

Assessment and Quantification of Risks Associated with Small Scale Mining, Khyber Pakhtunkhwa, Pakistan

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Abstract: Small scale mining industry is considered more hazardous than other industries worldwide. Large number of workers receive minor and major injuries leading to disabilities or loss of lives due to frequent accidents in mines. Main causes of accidents in mines are fall of roof, improper ventilation system, gases, fires and mine explosions. Beside these hazards, violation of rules and regulations for mine workers are common, which also cause accidents. This paper is focused on issues associated with the health and safety of workers of Cherat Coal Mines (CCM), Abbottabad Coal Mine (ACM) and Abbottabad Soapstone Mine (ASM), Pakistan. The collected data were analyzed with SPSS computer statistics software. The data analyses indicated that the lack of education and violation of safety laws cause accidents in mines. Results show that problems that were rated higher by more than 60% of workers included slide and fall, dust, roof fall and explosive related hazards. In survey more than 50% of the workers admitted the existence of gases, fire and low height mines are common hazards in their workplace. The results also indicated that not only workers but management are also affected by accidents. More than 17% of worker in CCM faced serious accidents up to 3 times during one year. Up to 26% of workers in CCM, 13% in ACM and 15% in ASM suffered accidents for which they had 3 workdays off. It has been concluded that training should be arranged, especially the safety related training on regular basis to reduce the risk of accidents.

Keywords: Accidents, diseases, hazards, mines, quantification.

Introduction

Workers are the backbone of an industry. Safe and healthy environment enhance worker's performance which ultimately affects the growth of an industry. Mining activities both on small and large scales are hazardous and can cause diseases and injuries. Gases, dust, weak mine roofs, low heights, poor ventilation, mine fires, water flooding and explosions are the most common hazards associated with mines (Quanlong et al., 2016; Amponsah et al., 2013). In Pakistan, like other developing countries mine workers are not due to improper mechanization of the mines, lack of safety equipment and improper training of the mine workers. Therefore, a great number of workers face accidents with fatalities or get injured and/or acquire occupational diseases. More than 374 million accidents and work related diseases are faced by workers per year in the world, out of which at least 2.78 millions persons die, consequently causing a huge personnel loss (ILO, 2019).

Mining is basically unsafe, due to both occupational injuries and diseases (Jamison et al., 2017). Underground coal mines are considered to be riskier than other mines. The safety and health issues are due to presence of physical and chemical hazards in mines.

Fall of mine roofs, low height mines, material handling, mine fires and explosions are the main physical hazards in underground mines and responsible for serious accident in mines, which almost completely stop the mining activities for short or long time, depending on

the gravity of the accident. These accidents bring major damages like loss of lives, injuries, disabilities, equipment damages and ultimately economic losses. The maximum fatalities in underground coal mines of Pakistan are due to fall of mine roofs (Jadoon and Edwards, 1999; CIM, 2004). Mine explosions occur mostly due to presence of methane gas. The majority of the coal mines in Pakistan are either free from methane or have low percentage. In China, where the production of coal from small scale mines is 11% of the world's total coal production, more than 6,000 coalminer fatalities are recorded annually, mostly due to presence of methane in underground mines (Gunson and Jian, 2001). In underground coal mines, high temperature and heat initiate fire. The main sources of fire in mines are flame cutting and welding activities, heat and electrical shorts. (Michael A.T. et.al., 2007). The U.S. mining industry, relatively safest industry as compared to the developing countries, also faces about more than 1600 reportable fires during the time period of 1990-2007 (Trevits et al., 2008). Low height mines and manual material handling are common problems in those mines which are not properly mechanized. Such types of hazards causes injuries and musculo-skeletal disorders (Jadoon and Edwards, 1999).

Chemical hazards are due to presence of chemicals in the form of solid, liquid or gas in the workplaces may cause occupational diseases. Underground coal mines consist of hazardous materials like mine dust and noxious gases including carbon dioxide, methane, carbon monoxide, hydrogen sulphide and oxides of nitrogen (nitrous fumes). More than 32 million workers

are affected by one or more hazardous chemical substances and more than 650 thousand chemical products exist and more than hundred are introduced every year. This is the major cause of ill health in the exposed workers (OSHA, 1998). Dust in mines are produced during different activities like blasting, cutting, excavation, handling and accumulating above the allowable limit due to poor ventilation (Hartman, 1961). This ultimately results in fatalities. Mine dust is not only main source of diseases in workers but also causes dust explosions.

Table 1. Age and Total Work Experience of the Workers selected in the Samples.

Nature of Job	Percentage			
	CCM %age (count)	ACM %age (count)	ASM %age (count)	Total %age (count)
Face worker	30(30)	28(11)	5(2)	24(43)
Haulage operators	16(16)	26(10)	33(13)	22(39)
Laborer	27(27)	26(10)	20(8)	25(45)
Supervisor	10(10)	21(8)	13(5)	13(23)
*Others	17(17)	0	30(12)	16(29)
Total	100(100)	100(39)	100(40)	100(179)

*Others include: Shot Firer, Mechanics, Electricians, Timber men.

Pneumoconiosis is the general term used for the diseases of lungs initiated due to inhaling of different types of dust particles. Pneumoconiosis includes coal workers pneumoconiosis initiated due to inhalation of coal dust, silicosis is caused due to inhaling silica dust and asbestosis due to asbestos. These dusts affect the respiratory tract and lungs. Severity of the infection depends up on concentration of dust and time of exposure, age, working environment and the type of dust inhaled (Aydin, 2010). Early symptoms of these diseases include difficulty in breathing after any effort followed by productive cough with sputum, if condition becomes severe (Ayaaba et al., 2017).

Hazardous environment leads to accidents and results in low enthusiasm among workers. Improvement in occupational safety and health reduces number and severity of accidents. The objective of present study was to identify the acts and conditions resulting in accidents mainly caused due to human errors, which could be responsible for accidents and occupational diseases in small scale mines of Khyber Pakhtunkhwa.

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Materials and Methods

The data were collected from the workers during field visits to know the problems related to health and safety

of workers Khyber Pakhtunkhwa. The samples of 179 workers were and only collected from Cherat coal mines, Abbottabad coal mines (located in Daisal, Abbottabad) and Abbottabad Soapstone mines (located in Sherwan, Abbottabad). The workers were selected from different job positions, age groups and work experience in mines. The perception of the workers on safety awareness, workplace hazards and accidents were sought through questionnaire. The workers were given 3 to 6 options for each question and asked to select any suitable answer. Details obtained about the workers age and their work experience and show that majority of workers selected below 26 to 35 years age and only 11% of the workers had age 46 years or more (Table 1). Maximum workers in the samples had 1 to 10 years of relevant experience. The workers were involved in different types of jobs associated with mining (Table 2). Data also reveal illustrate that around 10% of the workers were supervisors while more than 70% workers were the laborers, face workers or haulage operators, who are directly exposed to all the problems and suffer due most of the incidents.

Table 2. Job status of the workers

Age group (Years)	Total Work Experience			Total %age (count)
	01-10 years %age (count)	11-25 years % age (count)	26-40 years % age (count)	
15-25	26(47)	1(1)	0	27(48)
26-35	20(35)	21(38)	0	41(73)
36-45	7(12)	9(17)	6(10)	22(39)
46& above	1(2)	3(6)	6(11)	11(19)
Total	54(96)	35(62)	12(21)	100(179)

*Others include: Shot Firer, Mechanics, Electricians, Timber men.

Results and Discussion

Hazards in Mines Workplaces

Safe performance of workers depends on the physical environment of the workplaces and act of the individuals. Unsafe working environment or conditions in mines are major source of accidents and diseases. It is therefore, important to identify the hazardous working conditions in mines. During survey of this study the workers were asked to identify different hazards associated with mining at workplaces. Major causes of accidents mentioned were the roof and sidewalls strength conditions, mine gases and dust, explosives and mine machinery (Fig. 1).

Factors of Accident

Beside hazards there are other several factors which are responsible for accidents in mines. Among them violation of rules and regulations, carelessness, negligence of safety procedures and lack of proficiency are common. The view of the workers was sought about these factors on four-point scale with 4 for great extent and 1 to show that these factors are common in their

places. Mine workers admit that they are equally responsible in causing accidents (Fig. 2). The risk of accidents due to human error can be reduced by safety awareness, positive motivation and related training.



Fig. 1 Hazards in workplaces

Relationship between age group and involvement in accidents

Accidents occur in mines frequently and workers of all age group are involved in these accidents. The miners were asked to give response about the frequency of accidents on a three-point scale i.e. none, 1-3 times and more than three times. The workers of the CCM faced more accidents than ACM and ASM. The percentage of workers in the age group 26 - 35 of each mine faced more accidents than other age groups on the scale of 1-3 times (Table 3).

Table 3 Injuries with 1-3 workdays off.

		Percentage			
Age Group		None %age (count)	1-3 times %age (count)	More than 3 times %age (count)	Total %age (count)
Cherat Coal Mines	15-25 years	17(17)	3(3)	1(1)	21(21)
	26-35 years	32(32)	13(13)	0	45(45)
	36-45 years	17(17)	8(8)	0	25(25)
	46 years & above	7(7)	2(2)	0	9(9)
	Total	73(73)	26(26)	1(1)	100(100)
Abbottabad Coal Mines	15-25 years	31(12)	0	0	31(12)
	26-35 years	31(12)	5(2)	3(1)	38(15)
	36-45 years	18(7)	3(1)	0	21(8)
	46 years & above	5(2)	5(2)	0	10(4)
	Total	56(22)	41(16)	3(1)	100(39)
Abbottabad Soapstone Mines	15-25 years	38(15)	0	0	38(15)
	26-35 years	25(10)	8(3)	0	33(13)
	36-45 years	13(5)	3(1)	0	15(6)
	46 years & above	10(4)	5(2)	0	15(6)
	Total	85(34)	15(6)	0	100(40)

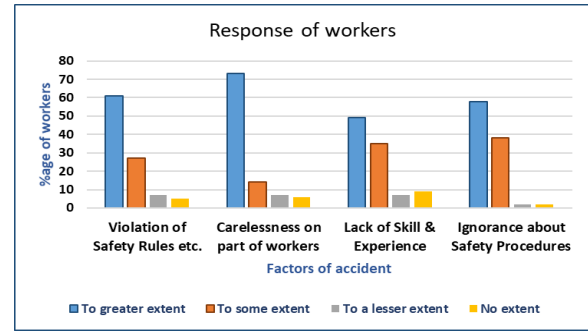


Fig 2. Factors of Accident

Table 4. Serious injuries with 20 workdays off

		Percentage			
Age Group		None %age (count)	1-3 times %age (count)	More than 3 times %age (count)	Total %age (count)
Cherat Coal Mines	15-25 years	19(19)	2(2)	0	21(21)
	26-35 years	35(35)	8(8)	2(2)	45(45)
	36-45 years	20(20)	5(5)	0	25(25)
	46 years & above	7(7)	2(2)	0	9(9)
	Total	81(81)	17(17)	2(2)	100(100)
Abbottabad Coal Mines	15-25 years	31(12)	0	0	31(12)
	26-35 years	38(15)	0	0	38(15)
	36-45 years	21(8)	0	0	21(8)
	46 years & above	8(3)	3(1)	0	10(4)
	Total	97(38)	3(1)	0	100(39)
Abbottabad Soapstone Mines	15-25 years	38(15)	0	0	38(15)
	26-35 years	33(13)	0	0	33(13)
	36-45 years	15(6)	0	0	15(6)
	46 years & above	13(5)	3(1)	0	15(6)
	Total	98(39)	3(1)	0	100(40)

About 17% of CCM workers had 1 to 3 accidents and 2% faced serious accidents more than 3 times serious accidents for which they had to take off from their work up to 20 days. The frequency of serious accidents in ACM and ASM is relatively low. About 3% workers from these mines received injuries due to which they have to off from their work. Data show that serious accidents occur in all three mines but the incidence rate in CCM is two times higher (Table 4).

During one year, several minor accidents occurred in these mines in which 7% of CCM workers and up to 3% each from other two mines faced more than 3 times minor injury for which they do not need to have day off. More than 40% of the total workers in each mine were involved in the minor accidents. It shows that minor accidents occur frequently in these mines (Table 5).

Based on analysis of data collected from different mines it is concluded that the providing safe environment to mine workers is an important issue in these mines which is due to lack of financial and technical resources. The safety is not treated on priority basis in mines. The

standards of the physical environment are not satisfactory which result in frequent accidents. Workers are not properly trained which increases the risks of accidents. The dust is common problem in these mines but no proper record of occupational diseases was found. Rules and regulations are not followed by all the stakeholders which leads to fatalities.

Table 5. Minor injury with no workday loss.

	Age Group	Percentage			
		None %age(count)	1-3 times %age(count)	More than 3 times %age(count)	Total %age(count)
Cherat Coal Mines	15-25 years	14(14)	6(6)	1(1)	21(21)
	26-35 years	22(22)	19(19)	4(4)	45(45)
	36-45 years	14(14)	9(9)	2(2)	25(25)
	46 years & above	4(4)	5(5)	0	9(9)
	Total	54(54)	39(39)	7(7)	100(100)
Abbottabad Coal Mines	15-25 years	13(5)	18(7)	0	31(12)
	26-35 years	28(11)	8(3)	3(1)	38(15)
	36-45 years	13(5)	8(3)	0	21(8)
	46 years & above	3(1)	8(3)	0	10(4)
	Total	56(22)	41(16)	3(1)	100(39)
Abbottabad Soapstone Mines	15-25 years	28(11)	10(4)	0	38(15)
	26-35 years	23(9)	10(4)	0	33(13)
	36-45 years	10(4)	5(2)	0	15(6)
	46 years & above	3(1)	10(4)	3(1)	15(6)
	Total	63(25)	35(14)	3(1)	100(40)

Conclusion

To reduce the number and severity of accidents in mines the workers as well as management should be provided regular safety related training along with other skills development trainings. The personal protective equipment should be provided and its use should be ensured. Regular medical facilities should be provided and documented. The inspector of mines should make mandatory is its implement the mine laws by the workers as well by the management. The existing legislation is old and is no more compatible with the current requirements of the mining industry. The mining legislation needs to be revised keeping in mind the current safety and environmental requirements of the industry.

References

Amponsah-Tawiah, K., Jain, A., Leka, S., Hollis, D., Cox, T. (2013). Examining psychosocial and physical hazards in the Ghanaian mining industry and their implications for employees' safety

experience. *Journal of Safety Research*, **45**,75–84. <https://doi.org/10.1016/j.jsr.2013.01.003>

Ayaaba, E., Liu, Y., Li, Y., Han, L., Yedu, Q., Chunhui, N. (2017). Measures to control the prevalence of pneumoconiosis in coal mining: a review of the literature. *International Journal of Translational Medical Research and Public Health*, **1**(1). <https://doi.org/10.21106/ijtmrph.14>

Aydin, H. (2010). Evaluation of the risk of coal workers pneumoconiosis (CWP): A case study for the Turkish hardcoal mining. *Scientific Research and Essays*, **5** (21), 3289–3297.

CIM. (2004). Annual Report. Chief Inspector of Mines, Government of the Punjab Mines & Minerals Department.

Gunson, A.J., Jian, Y. (2001). Artisanal mining in the people's republic of China. *Mining, Minerals and Sustainable Development*, (74),19.

Hartman, H. L. (1961). Mine ventilation and air conditioning. <https://doi.org/10.20944/preprints201811.0602.v1>

ILO. (2019). Flagship programme strategy. in safety and health for all. The ILO flagship programmes. Route des Morillons 4 CH-1211 Geneva 22 Switzerland.

Jadoon, K. G., Edwards, J. S. (1999). Risk evaluation of lost-Time injuries in the coal mining industry of Pakistan. *Journal of Eng. and App. Sciences*, **38**(4), 34–40. https://doi.org/10.1007/0-387-30843-1_282

Jadoon, K. G., Edwards, J. S., Akbar, S. (2004). Safety trends in small-scale coalmines in developing countries with particular reference to china, India and Pakistan. *Journal of Engineering and Applied Sciences*, 23–30. Retrieved from <http://www.irisk.se>

Jamison, D. T., Nugent, R., Gelband, H., Horton, S., Jha, P., Mock, R. L. C. N. (2017). Injury Prevention and Environmental Health. *Disease Control Priorities, Third Edition (Volume 7)*, 7, 133–152.

OSHA. (1998). Toxicologic Review of selected chemicals. [https://doi.org/Chronic ischaemic mitral regurgitation. Current treatment results and new mechanism-based surgical approaches](https://doi.org/Chronic%20ischaemic%20mitral%20regurgitation.%20Current%20treatment%20results%20and%20new%20mechanism-based%20surgical%20approaches)☆

Quanlong Liu, Xianfei Meng, Maureen Hassall, X. L. (2016). Accident-causing mechanism in coal mines based on hazards and polarized management. *Safety Science*, **85**, 276–281. <https://doi.org/10.1016/j.jclepro.2016.04.124>

Trevits, M A, Yuan, L., Smith, A. C., Thimons, E. D., Goodman, G. V. (2008). The Status of Mine Fire

Research in the United States. *Proceedings of the 21st World Mining Congress, September 7-11, 2008, Krakow, Poland.*, 303–308. <https://doi.org/https://www.cdc.gov/niosh/mining/works/cover sheet448.html>

Trevits, Michael A., Smith, A. C., Brune, J. F. (2007). Remote Mine Fire Suppression Technology. *Proceedings of the 32nd International Conference of Safety in Mines Research Institutes, 28-29 September 2007 Beijing, China. Proceedings of the 32nd International Conference of Safety in Mines Research Institutes, 28-29 September 2007 Beijing, China.*, 306–312. Retrieved from [https:// www.cdc.gov/niosh/mining/works/cover sheet785.html](https://www.cdc.gov/niosh/mining/works/cover sheet785.html)