	79 (42.0)	21 (67.7)	58 (36.9)
Hypertension	48 (25.5)	15 (48.4)	33 (21.0)
Sedentary lifestyle	72 (38.3)	19 (61.3)	53 (33.8)
Tobacco use	98 (52.1)	18 (58.1)	80 (51.0)
Alcohol use	61 (32.4)	13 (41.9)	48 (30.6)
Service >10 years	119 (63.3)	25 (80.6)	94 (59.9)
Night/rotating shift work	93 (49.5)	20 (64.5)	73 (46.5)

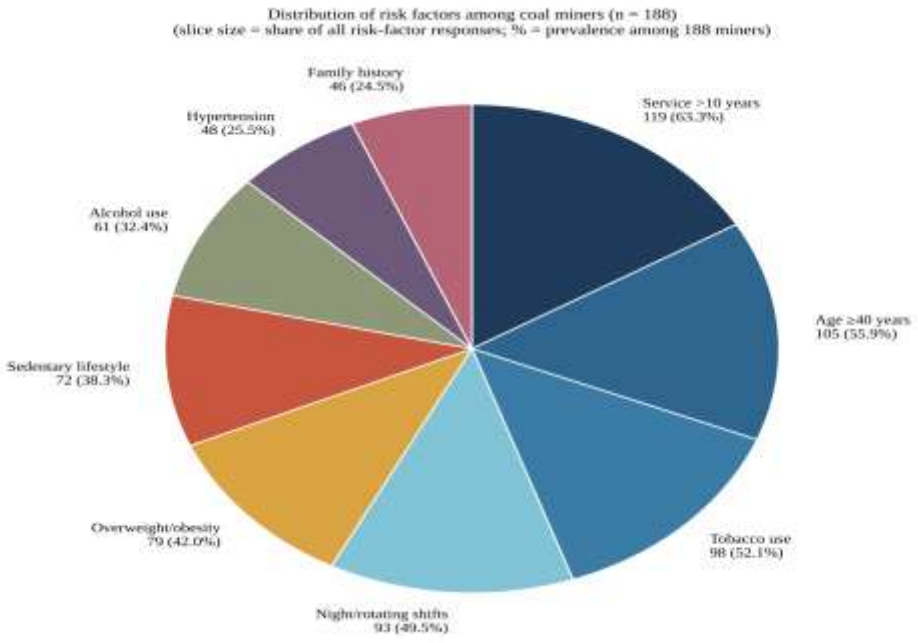


Figure 2. Pie chart showing the prevalence of risk factors among coal miners

4.4 Odds ratio analysis

Table 3 gives the crude odds ratios. In simple terms, an odds ratio above 1 means that miners with that factor had higher chances of having diabetes than miners without it, and the result is significant when the 95% confidence interval does not include 1. Overweight or obesity (OR 3.58), hypertension (OR 3.52), age of 40 years or above (OR 3.22), family history (OR 3.22), sedentary lifestyle (OR 3.11) and service of more than 10 years (OR 2.79) were significantly associated with T2DM. Night shift work (OR 2.09), alcohol use (OR 1.64) and tobacco use (OR 1.33) showed a higher odds but the association was not statistically significant.

Table 3. Crude odds ratios of risk factors for type 2 diabetes mellitus

Risk factor	OR	95% CI	p value	Result
Age ≥40 years	3.22	1.31 – 7.90	0.008	Significant
Family history of diabetes	3.22	1.44 – 7.21	0.003	Significant
Overweight/obesity (BMI ≥23 kg/m²)	3.58	1.58 – 8.14	0.001	Significant
Hypertension	3.52	1.58 – 7.86	0.001	Significant
Sedentary lifestyle	3.11	1.40 – 6.88	0.004	Significant
Tobacco use	1.33	0.61 – 2.90	0.469	Not significant
Alcohol use	1.64	0.74 – 3.61	0.217	Not significant
Service >10 years	2.79	1.08 – 7.20	0.028	Significant
Night/rotating shift work	2.09	0.94 – 4.66	0.067	Not significant

OR = odds ratio; CI = confidence interval; chi-square test used for p value.

4.5 Complications of diabetes

Of the 31 diabetic miners, 21 (67.7%) had at least one complication: nine had one, seven had two and five had three or more. Table 4 shows the pattern. Peripheral neuropathy was the commonest complication (35.5%), followed by retinopathy (22.6%). Nephropathy and recurrent infections were each seen in 19.4%, cardiovascular disease in 16.1% and diabetic foot ulcer or infection in 12.9%. All four miners with diabetic foot problems were underground or open-cast workers.

Table 4. Complications among diabetic coal miners (n = 31; multiple responses possible)

Complication	Number	Percentage (%)
Peripheral neuropathy	11	35.5
Diabetic retinopathy	7	22.6
Diabetic nephropathy	6	19.4
Recurrent infections (skin/urinary/respiratory)	6	19.4
Cardiovascular disease	5	16.1
Diabetic foot ulcer/infection	4	12.9
At least one complication	21	67.7
No complication	10	32.3

4.6 Clinical management of diabetic miners

Initial assessment. Every miner diagnosed with T2DM underwent a full evaluation in the colliery hospital: history of duration and symptoms, BMI, blood pressure, glycaemic profile, lipid profile, renal function and screening for complications as described above. The 12 newly detected miners were confirmed by repeat testing and registered for follow-up.

Lifestyle and medical nutrition therapy. All 31 miners received individual counselling from the physician and a dietician. The advice included a balanced diet with controlled portions of rice, roti and sweets, more vegetables, dal and fibre, avoidance of sugary tea and fried snacks, and regular meal timing even during night shifts. A 5–7% weight reduction was advised for those with excess weight, along with at least 150 minutes of brisk walking or similar activity per week, and quitting tobacco and alcohol. Four miners with HbA1c below 7.5% and no complication were managed with lifestyle measures alone.

Pharmacological treatment. Metformin was the first-line drug unless contraindicated, and it was used by 25 of 31 miners (Table 5). Eight miners needed a sulfonylurea and four a DPP-4 inhibitor as add-on therapy because their HbA1c remained

above target. Two miners with HbA1c above 10% and symptoms were started on insulin. Hypoglycaemia was explained in detail, because it is particularly risky during underground work, and sulfonylurea doses were kept low in those working in night shifts. Statins were prescribed to miners with dyslipidaemia or cardiovascular risk, and an ACE inhibitor or an angiotensin receptor blocker was preferred for hypertension, especially with albuminuria.

Management of complications. Miners with neuropathy were advised strict glycaemic control, daily foot inspection, protective footwear and pain relief when needed. Those with retinopathy were referred to the ophthalmologist for laser or injection therapy where indicated. Miners with albuminuria or reduced eGFR received renin-angiotensin blockade, blood pressure control and dose adjustment of drugs, with nephrologist referral for advanced stages. Miners with cardiovascular disease were given antiplatelet and lipid-lowering therapy and referred to a cardiologist, and those with foot ulcers got wound care, antibiotics and offloading. Infections were treated promptly, and sputum testing was done where chronic cough was present, since tuberculosis is common among miners.

Occupational advice and follow-up. Each worker was given a fitness advice letter to the colliery medical officer. Miners with unstable control, insulin use or visual loss were recommended for temporary placement on safer, surface-level duties. Follow-up was planned every three months for HbA1c, blood pressure and weight, with yearly eye, kidney and foot examination.

Table 5. Treatment pattern among diabetic coal miners (n = 31)

Treatment	Number	Percentage (%)
Lifestyle modification alone	4	12.9
Metformin monotherapy	13	41.9
Metformin + sulfonylurea	8	25.8
Metformin + DPP-4 inhibitor	4	12.9
Insulin-based regimen	2	6.5

Among the 19 known cases, only six (31.6%) had HbA1c below 7%, and only eight (42.1%) were attending regular follow-up. Five of 15 diabetic miners with hypertension (33.3%) had blood pressure below 130/80 mmHg, and just five of the 19 known cases (26.3%) had undergone an eye examination in the previous year. These figures indicate that treatment was started but the targets were not often achieved.

DISCUSSION

The present study found that 16.5% of coal miners in Jharkhand had T2DM, and that more than one-third of them were unaware of their disease. This figure is higher than the state-level estimates for Jharkhand from the general population in the ICMR-INDIAB study [6] and is also above the national figure of 11.4% reported in the later phase [5]. Community studies from other parts of India, such as the STEPS survey in Punjab, have reported prevalence in a similar range for adults [19], and the National Noncommunicable Disease Monitoring Survey also showed a high burden of metabolic risk factors in the Indian adult population [20]. The higher prevalence in our sample may be explained by the age profile of the workers, as almost 56% were 40 years or older, and by the fact that the study used glucose tolerance testing and HbA1c, which detect more cases than fasting glucose alone [21]. The finding that 38.7% of the cases were new also matches the well-known problem of undiagnosed diabetes in India [5,16].

Age, overweight, family history and hypertension showed the strongest association with diabetes. Advancing age is a well-established risk factor, and the prevalence in our miners rose from 6.5% in the youngest group to 25.0% in those above 50 years [4,7]. Overweight and obesity gave the highest odds ratio (3.58). Asian Indians develop diabetes at lower BMI values than Europeans, which is why the lower cut-off of 23 kg/m² was used [22,23]. The strong link with hypertension reflects the clustering of cardiometabolic risk factors, which is typical in the Indian population [7,16]. A positive family history, with an odds ratio above three, supports the role of genetic susceptibility along with shared lifestyle.

Sedentary behaviour was also significantly associated with T2DM. Several meta-analyses have shown that regular physical activity lowers diabetes risk, and that prolonged sitting is related to higher risk irrespective of exercise [24,25]. Mining was traditionally a labour-intensive occupation, but the trend in our sample, where surface workers had a slightly higher prevalence (19.4%) than underground workers (14.9%), suggests that mechanisation may have changed the profile of the risk. Service of more than 10 years was another significant factor. This probably reflects the combined effect of ageing, cumulative occupational exposure and a gradual shift towards a sedentary pattern.

Night and rotating shift work had an odds ratio of 2.09 that did not reach statistical significance, possibly because of the limited sample size. However, the direction of the association is in line with large cohort studies and a meta-analysis that found a higher risk of T2DM among shift workers [14,15]. Tobacco and alcohol showed weaker, non-significant

associations. Pooled studies have found that active smoking raises diabetes risk by about 44% and that heavy alcohol intake increases the risk, while light to moderate intake may show a different pattern [26,27].

Two-thirds of the diabetic miners had at least one complication, which is a concerning finding considering the relatively young age of the group. Neuropathy was the commonest complication (35.5%), and this agrees with the observation that neuropathy affects a substantial proportion of Indian patients with diabetes and is often detected only on formal testing [16,28]. Retinopathy was seen in 22.6%, which is comparable to the figures reported from the CURES eye study in urban South India [29]. Nephropathy and cardiovascular disease were found in 19.4% and 16.1% respectively, and these need particular attention because they determine survival [30,31]. The occurrence of complications in newly detected cases suggests that diabetes had been present for several years before diagnosis. This is consistent with the UKPDS observation that many patients already have complications when they are diagnosed [17]. For miners, neuropathy and foot lesions have an added occupational importance because of heavy boots, wet and uneven surfaces, and risk of injury.

The management pattern in our study followed the standard recommendations. Lifestyle modification, medical nutrition therapy and weight loss form the foundation of care, and metformin is the preferred first-line drug, with add-on agents chosen according to HbA1c, comorbidity and risk of hypoglycaemia [32,33,34]. Indian guidelines from the Research Society for the Study of Diabetes in India give similar advice and stress cost, availability and local practice [35]. Intensive glucose control reduces microvascular complications, and blood pressure control gives an additional benefit, as shown in the UKPDS trials [17,36]. Intervention studies from Finland and the Diabetes Prevention Program have shown that lifestyle change can prevent or delay diabetes in high-risk persons, which is relevant to the large number of prediabetic and high-risk miners who may be present in this workforce [37,38]. The weak achievement of glycaemic and blood pressure targets in our known cases, and the low proportion who had eye examination, indicate gaps in continuity of care that are probably related to shift duty, distance from health facilities and lack of awareness. A systematic annual screening for retinopathy, nephropathy, neuropathy and foot disease is recommended by current standards of care [30,39].

The strengths of this study include random selection of participants, use of standard diagnostic criteria with HbA1c and oral glucose tolerance testing, and clinical screening for complications. There are also some limitations. The cross-sectional design does not allow a causal inference or the sequence of exposure and disease to be established. The sample is modest in size and drawn from selected collieries, which limits generalisation to all miners, and subgroup comparisons and odds ratios had wide confidence intervals. Only crude odds ratios were calculated, so confounding by age and BMI may be present. Larger multicentre studies with adjusted analysis and follow-up are needed.

CONCLUSION

About one in six coal miners in Jharkhand had type 2 diabetes mellitus, and a significant share of them was undiagnosed. Increasing age, overweight or obesity, hypertension, family history, sedentary lifestyle and long years of service were the major risk factors. Two-thirds of diabetic miners had already developed at least one complication, with neuropathy, retinopathy and nephropathy being the commonest, and glycaemic control was achieved in only a minority of known cases. Diabetes in coal miners is therefore not only a clinical issue but also an occupational health and safety issue that requires prompt attention.

RECOMMENDATIONS

Annual diabetes screening (fasting glucose or HbA1c) should be included in the periodic medical examination of all miners, starting at 30 years of age or earlier for those with obesity, hypertension or family history. Colliery hospitals should run dedicated diabetes clinics with a fixed protocol for drugs, laboratory monitoring and referral, and with free supply of essential medicines. Every diabetic miner should undergo yearly screening of eyes, kidneys, nerves and feet, and neuropathy or foot disease should lead to provision of protective footwear. Health education on diet, physical activity, weight control and quitting tobacco and alcohol should be given at the workplace, in Hindi and local languages, with attention to meals during night shifts. Management should consider the work environment, avoiding hypoglycaemia-prone regimens for underground workers, and arranging temporary safer duties where required. Multicentre, longitudinal studies with adjusted analysis should be carried out to confirm the role of dust exposure and shift work.

DECLARATIONS

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Conflict of interest: The authors declare that they have no conflict of interest.

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Ethical approval: The study was approved by the Institutional Ethics and written informed consent was obtained from all participants.

Submission declaration: We declare that this manuscript is original, has not been published previously and is not under consideration for publication elsewhere. All authors have read and approved the final manuscript, and they accept responsibility for its content. The manuscript has been checked for similarity, and all sources of information have been acknowledged.

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