An Analysis of the Mine Dust Exposure Risk and Other Risks for Tuberculosis Suspects Among the Workers of the People's Gold Mine in Poboya Village, Palu City

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ABSTRACT
The aim of study to determine risk level of dust in Poboya gold mining at Palu city. The risk factor correlation study on the tuberculosis pulmonary suspect on gold miners based on dust exposure duration, lack of nutritional status, alcohol consumption behavior and smoking behavior in Poboya gold mining of Palu city. The study was conducted in analytic observational by used cross sectional study design for suspected pulmonary tuberculosis (TB) and non-suspect in pulmonary TBs identified among mining worker in Poboya gold mining of Palu City. This study design was determined relationship between exposure and diseases at certain period in population. The samples are chosen by purposive sampling method. The samples were 136 male residents who lived in Poboya sub district and worked as traditional mining workers in gold mining in Poboya village of Palu city which their job scope related to dust and dig mining holes. There was a correlation between dust exposure duration to gold miners who worked more than 8 hours per day toward tuberculosis pulmonary suspect. Besides, lack of nutritional status also leads mining workers suffered tuberculosis pulmonary disease. The alcohol consumption is not related to tuberculosis pulmonary in mining workers. The smoking habit is most influential factors lead to TB pulmonary among mining workers and this study found most of respondents had smoked more than 20 cigarettes per day. The special attention needed on mining workers for their health problem especially in nutritional status and smoking habit.

CCS Concepts
- **Social and professional topics → User characteristics**

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Keywords
Gold mine; risk factor; tuberculosis pulmonary suspect

1. INTRODUCTION
Tuberculosis (TB) is among top disease caused death worldwide. An estimated 10.4 million new TB cases worldwide which 5.9 million (56%) were men and 1.2 million (11%) of new TB cases in people with HIV in 2015 [1]. There were seven countries had high TB cases included India, Indonesia, China, Philippines, Pakistan, Nigeria and South Africa [2]. Meanwhile, African region had highest TB cases with HIV infection. In United States, 9287 new TB cases had been recorded with case rate of 2.9 per 100, 000 in 2016 [3]. Based on World Health Organization (WHO), zero TB epidermic by 2030 was main health target in Sustainable Development Goals [2].

TB is infection diseases by mycobacterium TB complex included *M. Tuberculosis, M. Microti, M.bovi, M.canettii, M. pinnipedii and M. Africanum* [4-9]. Non-TB mycobacteria were *M. Intracellulare and M. Avium* [5]. *M.tuberculosis* is transmitted through airborne particles known as droplet nuclei. The *M.tuberculosis* spread through air but not surface contact from TB infected person to healthy person [5]. Many factors influenced airborne particles such as dimensions, composition, and velocity as well as temperature, humidity, air quality, and air movement [10]. The droplet nuclei traveled through mouth or nasal passages and reached at the lung [11].

The TB symptoms such as cough, weight loss, sputum, breath and sleep difficulty, fever, malaise and wasting [12-14]. The lantern TB infected individual had no any sign or symptom [15]. The *M.tuberculosis* is grown slowly with doubling time within 12-24 hours under specific condition [16,17]. The TB infection activated from half within first year and remained in lifetime [18]. No symptoms were common to TB. The 6 months or more treatment was introduced in cure of TB patients [19-22].

The gold miner is among high risk suffered tuberculosis pulmonary disease. In South Africa had recorded highest number of gold miners suffered tuberculosis pulmonary in world. There were some reasons gold miners had high risk to tuberculosis pulmonary such as exposure to silica dust and silicosis [23]. A study showed a relationship between mining production and TB

diseases in the population [24]. The comparison between country with gold mining production and non gold mining production country, observation was TB was higher occurred at the gold mining production. There was related to gold miners were exposed to high level of silica and other mineral dust.

In this study, the author was interested to determine risk level of dust in Poboya gold mining at Palu city. The risk factor correlation study on pulmonary tuberculosis suspect on gold miners based on dust exposure duration, lack of nutritional status, alcohol consumption behavior and smoking behavior in Poboya gold mining of Palu city.

2. METHODOLOGY

The study was conducted in analytic observational by used cross sectional study design that suspected pulmonary TB and non suspect in pulmonary TB is identified among mining worker in Poboya gold mining of Palu City. This study design was determined relationship between exposure and diseases at certain period in population. The samples were chosen by purposive sampling method. The samples were 136 male residents who lived in Poboya subdistrict and worked as traditional mining workers in gold mining in Poboya village of Palu city which their job scope related to dust and dig mining holes. The inform consent and questionnaires were provided to miners who willing involved in this study.

The respondent was identified based on TB symptoms such as persistent cough or more than two weeks. Meanwhile, dust measurement was determined based on point of measurement location and placed in an open area that not interfered with maximum air sampling. The study implementation was interview and observation in workplace health and environmental conditions of miners. Besides, body weight and height were measured on samples. The high volume air sampler (HVAS) was located at 2 points: excavation mining and gold material process. The personal dust sampler (PDS) was given to samples and used for 30 minutes per day.

The data collected based on pulmonary TB suspected, nutritional status, smoking habit, alcohol consumption and workplace environment condition. The statistical test on bivariate analysis was used chi-square test. The chi-square test was performed toward independent variable with dependent variable and alpha significant level (α) =0.05.

Meanwhile, multivariate analysis was conducted to observe relationship between independent variables with dependent variables. The analysis used was logistic regression analysis. The risk analysis has calculated total dust exposure level in mining on respondent (Intake/I) and total dust risk level in mining toward respondent (Risk Quotient/RQ).

Exposure level (Intake)

$$I = \frac{CxRxt_E x f_E x D_t}{W_b x t_{avg}}$$

I = Intake, total risk agent penetrated into human body (mg/kg/day)

C= risk agent concentration (mg/ m^3)

R= intake rate (m^3/hour)

t_E= exposure time (hour/day)

f_E= annual exposure frequency (day/year)

D_t= exposure period (years)

W_b= respondent body weight (kg)

t_{avg} = average period time (30 years x 365 days/years for noncarcinogen substances

Risk level

$$RQ = \frac{ln(k)}{RfC}$$

The risk management was used to understand health management risk reduction due to silica dust among community around gold mining of Poboya village in Palu city. Risk reduction management calculated by:

a) Concentration reduction

$$C = \frac{RfDxW_B x t_{avg}}{Rx f_E x D_t} \text{mg/L}$$

b) Consumption rate reduction

$$R = \frac{RfDxW_B x t_{avg}}{C_{As} x f_E x D_t}$$

c) Exposure duration limit

$$D_t = \frac{RfDxW_B x t_{avg}}{CxRx f_E}$$

D_t = Exposure duration

RfD = Reference dose

W_B = Body weight (kg)

C = contaminant concentration (mg/kg) or (mg/L)

t_{avg} = average period (70 years for cancer effect)

R = intake rate

f_E = annual exposure frequency (day/year)

3. RESULT AND DISCUSSION

3.1 Univariate Analysis

Based on Table 1, most of respondents aged 40-44 years (27.2%). There were 24 respondents (25.3%) with non TB suspect aged 40-44 years. Meanwhile, 13 respondents (31.7%) was TB suspect aged 40-44 years. In addition, 40 respondents (28.7%) was not attended school and 15 respondents with suspect TB was junior high school. There were 27 respondents with non TB suspect was not attended school. There were 86 respondents had fever among miner workers and 54 respondents had abnormal heart rhythm in gold mining of Poboya village in Palu city.

Based on Table 2, there were 41 respondents suspected had continuously cough more than 2 weeks and 33 respondents had experienced weight loss. Most of suspected respondents (29 respondents) and 57 non-suspected respondents had fever.

The dust intensity was air ambient level measurement was measure in mining workers used HVAS as shown in Table 3. The point 1 was selected at 75 m above sea level and point 2 was located at 40 m above sea level. Based on Table 4, there were 94 respondents (69.1%) worked at point 2 and 42 respondents (30.9%) worked at point 1. There were 7 respondents with TB suspect (17.1%) and 35 respondents with non TB suspect (36.8%) worked at point 1. Meanwhile, 34 respondents (82.9%) with TB suspect and 60 respondents (63.2%) with non TB suspect worked at point 2.

Table 1. Characteristic respondent distribution based on age and education among mining workers in gold mining at Poboya village of Palu city 2015.

Characteristics	TB Pulmonary				Total	
	Suspected		Non Suspected			
	n	%	n	%	n	%
Age (Years)						
20-24	1	2.4	7	7.40	8	5.9
25-29	3	7.3	10	10.5	13	9.6
30-34	4	9.8	15	15.8	19	14.0
35-39	6	14.6	17	17.9	23	16.9
40-44	13	31.7	24	25.3	37	27.2
45-49	7	17.1	1	12.6	19	14.0
50-54	5	12.2	5	5.3	10	7.4
55-59	2	4.9	2	2.1	4	2.9
60-64	0	0.0	3	3.2	3	2.2
Total	**41**	**30.1**	**95**	**69.9**	**136**	**100.0**
Education						
Not attended school	13	30.8	27	28.4	40	28.7
Primary school	6	14.6	26	27.4	32	23.5
Junior high school	15	39.0	20	21.1	35	26.5
Senior high school	7	17.1	21	22.1	28	20.6
Academic/Education/ Undergraduate	0	0.0	1	1.1	1	0.7
Total	41	30.1	95	69.9	136	100.0

Source: Primary data, 2015

Table 4 showed respondent distribution based on exposure dust period in mining worker. There were 85 respondents (62.5%) had worked more than 8 hours per day, while 51 respondents (37.50%) worked less than 8 hours per day. Based on Table 5, there were 87 respondents (63.97%) worked on hole excavation. Meanwhile, 14 respondents (10.29%) worked as mining supervisor.

Based on Table 6, 70 respondents (51.50%) experienced underweight and 66 respondents (48.50%) had normal nutritional status.

Based on Table 7, 92 respondents (67.6%) had consumed alcohol and 44 respondents never consumed alcohol. There were 69 respondents (50.70%) had consumed more than 4 glasses alcohol per day and 67 respondents (49.30%) consumed than 4 glasses per day.

In Table 8, there were 107 respondents (78.70%) had smoking and 29 respondents (21.30%) were non-smoking. There were 30 respondents (22.10%) had smoking more than 20 years and 59 respondents (43.40%) had smoked between 10 years and 20 years. Meanwhile, 66 respondents (48.50%) had smoked more than 20 cigarettes per day and 70 respondents (51.50%) had smoked less than 20 cigarettes. There were 73 respondents (53.70%) had smoked filter smoking types and 34 respondents (25.00%) had smoked non-filter smoking types.

Table 2. Health Disorders and Symptoms distribution of Mine workers in gold mining of Poboya village in Palu city 2015.

Health disorder and symptoms	TB pulmonary				Total	
	Suspected		Non suspected			
	n	%	n	%	n	%
Persistent cough more than 2 weeks	41	100.0	0	0.00	41	100.0
Difficulty in breath	21	42.00	36	58.00	57	100.00
Chest pain	27	64.30	15	35.70	42	100.00
Fever	29	33.70	57	66.30	86	100.00
Night sweat	30	53.60	22	47.40	52	100.00
Abnormal heart rates	19	30.20	35	64.80	54	100.00
Loss appetite	16	34.00	31	66.00	47	100.00
Weight Loss	10	30.30	23	69.70	33	100.00

Source: Primary data,2015

Table 3. Respondents distribution based on dust intensity on mining workers at gold mining in Poboya village of Palu city 2015.

Dust Intensity	TB Pulmonary				Total	
	Suspect		Non suspect			
	n	%	n	%	n	%
Point 1	7	17.10	35	36.80	42	30.90
Point 2	34	82.90	60	63.20	94	69.10
Total	41	100.00	95	100.00	136	100.00

Source: Primary data, 2015

Table 4. Respondents distribution based on exposure dust period in mining worker at gold mining in Poboya village of Palu city 2015.

Exposure period (hour)	n	%
>8	85	62.50
≤8	51	37.50
Total	136	100.00

Source: Primary data, 2015

Table 5. Mining work distribution among mining worker at gold mining in Poboy village of Palu city 2015.

Mining work types	n	%
Hole excavation	87	63.97
Ground excavation	48	35.29
Mining supervisor	14	10.29
Gold deposit process	25	18.38
Material load	26	19.12

Source: Primary data,2015

Table 6. Respondent distribution based on nutritional status of mining workers at gold mining in Poboya village of Palu city 2015.

Nutritional status (BMI)	n	%
<18.5	70	51.50
≥18.5	66	48.50
Total	136	100.00

Source: Primary data, 2015

Table 7. Respondents distribution based on alchol consumption habit of mining workers at gold mining in Poboya village of Palu city 2015.

Alcohol Consumption Habit	n	%
Alcohol consumption		
Yes	92	67.60
No	44	32.40
Alcohol consumption per day (glasses)		
>4	69	50.70
≤4	67	49.30
Total	**136**	**100.00**

Source: Primary data,2015

Table 8. Respondents distribution based on smoking habit of mining worker at gold mining in Poboya village of Palu city 2015.

Smoking Habit	n	%
Smoking		
Yes	107	78.70
No	29	21.30
Smoking history (years)		
Non-smoking	29	21.3
<20	18	13.2
10-20	59	43.4
>20	30	22.1
Smoking habit per day		
>20	66	48.5
≤20	70	51.5
Smoking types		
Non-smoking	29	21.3
Filter	73	53.7
Non filter	34	25.0
Total	136	100.0

Source: Primary data, 2015

3.2 Bivariate Analysis

Table 9. Relationship of dust exposure duration toward the tuberculosis pulmonary .

Exposure Duration (hour)	Tuberculosis pulmonary				Total		X^2 p value
	Suspect		Non suspect				
	n	%	n	%	n	%	
>8	32	78.0	53	55.8	85	62.50	5.14 0.02
≤8	9	22.0	42	44.2	51	37.50	
Total	**41**	**30.1**	**95**	**69.9**	**136**	**100.0**	

Source: Primary data, 2015

Table 9 showed that 78% (32 people) tuberculosis pulmonary suspect and 55.8% (53 people) of non suspect for tuberculosis pulmonary worked more than 8 hours per day. Based on Table 1 showed that p value =0.02, and concluded that dust exposure duration was significantly related to tuberculosis pulmonary suspect.

Table 10. Relationship of nutritional status toward tuberculosis pulmonary suspect.

Nutritional status (BMI)	Tuberculosis pulmonary				Total		X^2 p value
	Suspect		Non suspect				
	n	%	n	%	n	%	
<18.5	27	65.90	43	45.30	70	51.50	4.07 0.04
≥18.5	14	34.10	52	54.70	66	48.50	
Total	**41**	**30.10**	**95**	**69.90**	**136**	**100.00**	

Source: Primary data, 2015

Based on Table 10 showed that 27 people (65.90%) tuberculosis pulmonary suspect suffered less nutritional status. Meanwhile, 52 people (54.7%) of tuberculosis pulmonary non suspect achieved normal nutritional status. There was related between less nutritional status with tuberculosis pulmonary suspect.

Table 11. Relationship alcohol consumption habit toward the tuberculosis pulmonary suspects.

Nutritional status (BMI)	Tuberculosis pulmonary				Total		X^2 p value
	Suspect		Non suspect				
	n	%	n	%	n	%	
>4	26	63.40	43	45.30	69	50.70	3.08 0.08
≤4	15	36.60	52	54.70	67	49.30	
Total	**41**	**30.10**	**95**	**69.90**	**136**	**100.00**	

Source: Primary data, 2015

Table 12 showed tuberculosis pulmonary suspect had consumed more than 4 glasses of alcohol per day, 63.4% (26 people). There was 54.7%(52 people) of tuberculosis pulmonary non suspect had consumed less than 4 glasses per day. Based on Table 12, alcohol consumption habit was not related to tuberculosis pulmonary suspect (p>0.08).

Table 12. Relationship smoking habit toward tuberculosis pulmonary suspects.

Nutritional status (BMI)	Tuberculosis pulmonary				Total		X^2 p value
	Suspect		Non suspect				
	n	%	n	%	n	%	
>20	28	68.30	38	40.00	66	48.50	8.08 0.004
≤20	13	31.70	57	60.00	70	51.50	
Total	**41**	**30.10**	**95**	**69.90**	**136**	**100.00**	

Source: Primary data, 2015

Based on Table 12, respondent with tuberculosis pulmonary suspect smoked more than 20 cigarettes per day, ehich was 68.3% (28 people). Meanwhile, 60.0% (57 people) of tuberculosis pulmonary non suspect had smoked less than 20 cigarettes per day. The analysis result showed p value =0.004 and concluded that smoking habit had influenced toward tuberculosis pulmonary suspect.

3.3 Multivariate Analysis

In Table 13, there were nutritional status and smoking habit had influenced TB suspect among mining workers in gold mining area. The smoking habit was most influenced factor in TB suspect with OR=2.67. In Table 14, the smoking habit was most influenced factor in gold mining at Poboya village with OR=3.5.

Table 13. Modelling Multivariate Analysis of Exposure dust risk and other risk to TB pulmonary suspect in gold mining at Poboya village of Palu city 2015.

Study variable	B	Wald test	Sig.	Exp (B)	95% CI	
					Lower	Upper
Exposure Duration	0.72	2.45	0.12	2.06	0.83	5.07
Nutritional status	0.89	4.61	0.03	2.42	1.08	5.44
Alcohol consumption status	0.44	1.15	0.28	1.56	0.69	3.50
Smoking Habit	0.98	5.22	0.02	2.67	1.15	6.19
Constant	-0.44	1.48	0.22	0.64	-	-

Source: Primary data,2015

Table 14. Modeling of Multivariate Advanced Analysis of Dust exposure risks and other risks in TB pulmonary suspects in gold mining at Poboya village of Palu city 2015.

Study variables	B	Wald	Sig.	Exp (B)	95% CI	
					Lower	Upper
Nutritional status	0.95	5.47	0.02	2.59	1.17	5.75
Smoking habit	1.25	9.45	0.00	3.50	1.58	7.78
Constant	-0.15	0.23	0.63	0.86	-	-

Source: Primary data,2015

Table 15 showed risk management had obtained RQ<1 value on seven respondents, this study indicated that with risk management had reduced intake rate, dust exposure at gold mining in Poboya village of Palu city.

Table 15. Anthropometric tables, exposure factor and risk characteristics after risk management implementation.

C (mg/m^3)	R (mg/ m^3/day)	t_E(hour/year)	f_E(day/year)	D_t(year)
0.0768	0.00325	5	360	2
0.0768	0.00136	8	335	8
0.0768	0.00190	12	360	4
0.0966	0.00945	12	360	8
0.0966	0.00142	10	360	4
0.0966	0.00151	14	360	4
0.0966	0.00105	8	346	6

Source: Primary data, 2015

Table 16. Anthropometric tables, exposure factor and risk characteristics after risk management implementation.

W_b(kg)	t_{avg}	$ln(k)$	RQ
41	10950	$2x10^{-6}$	0.01
64	10950	$32x10^{-7}$	0.01
48	10950	$48x10^{-7}$	0.01
60	10950	$48x10^{-7}$	0.01
45	10950	$4x10^{-6}$	0.01
48	10950	$56x10^{-7}$	0.01
48	10950	$32x10^{-7}$	0.01

Source: Primary data, 2015

3.4 Overall Discussion

The result found dust concentration at 2 points was 76.8µg / m3 and 96.56 µg / m3 which still within threshold value (NAB) was 230 µg / m3. RQ calculation for dust content more than 1 and average value of RQ for this study was 2.94. This indicated that dust in gold mining had risk in mining worker's health. The personal protective equipment (PPE) was useful in protected mining worker in dust exposure. The silica exposure was an effective way in TB incidence. The silica exposure had increased TB risk even in absence of silicosis [25,26].

The gold miners in Poboya gold mining in Palu city worked more than 8 hours per day, that was equal to 62.5%. Based on Table 10, 78% (32 people) of tuberculosis pulmonary suspect worked more than 8 hours per day and 55.8% (53 people) of tuberculosis pulmonary non suspect worked more than 8 hours per day. From mean value, average miner in Poboya gold mining in Palu city worked for 10 hours which exceeded standard working hour that specified in Government Regulations No. 41 year 1999.There was significantly relationship between exposure duration with TB suspect (p=0.02<0.05). A study showed silica exposure among workers had increased risk in TB diseases [27]. Besides, dust exposure among mining workers was higher even without silicosis for TB incidence [28].

More respondents had less nutrient as much as 70 people (51.5%). Based on Table 11, 65.9% (27 people) with tuberculosis pulmonary had less nutritional status, whereas 52 people (54.7%) of tuberculosis pulmonary had normal nutritional status. The result had indicated nutritional status had related to tuberculosis pulmonary suspect (p=0.04). A study suggested that obesity and overweight had lower risk on TB infection compared person with normal BMI [29]. The gold miners had more working time and too active were high risk to suffer tuberculosis pulmonary. Besides, working environment and miner's behavior itself also had high risk in suffering tuberculosis pulmonary.

Meanwhile, 67.6 % of gold miners were consumed alcohol which was consumed more than 4 glasses per day. Based on the analysis result, alcohol consumption habit was not related to tuberculosis pulmonary suspect (p=0.08). This study was opposite with a study suggested heavy alcohol used and tuberculosis pulmonary was related [30]. Based on this study, respondent who had suspected tuberculosis pulmonary consumed more 4 glasses per day which equal to 63.4% (26 people), in contrast with the respondents who were tuberculosis pulmonary non suspect had consumed less than 4 glasses per day, 54.7% (52 people).

The smoking habits is among factors caused TB pulmonary. The result showed that the smoking habit was related to tuberculosis pulmonary suspect in the gold miners in Poboya gold mining at Palu city (p =0.004). The smoking is more dominated in developed countries. From this study also showed smoking habit was found in low income person. The younger age involved in smoking had high risk in TB infection. The smoking habit variable was the most influential variable to suspect the tuberculosis pulmonary in the mining workers. In this study was found that more respondents smoked than non-smokers, which was 78.7% (107 people). The respondents about 66 peoples that consumed more than 20 cigarettes per day while the respondents who smoked less than equal to 20 cigarettes per day as much as 70 people (51.5%).

4. CONCLUSION

In conclusions, there was a correlation between dust exposure duration to the gold miners who worked more than 8 hours per day toward the tuberculosis pulmonary suspect. Besides, lack of nutritional status also leads mining workers suffered tuberculosis pulmonary disease. The alcohol consumption was not related to tuberculosis pulmonary in the mining workers. The smoking habit was most influential factors lead to TB pulmonary among mining workers and most of respondents had smoked more than 20 cigarettes per day. The special attention needed on mining workers on their health problem especially in nutritional status and smoking habit.

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