Journal of Health and Social Sciences 2017; 2,2:69-82

ORIGINAL ARTICLE
IN OCCUPATIONAL MEDICINE

Awareness of workplace hazards and preventive measures among sandstone mineworkers in Rajasthan, India: A cross-sectional study

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Abstract

Objective: The aim of this study was to assess awareness of workplace hazards and personal protective equipments (PPEs) among mineworkers employed in a sandstone quarry in Rajasthan, India.
Materials and Methods: A cross-sectional study of 218 miners was conducted in Karauli, Rajasthan, India. We used a standardized semi-structured questionnaire that was administered to each subject by face-to-face interviews. Descriptive statistics and Pearson chi-square test were used to show frequency distributions and associations between variables.
Results: Almost all respondents were aware of at least one hazard in mining occupation (93.6%), but no of them was trained by a recent (within 1 year) health and safety training course. However, mineworkers recognized only the risk of injury (74.3%) and exposure to crystalline silica dust (40.4%). A high percentage of mineworkers were aware of PPEs (87.6%), but an only 16.5% of them used PPEs during their employment. The only PPEs mentioned by mineworkers was the dust protective mask. Occurrence of at least one occupational injury during work-life was associated with use of dust masks, while work-related diseases were associated with a low level of education, underweight (BMI < 18.5 kg/m^2), and current smoking. Awareness of workplace hazards was associated with age less than 60, young age of starting work in mines (< 30 years), hours work per day (< 8 hr), and no availability of drinking water facility. Failure to use PPEs at work was statistically significant associated with belonging to scheduled castes or scheduled tribes, lower distance from home to workplace (1–3 Km), hours work per day (< 8 hr), and no availability of safe drinking water.
Discussion and Conclusion: In Rajasthan, India, there is a certain level of awareness about workplace hazards but usage of PPEs by sandstone mineworkers is very low. Policy makers should implement health and safety training programmes to promote use of PPEs among mine workers.

KEY WORDS: India; miners; awareness; personal protective equipment; occupational injuries; occupational diseases.

Riassunto

Introduzione: L'obiettivo di questo studio è stato quello di valutare la conoscenza dei rischi lavorativi e dei dispositivi di protezione individuali (DPI) tra i minatori impiegati nelle cave di arenaria di Rajasthan in India.
Materiali e Metodi: Uno studio trasversale su 218 minatori è stato effettuato in Karauli, nello Stato di Rajasthan, in India. Abbiamo usato un questionario standardizzato semi-strutturato somministrato a ciascun partecipante attraverso un "colloquio faccia a faccia".
Risultati: Quasi tutti i partecipanti hanno riconosciuto almeno un fattore di rischio esistente nel lavoro in miniera (96%), ma nessuno di loro era stato sottoposto ad un recente (nell'arco di 1 anno) corso di formazione sulla salute e la sicurezza nei luoghi di lavoro. Tuttavia, i minatori hanno evidenziato soltanto il rischio di infortunio (77%) e di esposizione alle polveri di silice cristallina (42%). Un'alta percentuale di minatori conosceva i DPI (87,6%) ma soltanto il 16,5% di loro li usava durante l'attività lavorativa. L'unico DPI menzionato dai lavoratori è stato la maschera anti-polvere. Avere avuto almeno 1 infortunio sul lavoro nell'arco della propria vita lavorativa è stato associato all'uso della maschera anti-polvere, mentre l'essere affetto da malattie lavoro-correlate è stato associato ad un basso livello di istruzione e ad una condizione di sottopeso (BMI < 18,5 Kg/m^2). La conoscenza dei rischi lavorativi è stata associata all'età (< 60 anni), all'inizio del rapporto lavorativo in giovane età (< 30 anni) e ad un minore numero di ore di lavoro giornaliero (< 8 ore/die). Il mancato uso dei DPI è stato associato in modo statisticamente significativo all'essere appartenenti alla casta "Scheduled" o "Tribes", alla breve distanza casa-luogo di lavoro (1–3 Km) ed al minore numero di ore di lavoro giornaliero (< 8 ore/die).
Discussione e Conclusione: Nello Stato di Rajasthan in India, c'è una certa conoscenza dei rischi lavorativi ma l'uso dei DPI tra i minatori di arenaria è molto basso. I responsabili politici dovrebbero implementare programmi di educazione sulla salute e la sicurezza nei luoghi di lavoro per promuovere l'uso dei DPI tra i minatori.

TAKE-HOME MESSAGE

Use of personal protective equipment (PPEs) by Indian mine workers could lead to a considerable reduction of costs and disability caused by injuries and work-related diseases. However, it is need to increase workplace educational programs to promote their awareness of workplace hazards and use of PPEs.

Competing interests - none declared.

Cite this article as - Ahmad A. Awareness of workplace hazards and preventive measures among sandstone mineworkers in Rajasthan, India: a cross-sectional study. J Health Soc Sci. 2017;2(1):69-82

DOI 10.19204/2017/wrns6

Received: 02/07/2016 Accepted: 10/01/2017 Published: 15/03/2017

INTRODUCTION

Rajasthan is the largest state in India (in terms of area) and is unique for its geology, having a wide range of rocks and mineral deposits. Due to its mineral resources, India is one of the most important developing countries in the world and Rajasthan is the second most mineral rich state in India having a wide spectrum of mineral deposits [1]. Indeed, it is considered as a museum of minerals both metallic and non-metallic including renowned building stones and accounts for about 90 per cent of the country's total stone production [2]; globally, mining sector contributing 4.4% to the India's GDP, affects every segment of life, like infrastructure, health and medical, education and skill development [3]. Mining is the second largest employment sector in Rajasthan, which has the highest number of mine leases in the country - 1,324 leases for major minerals, 10,851 for minor minerals and 19,251 quarry licenses for mining stones [1]. There are 2.5 million mine workers engaged in over 30,000 small and large mines [4]. Mining is recognized as one of the world's most arduous and liable to injury and disease occupations [5]. The total workplace of the mining industry in India comprises more than one million workers and, compared to other factories, the mining industry has a higher proportion of fatal and nonfatal injuries (almost two to three times more). In his in-depth review, Donoghue reviewed the most important issues in the mining sector, including noise induced hearing loss, ergonomics and respiratory diseases, and system safety/risk management [6]. In general, hazard identification and risk analysis in mining industry should consider physical, chemical, biological, ergonomic, and psychosocial risk factors. According to Donoghue (2004), traumatic injury and noise-induced hearing loss are very common problems [6], but silicosis that arises from a chronical inhalation of dust containing crystalline silica into lungs, is, probably, the most common occupational disease and the most frequent cause of death among mineworkers who work in Rajasthan [7]. In 1999, the Indian Council of Medical Research reported that around 3 million workers are at high risk of exposure to silica; of these, 1.7 million work in mining or quarrying activities [8]. Many studies showed a high incidence of life-threatening lung diseases such as silicosis, tuberculosis (TB), silico-tuberculosis and asthma in this occupational sector [9–13]. However, in India, another big problem is that occupational diseases are mostly underreported because they often occur in unorganized sectors. Due to the nature of unorganized sector, health and safety educational programmes or training for using PPEs at workplace are often insufficient. Mine workers started working in mines as a helping hand of father and, then, they become full mine workers [14]. In occupational health and safety (OHS), personal protective equipment (PPE) is equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses. The most commonly needed respiratory protection in mining operations is dust protection. Other useful PPEs in mining working are ear muff type protectors, which are slot-mounted on the miner's cap, because underground vehicles, machinery and power tools generate high ambient noise levels that can create long-term damage to human hearing. Protective eye and face protection devices, hard hats, safety shoes, gloves, blankets and vests are also considered PPE. Several studies among welders in Nepal [15] and sawmill workers in Nigeria [16] showed a close relationship between low awareness of workplace hazards and non-use of PPEs. In developing countries, some studies focused on the scarcity of safety measures among stone quarry workers in Nigeria, where all the quarry sites had not any preventive or safety measures for the workforce, nor recreational lavatory facilities [17]. A study carried out in Rajasthan, India (2011) highlighted that awareness of personal protection and preventive measures against silicosis, such as the use of dust mask, can effectively improve the health status of mineworkers [18]. However, this research area is neglected in our country. For this reason, the purpose of this study was to determine the knowledge of occupational hazards and level of awareness of PPE and other safety measures as a way of preventing and/or reducing a variety of health hazards among mineworkers employed in a sandstone quarry in Rajasthan, India. We also tried to find the factors that are associated with awareness of occupational hazards and protective measures, PPE training and use, and prevalence of injuries and occupational diseases in this type of workers.

METHODS

To obtain information on level of knowledge and self-reported risk factors of occupational diseases in Indian mines, we conducted a cross-sectional survey of mineworkers working in sandstone mines in Rajasthan, state of India, between May and September of 2014. The population consisted of healthy workers employed in the most important block of Karauli district, named 'Karauli'. This block was selected for the study because it is the most important in terms of number of workers employed in mining. The sample size was estimated by using the following formula: Z^2pq/d^2 [23], where 'p' is the proportion of miners in Karauli district, 'Z' is the type 1 error at 5%, and 'd' is the absolute error. Therefore, based on the sample size calculations ($p = 0.15$, $Z = 1.96$, $d = 0.05$), we randomly selected a representative sample of 218 miners. A standardized semi-structured questionnaire was designed based on a review of the literature, field observation, and personal interviews with experienced miners during a pilot survey. It was administered to each subject by face-to-face interviews. The questionnaire included questions on socio-demographic characteristics (gender, age, marital status, income and educational levels, number of households) and occupational aspects (age of starting work, work years, distance between home and workplace). The questionnaire included some items about participants' PPEs ('Do you ever use protective equipment') and facilities. Moreover, the questionnaire included some medical information such as occupational injuries ('Have you ever had a workplace injury?') or diagnosis of occupational diseases ('Have you any work-related disorders or diseases that was caused by working?'). The Body Mass Index (BMI) was calculated as a ratio of weight divided by height squared (kg/m^2). World Health Organization classifications were used to define BMI categories: underweight (<18.5 kg/m^2), normal (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), and obese (≥30 kg/m^2) [19]. Finally, the questionnaire investigated the types of PPE that workers have been using, and included a single-item question about awareness of workplace hazards and PPE use. Each questionnaire had attached an informative letter on the first page, which clarified the free participation, anonymity, and confidentiality of this study. We did not ask participants for written consent. Those who answered the questionnaire were deemed to have provided voluntary informed consent to participate. This procedure was specifically approved by the Ethics Committee of International Institute of Population Sciences, Mumbai, India, prior to commencing the study. The Statistical Package for Social Sciences (SPSS, version 20.0) was used to create the tables and compare groups using Pearson chi-square test. P-values less than 0.05 were considered statistically significant. Descriptive statistics were used to show frequency distributions and percentages for all responses.

RESULTS

As showed in Table 1, a total of 218 mine workers (M = 213, 97.7%; F = 5, 2.3%) were interviewed. The mean age of the study group was 41.2 ± 12.3 years. Almost half (44%) of the miners were in the age group of 31–45. Majority of the respondents belong to scheduled castes (53.2%) or other backward class (33.5%). About half of the respondents (44%) did not have any form of education. Most respondents (n = 83, 38.1%) were underweight (BMI = <18.5 kg/m^2), married (90.8%), and received a monthly household income of less than INR 4,000. The currency of India is Indian Rupee (code = INR). In our sample, the average monthly household income was INR 5,453 (82 US Dollar). Majority of participants had spent 11–20 years (35.7%) or > 20 years (54.2%) in employment. Table

2 shows that almost all respondents (93.6%) were aware of at least one hazard in mining occupation. However, participants recognized, above all, the risk of injury (74.3%) and exposure to crystalline silica dust (40.4%). Although a high percentage of mineworkers were aware of PPEs (87.6 %), only 16.5 % of them used PPEs during their employment. Unfortunately, the only PPEs mentioned by mineworkers, in this study, was dust protective mask. Moreover, none of participants was trained by a recent (within 1 year) health and safety training course. Table 3 shows that awareness of occupational health and safety hazards was associated with age less than 60 (χ^2 (3) = 41.20, P = .000), young age of starting work in mines (χ^2 (2) = 16.32, P = .000), hours work per day (< 8 hr) (χ^2 (1) = 4.72, P = .025), and no availability of drinking water facility (χ^2 (1) = 20.57, P = .001). Failure to use any of PPEs at work was statistically significant associated with belonging to scheduled castes or scheduled tribes (χ^2 (4) = 20.0, P = .000), low distance to workplace (1–3 Km) (χ^2 (2) = 11.85, P = .003), hours work per day (< 8 hr) (χ^2 (1) = 3.53, P = .047), and no availability of safe drinking water (χ^2 (1) = 4.71, P = .042). Table 3 shows that being afflicted by at least one occupational injury during the course of own working life was statistically significant associated with use of PPEs (χ^2 (1) = 4.73, P = .026), while being affected by a work-related disorder or disease was associated with a low education level (χ^2 (2) = 8.69, P = .013), underweight (BMI < 18.5 kg/m^2) (χ^2 (3) = 6.56, P = .037), and current smoking (χ^2(2) = 15.59, P = .000). Finally, we did not find any associations between work-related diseases or occupational injuries and awareness or use of PPEs, and there were no any associations between use and awareness of PPEs.

Table 1. Personal and occupational factors among mine workers from block 'Karauli', Karauli district, Rajasthan, India (*n* = 218).

Personal Factors	**(%, n)**	**Occupational Factors**	**(%, n)**
Gender		**Working years in mines**	
Male	*97.7 (213)*	≤ 5 year	*3.4 (7)*
Female	*2.3 (5)*	6-10 year	*7.3 (16)*
Age group		11-20 years	*35.7 (78)*
≤ 30 year	*19.7 (43)*	≥ 20 year	*54.2 (117)*
31-45 year	*45.0 (98)*	**Age of starting work**	
46-60 year	*32.6 (71)*	< 15 years	*43.1 (94)*
≥ 60 year	*2.8 (6)*	16-30 years	*54.1 (118)*
Level of education		> 30 years	*2.7 (6)*
Illiterate	*43.6 (95)*	**Distance from home to work-place**	
Primary school	*24.3 (53)*	1-3 Km	*55.5 (121)*
High School	*22.9 (50)*	> 3 Km	*43.5 (95)*
		Out of' 'Karauli' district	*0.9 (2)*
Marital status		**Hours work per day**	
Single	*5.5 (12)*	< 8 hr	*63.7 (139)*

Married	*90.8 (198)*	≥ 8 hr	*36.3 (79)*
Divorced	*3.6 (8)*	**Occupational Injury**	
Type of Caste		Yes (during work-life)	*19.7 (43)*
'Scheduled castes'	53.2 (116)	Yes (within 1 year)	70.6 (154)
'Scheduled tribes'	10.6 (23)	Not	29.4 (64)
Other 'backward class'	33.5 (73)	**Occupational Diseases**	
General	2.8 (6)	Yes	18.3 (40)
Household Income Level * (Monthly)		Not	81.7 (178)
< 4000	51.8 (113)	**Recent Educational Training (within 1 year)**	
4000-7000	30.3 (66)	Yes	0
> 7000	17.9 (39)	Not	100 (218)
Smoking habits		**BMI (kg/m²)**	
Current Smoker	85.8 (187)	< 18.5	38.1 (83)
Non-smoker	10.6 (23)	18.5-25	59.6 (130)
Ex-smoker	3.7 (8)	> 25	2.3 (5)

* Monthly household income level is expressed in Indian Rupee (INR) where 1,000 INR = 15.04 US Dollar.

Table 2. Awareness of workplace hazards and PPEs and use of PPEs among mine workers from block 'Karauli', Karauli district, Rajasthan, India (*n* = 218).

Factors	**'Yes' (%, n)**	**'No' (%, n)**
Awareness of workplace hazards		
At least one	93.6 (204)	6.4 (14)
Injury*	74.3 (162)	25.7 (56)
Crystaline silica dust	40.4 (88)	59.6 (130)
High loads	20.2 (44)	80.8 (174)
Attacks from wild animals	8.7 (19)	91.3 (199)
Attacks from dacoit	4.1 (9)	95.9 (209)
Other risks**	7.0 (15)	93.0 (203)
Awareness of PPEs		
At least one	87.6 (191)	12.4 (27)
Dust face masks	74.3 (162)	25.7 (56)
Protective gloves	7.8 (17)	92.2 (201)

Footwear	27.5(60)	72.5 (158)
Miners helmet	56.0 (122)	44.0 (96)
Face shield	0	100 (218)
Rain gear or Head gear	0	100 (218)
High-visibility jackets	0	100 (218)
Earmuffs	5.5 (12)	94.5 (206)
Use of PPEs		
At least one	16.5 (36)	83.5 (183)
Dust face masks	16.5 (36)	83.5 (183)
Protective gloves	0	100 (218)
Sturdy footwear	0	100 (218)
Miners helmet	0	100 (218)
Face shield	0	100 (218)
Rain gear or Head gear	0	100 (218)
High-visibility jackets	0	100 (218)
Earmuffs	0	100 (218)
Footwear	0	100 (218)

*It includes fall from height, rock falls and equipments/ tools injury.
** It includes cold and heat stress, oliguria (urinary tract obstruction), weakness, Malaria

Table 3. Use of PPEs, awareness of workplace hazards, occupational injuries and work-related diseases among mine workers from block 'Karauli', Karauli district, Rajasthan, India (*n* = 218).

	Use of PPEs		**Awareness of Hazards**		**Occupational Injuries**		**Work-related diseases**	
	χ^2	p-value	χ^2	**p-value**	χ^2	p-value	χ^2	p-value
Age groups	2.24	*0.523*	*41.20*	0.000*	3.02	*0.387*	*7.257*	*0.064*
Gender	1.01	*0.402*	*19.10*	0.011**	0.21	*0.541*	*1.150*	*0.359*
Education	0.10	0.949	0.147	0.929	1.97	*0.373*	*8.698*	*0.013***
BMI	2.76	*0.250*	*4.835*	0.089	4.73	*0.094*	*6.569*	*0.037***
Type of caste	20.0	*0.000**	*3.092*	0.378	2.31	0.509	1.645	0.649
Marital Status	7.19	*0.027***	*11.76*	0.003**	1.29	*0.524*	*0.220*	*0.896*
"Smoking Habits"	1.95	0.376	3.93	0.140	0.42	*0.810*	*15.59*	*0.000**
Household size	0.00	*0.548*	*0.013*	0.608	1.67	0.127	0.191	0.396
Household income (INR)	3.09	*0.212*	*3.609*	0.165	4.96	*0.084*	*0.758*	*0.685*

Age of starting work	0.32	*0.852*	*16.32*	0.000*	2.72	*0.256*	*1.765*	*0.414*
Working years in mines	1.71	0.633	1.442	0.696	4.72	*0.193*	*5.340*	*0.149*
Distance from home to work-place	**11.85**	0.003**	3.449	0.178	1.25	0.533	1.297	0.523
Hours work per day	3.53	*0.047***	*4.720*	0.025**	0.75	*0.237*	*0.825*	*0.236*
Drinking water facility	4.71	*0.042***	*20.57*	0.001*	1.24	*0.199*	*3.534*	*0.067*
Awareness of workplace hazards	0.09	*0.608*	----	----	0.07	*0.568*	*2.033*	*0.164*
At least one injury during work-life	4.73	*0.026***	*0.076*	0.568	---	---	*2.069*	*0.104*
Work-related diseases	0.03	*0.506*	*2.033*	0.164	2.06	*0.104*	---	---
Use of PPEs	----	----	*0.097*	0.608	4.73	*0.026***	*0.035*	*0.506*
Awareness of PPEs	0.09	*0.472*	*10.82*	0.009**	0.87	*0.235*	*2.61*	*0.092*

*P < 0.001; ** P < 0.05

Figure 1. 'Karauli District', Rajasthan

Figure 2. Miners at work without any PPEs during working in Rajasthan, India

DISCUSSION AND CONCLUSIONS

In our study, most participants were aged 31–45 years. A similar finding was found among miners employed in artisanal and small-scale mining in Nigeria [20]. However, this finding is not in agreement with other studies carried out in India [21] and Nigeria [22] were the miners were aged 20–29 years. Probably, present generation of Indian youth is aware that the mining profession can be very dangerous, and emigration is high among young people. In addition, in our sample almost all miners were males (M = 213, 97.7%). These two findings are not consistent with reports recently released by Indian NGOs revealing the desperate situation for children and adults living and working in mining areas. Indeed, in India around 37% and 15% of the total mine workers are women and children, respectively [23]. According to Dhaatri [24], a resource centre for women and children's right, because of mining children have to face an increased morbidity and illnesses, an increased food security and malnutrition leading to various diseases like anaemia, vitamin deficiency, pulmonary tuberculosis, malaria and intestinal infections; in addition, they are exposed to a more vulnerability to exploitation and abuse, and a violation of right to education. Indeed, in literature, it is well-known the association between tuberculosis (TB) and malnutrition, because TB can lead to malnutrition and malnutrition may predispose to TB [25]. For instance, according to Tyagi (2004) there is also a high mortality rate in Rajasthan because of overwork during pregnancy, inadequate food and lack of sanitation [26]. Consistently with a study on marble mine workers in Rajasthan [27] and with a study on construction workers in Kolkata [28], our research included a high proportion (38.1%) of participants with a low Body Mass Index (BMI < 18.5 kg/m^2). The causes of underweight are multifarious. In India, some of the major causes for malnutrition are depending on economic inequality. Indeed, due to the low social status of some population groups, their diet often lacks in quality and quantity [29]. Underweight is associated with increased risk of mortality and morbidity. However, this issue needs to be analyzed in further research. In our study, the percentage of miners with poor education was higher than that reported by Babatunde et al. [30] in South-west Nigeria (19%), and less than that indicated by Aggarwal [31] in agate workers from Gujarat (27%), and by Yadav et al. [32] in miners from Jodhpur (71.5%). In India, education suffers because parents encourage their children as young as eleven to work instead of going to school. In agreement with past studies [32, 43], our research showed a high prevalence of tobacco smoking (85.8%) among mineworkers. With regard to occupational aspects, unexpectedly, for each of the study participants, it was revealed that 93.6 % of the miners were aware of at least one mining related health hazard. On the contrary, about 6.4% (*n* = 14) of the miners were not aware of any health hazards related to their work. Unfortunately, even though miners were exposed to many health or safety risk factors during their work [6], they were able to only cite the risk of injury (74.3%), such as rocks fall, accidents from tools and equipment, fall from height, and health-related problems caused by exposure to dust (41%); a few respondents cited musculoskeletal disorders caused by high loads and manual handling tasks (20.2%), and attacks from dacoit (4.1%) or wild animals (8.7%). However, a recent systematic review on the mining industries in Rajasthan [33] reported many studies concerning a lot of occupational health issues in Indian mineworkers. Indeed, physical hazards include noise, which is almost ubiquitous in mining, thermal stress, and traumatic injury, which ranges from the trivial to the fatal. Common causes of fatal injury can include rock fall, fires, explosions, mobile equipment accidents, falls from height, entrapment, and electrocution. Physical hazards consist of whole-body and hand-harm vibrations, radon, barometric pressure, and solar ultraviolet. Chemical hazards include crystalline silica and coal dust, diesel particulate, arsenic, nickel compounds, and other metal ores such as lead, cadmium, manganese, platinum, and cobalt. For instance, cyanide can be used as a solvent for metals and xanthates, which are reagents commonly used in hydrometallurgical processes, and mercury is still used in some gold mining operations, especially in developing nations, to extract gold through the formation of mercury–gold amalgams [34]. All the above-mentioned irritant chemical agents are common in mining and, often, they result in dermatitis [35]. According to Das and Singh (2011), miners are also exposed to pollutants and toxicants, such as cromium, lead, mercury, and cadmium [36]. Moreover, it is well-recognized that chronical inhalation of hexavalent chromium compounds increases the risk of lung cancer. Regarding the biological hazards, Leptospirosis and Ankylostomiasis were eradicated in developed countries, but they are still a common issue in developing countries like India. In addition, Legionella is a biological risk because cooling towers are commonly found on mine sites, while Malaria and Dengue Fever are common at some remote mining locations. Furthermore, ergonomic hazards include cumulative trauma disorders, which continue to constitute the largest category of occupational disease in mining and, often, result in prolonged disability [35]. Indeed, overhead work is common underground, during ground support and during the suspension of pipes and electrical cables. This can cause or exacerbate shoulder disorders. Often, broken ground is encountered and can cause ankle and knee injuries. Finally, drug and alcohol abuse, working in remote locations with consequent work-family conflict, and fatigue in relation to shift-work are some of the most important, well-known, psychosocial hazards [6]. In spite of all these risk factors, and, probably, as a consequence of their low level of overall workplace hazards awareness, miners from our sample used only dust protection face masks [14, 21]. They did not know other PPEs such as mining helmet, sturdy footwear, protective gloves, hearing protectors, eye shield, earmuffs, and so on. However, percentage of miners who were aware of masks and used them during their employment was very low (16.5%). Many employees told that face masks were uncomfortable to wear and interfered with their working [14]. This finding was consistent with a study in sandstone miners carried out in Jodhpur where almost all miners did not wear any PPEs [17], and other studies in Nigeria where the percentage of mine workers wearing PPEs was 56% [30], 89% [37], and 33.4% [22], respectively. On the contrary, a study on mine workers who were exposed to asbestos, which is an internationally well-known human carcinogen, found that almost all of respondents used dust protection face masks [38]. Probably, as stated by Sharma (2011) [39], mine workers believe that PPEs are unmanageable, creating breathing problems, and making it difficult chewing tobacco. In this way, in a study carried out in Gujarat where about half of the workers (55%) were aware of the harmful effects associated with silica dust exposure (72%), only a minority of them (22%) used dust protection masks [32]. In another study from Jodhpur, India, none of the workers used dust masks [21]. PPEs can prevent or at least minimize injuries on the job. For newcomers, however, it's important to also include some information on selected PPEs through health and safety training at workplace. Moreover, manufactures of PPE could improve their comfortable use. In this sector, apart from dust face masks to prevent from coal workers' pneumoconiosis and silicosis, other useful PPEs include protective clothing such as rain gear, head gear, high-visibility jackets and coveralls, work gloves, footwear, which protect feet in both extreme cold and heat, eye protection such as safety glasses, and hearing protection. Our study showed that a certain level of awareness of occupational health and safety hazards was associated with age less than 60, early age of starting work in mines (< 30 years), and hours work per day (< 8 hr). These findings are not consistent with other studies where awareness of health and safety risk factors was positively associated with older age [40, 41]. Furthermore, Budhathoki found that awareness of workplace hazards was also positively associated with length of service [42]. Consistently with Sufian who carried out a study among quarry workers in Nigeria [37], our study showed a positive association between use of PPEs and to be afflicted by at least one occupational injury during own working life.

Saha showed that age, working hours per day, and level of education were significantly associated with occupational injuries; however, in our study this association was not statistically significant [43]. Finally, in our study failure to use PPEs at work was statistically significant associated with belonging to scheduled castes or scheduled tribes, lower distance from home to workplace (1–3 Km), and hours work per day (< 8 hr). The major occupational diseases/morbidity of concern in India are silicosis, musculoskeletal injuries, coal workers' pneumoconiosis, chronic obstructive lung diseases, asbestosis, byssinosis, pesticide poisoning, chemical hazards, and noise-induced hearing loss [5]. Although the present study did not specifically analyse in depth work-related health diseases affecting workers of our study sample, we showed that their self-reported work-related disorders were significantly associated with miners' educational level; probably, the improving educational level is likely to influence the development of good levels of occupational health and safety. Education and awareness of occupational diseases can be key-solutions to improve health and safety occupational levels of workers [44]. In all developed countries, the law requires employers to provide to their employees with health and safety educational programmes, immediately before and during time of employment. Workplace Education Programmes (WEPs) can be useful to reduce all costs of injuries and occupational disease. These costs consist of human costs, which are based on the value of the change in the quality of life of injured or unhealthy workers and those in his circle (family, friends, co-workers, and other members of the community) and, direct and indirect costs such as administrative and legal costs, productivity and salary costs [45–47]. Finally, the findings of our study are consistent with a study done on National Sample Survey (NSS) 68th round data that found more than 55% of mining and quarrying households belong to 'Dalit' (SCs) [48]. In India, people working in mines belong to 'Schedules Castes' (SCs) and have a very low education level. In India, the 'Schedules Castes' (SCs) and Scheduled Tribes (STs) are various officially designated groups of historically disadvantaged indigenous people. These terms are designated in the Constitution of India and the various groups are designated in one or other of the categories. In India, ninety-eight percent of the mining industry workforce is tribal or 'Dalit' (belonging to the 'untouchable' class), and for this reason, they are poor and systematically deprived of their proper wages and state-sponsored welfare, and social security schemes. Therefore, they are less aware of safety at work because of low educational status and face a high risk to be affected by injuries and occupational diseases.

Limitations of the study

This research has some limitations. Although the sample size was calculated through a scientific formula, the results in terms of age and gender of participants show that the sample size could be inadequate. A study with a larger sample size might provide a more accurate estimate of the study variables. In addition, we did not specifically focus on work-related diseases, and self-reporting of health-related data and certain exposure could lead to biased observations of association. Indeed, workers might be mistaken or misremember the material covered by the survey. Typically, a cross-sectional study contains several potential sources of bias such as attribution, which is the act of representing outcomes or embellishing events as more significant than is actually suggested from other data, and exaggeration, which is the act of attributing positive events and outcomes to one's own agency, and attributing negative events and outcomes to external forces. For all these reasons, the current study may not provide definite information about cause-and-effect relationship, but only associations, and its generalizability to the other parts of India could be limited.

Implications for policy makers

In the last fifty years, Indian Industry has grown rapidly and more so in the last two decades. This has resulted in increased manufacturing activities, technological advancements and change in work practices. Such a change has affected the health of working population, which would call for application of stricter and refined regime of occupational safety at workplaces, so that the productivity of workers continues to rise in the competitive market economy [49]. Occupational health remains neglected in India due to competing social, economic, and political challenges. Probably, this is happened because demand side articulated by workers (less powerful) rarely is recognized by employers and policy makers (more powerful) [50]. In addition, it is given very low priority among informal workers, as having work is more important than the quality of the job. As many workers say: "*We might die of work, but if we don't work our families will die of hunger*" [51]. Moreover, there is very little awareness about workplace hazards due to lack of access to information, or even any kind of formal education in India [50, 51]. It is also because there is underfunding of occupational health programmes due to lack of political will [50]. At present, the mining in India is one of four sectors having a regulation about the occupational safety and health of people at work. In India, the major legal provisions for the protection of health and safety at the workplace are the Factories Act and Mines Act. However, more than 90% of the Indian labour force does not work in factories; hence, these workers fall outside the purview of the various legislations [52]. Except in mines under private sector and public sector workers in other mines rarely use PPEs. Though provision has been made in the Safety Act for the use of dust- protecting masks, it is not practically done in any of the mines [53]. Rajasthan has thousands of unorganised mines, which can be as small as one-twentieth of a hectare, with no safety measures and constant violation of the human rights [54]. According to Pingle, the occupational safety and health (OSH) scenario in India is complex and two of the three most important OSH issues to address are 'legislation to extend OSH coverage to all sectors of working life including the unorganized sector', and 'spreading the awareness about OSH among stakeholders'[55]. Even though in the hierarchy of hazard control at the workplace, elimination, substitution and engineering controls are primary solutions, employees should be effectively trained to enable to recognize workplace hazards and to use safety measures, such as PPEs. This could lead to a considerable reduction of costs and disability caused by occupational injuries and work-related diseases.

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