ORIGINAL PAPER

Prevalence and Correlates of Lung Function Impairment Among Miners at Nchanga Open-Pit Copper Mine in Chingola, Zambia

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ABSTRACT

Background: Mineral extraction operations are dusty operations as they are characterized by large quantities of dust emissions. Persons working in such environments are potentially exposed to the harmful effects of respirable mineral dust, such as impaired lung function. This study investigated the prevalence and correlates of lung function impairment among open-pit miners at the Nchanga open-pit mine in Chingola, Zambia.

Methodology: A cross-sectional study was conducted in which all miners aged 18 years or older and had worked in the open-pit mine for at least 3 years were eligible to participate in the study. The uncorrected Pearson's Chi-square and the Fischer's exact tests were used to determine associations between exposure factors and the outcome. The level of statistical significance was set at 5%. A multivariate logistic regression analysis was used to adjust for possible confounding factors. Adjusted odds ratios and their 95% confidence intervals are reported.

Results: A total of 122 miners participated in the survey. Most of the participants were of age 45-54 years (58.2%), had more than 5 years of working experience (87.8%), and had attained secondary level education (87.7%). Overall, 27% participants (3.3% severe, 4.1% moderate, and 19.7% mild) had lung function impairment. Participants who had morning cough were 3.44 (95% CI 1.10, 10.70) times more likely to have had lung function impairment compared to those who did not have morning cough. Also, participants who had chest tightness in the past year were 2.37 (95% CI 1.22, 4.62) times more likely to have had lung function impairment compared to those who did not have chest tightness in the same period.

Conclusion: A high prevalence of lung function impairment was observed in this workforce. Morning cough and chest tightness could be used for early detection of cases of lung function impairment, and appropriate measures taken to reduce its prevalence.

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INTRODUCTION

Mining operations contaminate air with dust particles. These can singly or in combination cause lung function impairment if inhaled over a long period of time [1, 2]. Several millions of people are employed in the mineral extraction industry and these workers are exposed to the harmful effects of the respirable dust which include pneumoconiosis and impaired breathing [3].

Recent data from Zambia in a report by Simpere [4] indicate that working conditions in some mines are difficult and this is attributed to little or no ventilation whilst dusty operations are taking place. Industrial hygiene and dust control in the developing countries (which include Zambia) are still poor[5]. Studies have shown that weak dust monitoring exists in the Zambian mines and this may increase the risk of non malignant respiratory disease in many miners[6].

There is scanty information on the prevalence of lung function impairment world-wide. A study in a large open-pit copper mine in Mexico showed that a substantial percentage of miners had adverse respiratory symptoms. Further, obstructive patterns were found in 23% of miners and 3% had significant lung function impairment due to

dust exposure. Despite the fact that substantial progress has been made in the control of occupational health hazards, there remains room for further risk reduction [3,7,8].

In Zambia, there is no information on the prevalence of lung function impairment among miners. The present study aimed at determining the prevalence and correlates of lung function impairment among miners in an open-pit copper mine.

METHODS

Study design, sample size and sampling

This was a cross-sectional study conducted at the Nchanga open-pit mine, Chingola, Zambia after obtaining approval from the University of Zambia Biomedical Ethics committee. Since the prevalence of lung function impairment was unknown in the population of miners, it was assumed to be at 50%. Using Epi-Info software, the sample size for an infinitely large population was calculated to be 384. This was however adjusted to a finite population of 178 miners in the open-pit production area and therefore gave a sample size of 129 (after adjusting for a non-response of 5%). A stratified sampling method by section was used to select miners from the target population of 178. This target population was divided into three strata based on the job types and then simple random sampling proportional to the population size in each stratum was done to select the 129 miners. The first stratum had 48 miners; the second stratum had 38 miners while the last stratum had 78 miners.

Enrolment of the participants took place from November, 2011 to December, 2011. All consenting miners were requested to take part in the study if they had worked in the open-pit for at least 3 years, were aged 18 years and older, and worked in the open-pit production area. Recruitment was from Monday to Friday during all three shifts and an average of 10-14 eligible miners were enrolled to take part in the study per day.

Data collection

Using a structured questionnaire, information on demographic characteristics, respiratory symptoms, smoking, asthma, and also personal protective equipment was obtained. The participants also had their lung function measured with a Spiro bank G spirometer. The variables that were collected were FVC and FEV_1. The data were transcribed and entered into the computer using Epi-data software.

Three readings of lung function tests were made. A mean of these three readings was considered as the reading for an individual. FEV_1/FVC% was categorized as <40=Severe, 40-54=Moderate, 55-70=Mild, >70=Normal [9]. Any average lung function reading that was in the categories Severe, Moderate or Mild was considered to be impaired lung function.

Data analysis included running frequencies and generating appropriate tables. The uncorrected Pearson's Chi-square and the Fischer's exact (when expected frequencies were less than 5) tests were used to determine associations between exposure factors and the outcome. The level of statistical significance was set at 5%. A multivariate logistic regression analysis was used to adjust for possible confounding factors. Adjusted odds ratios and their 95% confidence intervals are reported.

RESULTS

Sample description

A total of 122 out of 129 miners participated in the survey, giving a response rate of 94.6%. Out of the 122 participants who were interviewed, 94.3 % of them were married. In terms of age, 58.2% of the respondents were in the age group 45-54 years. As for the duration of employment/service, 87.8% of the respondents reported that they had worked for a longer duration (6 years and above). For the educational level, 87.7% of the participants reported to have completed secondary level of education.

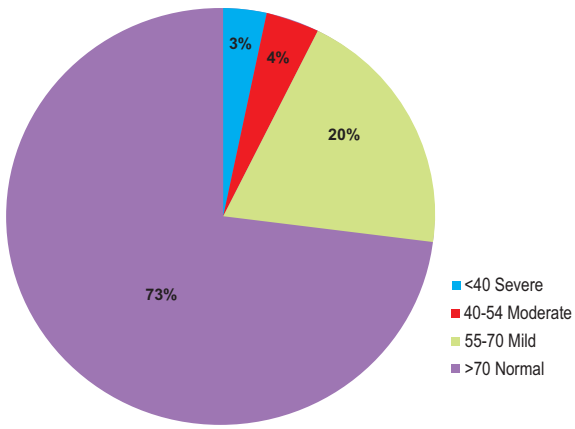
Table 1: Sample description of open-pit miners at the Nchanga copper mine

	Frequency	Percent
Age Group		
25 - 34	22	18
35 - 44	29	23.8
45 - 54	71	58.2
Marital Status		
Single	6	4.9
Married	115	94.3
Separated/Divorced/ Widowed	1	0.8
Duration of Employment		
Short (3 - 5 years)	15	12.3
Long (>6 years)	107	87.7
Educational level		
Primary	2	1.6
Secondary	107	87.7
Tertiary	13	10.7

Lung function value FEV1/FVC percent

Of the 122 respondents who were measured for lung function, 3.3% had severe lung function, 4.1% had moderate lung function, and 19.7% had mild lung function; while 73.0% had normal lung function. Overall, 27.0% of the participants had impaired lung function.

Figure 1 Lung function proportions among the open-pit miners at Nchanga copper mine n=122



Socio-demographic factors associated with lung function impairment

In bivariate analysis, age, educational level and duration of employment were not statistically significantly associated with lung function impairment.

Table 2: Socio-demographic factors associated with lung function impairment

	LUNG FUNCTION IMPAIRMENT Impairment n (%)	Normal n (%)	P-Value
Age	Total=33	Total=89	
25-39	9 (27.3)	28 (31.5)	
40-54	24 (72.7)	61 (68.5)	0.655
Educational Level	Total=33	Total=89	
Lower	29 (87.9)	80 (89.9)	
Upper	4 (12.1)	9 (10.1)	0.747
Duration of Employment	Total=33	Total=89	
3-5 Years	5 (15.0)	10 (11.2)	0.547
6 and above Years	28 (85.0)	79 (88.8)	

Personal protective equipment (PPE) associated with lung function impairment

Use of hard hat, safety goggles, respirator, work suit, and PPE in the summer were not statistically significantly associated with lung function impairment.

Table 3: PPE associated with lung function impairment

	LUNG FUNCTION IMPAIRMENT Impairment n (%)	Normal n (%)	P-Value
PPE			
Hard hat	Total=33	Total=89	
Yes	33 (100)	87 (98.0)	
No	0 (0)	2 (2.0)	1.000
Safety goggles	Total=33	Total=89	
Yes	28 (22.9)	80 (65.6)	
No	5 (4)	9 (7.4)	0.520
Respirator	Total=33	Total=89	
Yes	28 (85.0)	80 (89.9)	
No	5 (15.0)	9 (10.1)	0.520
Work suit	Total=33	Total=89	
Yes	32 (97.0)	87 (98.0)	
No	1 (3.0)	2 (2.0)	1.000
Wearing PPE in the summer	Total=33	Total=89	
Yes	24 (72.7)	60 (67.4)	
No	9 (27.3)	29 (32.6)	0.574
Frequency of using PPE	Total=33	Total=89	
Once	0 (0)	1 (1.1)	
Sometimes	12 (36.4)	34 (38.2)	
All the time	21 (63.6)	54 (60.7)	0.765

Symptoms (including smoking) associated with lung function impairment

Bivariate analysis showed that smoking, phlegm, wheeze, shortness of breath and chest tightness were not statistically significantly associated with lung function impairment. However, morning cough and chest tightness were statistically significantly (p=0.019 and p=0.009, respectively) associated with lung function impairment.

In multivariate analysis, the adjusted odds ratios showed that there were no statistically significant associations between socio-demographic factors, PPE factors, smoking on one hand and lung function impairment on the other. Respiratory symptoms were also not statistically significantly associated with lung function impairment with an exception of morning cough and past chest tightness.

Table 4: Symptom associated with lung function impairment

	LUNG FUNCTION IMPAIRMENT Impairment n (%)	Normal n (%)	P-Value
Smoking	Total=33	Total=89	
Yes	3 (9.1)	7 (7.9)	
No	30 (90.9)	82 (92.1)	1.000
Coughing 1st thing in the morning	Total=33	Total=89	
Yes	4 (12.1)	1 (1.1)	
No	29 (87.9)	88 (98.9)	0.019
Coughing during the day or night	Total=33	Total=89	
Yes	3 (9.1)	4 (4.5)	
No	30 (90.9)	85 (95.5)	0.387
Phlegm	Total=33	Total=89	
Yes	8 (24.2)	15 (16.9)	
No	25 (75.8)	74 (83.1)	0.526
Years had trouble with Phlegm	Total=8	Total=15	
< Month	0 (0)	2 (13.3)	
> Month	8 (100)	13 (86.7)	0.351
Wheezing	Total=33	Total=89	
Yes	5 (15.2)	14 (15.7)	
No	28 (84.8)	75 (84.3)	0.938
Shortness of Breath	Total=33	Total=89	
Yes	2 (6.1)	13 (14.6)	
No	31 (93.9)	76 (85.4)	0.351
Chest tightness	Total=33	Total=89	
Yes	1 (3.0)	1 (1.1)	
No	32 (97.0)	88 (98.9)	0.469
Chest tightness in the past	Total=33	Total=89	
Yes	7 (21.2)	4 (4.5)	
No	26 (78.8)	85 (95.5)	0.009

Participants who had morning cough were 3.44 (95% CI [1.10, 10.70]) times more likely to have lung function impairment compared to participants who did not have morning cough. Compared to participants who did not have chest tightness, those who had chest tightness were 2.37 (95% CI [1.22, 4.62]) times more likely to have lung function impairment.

Table 5: Factors associated with lung function impairment

Factor	Adjusted Odds ratio	95% Confidence Interval
Morning Cough		
Yes	3.44	1.10, 10.70
No	1	
Had chest tightness in the past year		
Yes	2.37	1.22, 4.62
No	1	

DISCUSSION

We found that 3.3% of our study participants had severe lung function, 4.1% had moderate, and 19.7% had mild lung function impairment. We also found that morning cough and chest tightness were independently associated with lung function impairment.

Results on the prevalence of lung function impairment are comparable to those reported in Mexico, where the prevalence of obstructive pattern was 23% and significant impairment was 3% [7]. Prevalence rates of cough (9.8%), and wheeze (15.6%) found in the present study are comparable to those reported in Mexico of cough (12%) and wheeze (12%) [7]. While, the prevalence rates of phlegm (18.9%) in the present study is higher than that reported in Mexico (10%), the prevalence of shortness of breath (12.3%) in the current study is lower than that reported in Mexico (46%)[7].

Despite being dust of a different source (cement), our finding contradicts that found by Siziya et al [10] who reported that there was no significant difference in the prevalence of cough between the exposed (23.0%) and un-exposed (19.4%) persons.

It was reported that length of service was a predisposing risk factor for the occurrence of impaired breathing[5]. However, reported that there was no association between length of employment and lung function impairment[10]. This concurs with the current study where there was no significant association between duration of employment and Lung function impairment. The contradictory findings may be due to differences in length of employment between the study sites.

Nandi et al. and Al-Neaimi et al. it was stated that stated that among the measures for the control of the workplace environment, use of PPE would help reduce morbidity amongst the miners[11, 12]. None of these studies stated explicitly if PPE was associated with lung function impairment or the occurrence of respiratory symptoms. In the current study however, PPE was not significantly associated with the occurrence of impaired lung function.

It was reported that severe lung function impairment could be prevented through the elimination of tobacco smoking[13]. In the current study there was no association between smoking and lung function impairment which was different from that reported by. [13] but similar to Siziya et al. [10].

By design the current study was conducted as a cross-sectional study and therefore it could not establish

causality. In order to establish causality however, research in form of longitudinal studies would have to be conducted. If this was to be done, instead of focussing on mere exposure measured by the duration of employment, we suggest that instead, dust sampling should be done in order to establish the relationship between ambient dust breathed in by the participants and the occurrence of impaired lung function.

For variables such as PPE (which includes frequency of use), questions on the behaviours and attitudes towards the same would be more appropriate as opposed to questions phrased in a quantitative manner. We further suggest that using qualitative methods of collecting data as opposed to quantitative methods would best explore the possible associations that may exist among the variables of the study unlike the case in this current study.

Most of the exposures were self reported hence bias was introduced in the study. Another source of bias was the physical presence of the interviewer during the data collection process which may have influenced responses[14]. Perhaps this could be the reason for the lack of information on chronic bronchitis and also chronic asthma in the current study among the Nchanga open-pit miners. However, we are unable to determine the extent of the bias and its direction.

CONCLUSION

A high prevalence of lung function impairment was observed in this workforce. Most of the independent variables in this study were not significantly associated with the occurrence of lung function impairment with an exception of morning cough and chest tightness. We recommend that miners be checked for respiratory symptoms (including spirometry tests) in order to check for the development of significant pulmonary symptoms which may bring about early intervention and perhaps reduced prevalence.

ACKNOWLEDGEMENTS

We thank the management of the Nchanga mine for allowing us have access to their employees for this project. The employees are thanked for their cooperation.

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