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Study of tuberculosis associated workplace risk factors among coal miners

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Abstract
Workplace screening of infectious diseases acts as the keystone in working environment in order to combat the associated risks. Present study was carried out to pin point risk factors associated with TB burden among coal workers, who live and work in hostile conditions conducive for spread of *Mycobacterium tuberculosis*. Chromatographic immunoassay technique was to diagnose disease. Standard questionnaire was used to obtain information regarding working conditions, living conditions and demography. Coal mining sites were acting as hot spots for dispersion of *Mycobacterium tuberculosis* (OR= 12.171), being migrant (OR=15.282), improper sneezing and coughing (OR=5.554), sharing of utensils (OR=5.554), single room for more than four workers (OR=6.451), inadequate ventilation (OR=3.276), prolonged working time (OR=8.290) and poor sanitary facilities (OR=8.171). Poor diet (OR=3.257), use of alcohol (OR=3.691), cigarettes (OR=8.122) and poor personal hygiene (OR=6.137) were also aggravating the problem. Coal mines play significant role in spreading and sustaining the tuberculosis epidemic.

Keywords: *Mycobacterium tuberculosis*, coal miners, workplace risk factors, infectious diseases

Introduction
Being a communal disease, Tuberculosis is disproportionately present in mining industry. Poor working conditions [1], homeless, malnourished as well as overcrowded situations [2, 3] and less ventilated workplace [4] are the root hazards in this aspect. Tuberculosis (TB) falls under the category of air born infection that is transmitted via droplet nuclei having the diameter of 1-5 microns and has long been represented an occupational threat to mine workers [5, 6]. Lethal mix of conditions like sneezing and coughing in overcrowded mining environment, exposure to dust and chemicals, enclosed underground environment, close proximity, weakened lungs due to coal dust and silica exposure, extreme conditions of temperature, longer duration of work in underground settings, overcrowding in single allotted room with more than fifteen workers make mining environment conducive for transmission of tuberculosis. Insufficient dilution and removal of droplet nuclei due to inadequate and closed ventilation [7], recirculation of air carrying infectious droplets, high levels of HIV, improper way of coughing and sneezing, poor personal hygiene, body cuts, sharp injuries and dermatitis act as facilitators of Tuberculosis [8]. Silicosis resulted from silica dust exposure decrease the body immune response among miners for the bacteria responsible for tuberculosis [9], thus rendering coal miners at higher susceptibility to tuberculosis [1].

Miners become exposed to air born Tuberculosis bacilli by sneezing, coughing, shouting and singing of infected person. An infected person releases this bacterium into air that remain suspended in mining environment for several hours until it enters into respiratory tract of miners along with dust and chemicals present in air reach. High humidity, coal dust [10], confined space, inadequate ventilation [1], exposure to silica dust [9], higher depth of mines (4 kilometer deep), lesser width of coal seam(1-2 kilometers), poor nourishment [11], overcrowded and poor ventilated spaces like this increase the probability of inhaling droplets spewed by infected person in such settings.

Data regarding health problems in coal miners of Baluchistan (Pakistan) revealed highest number of workers with TB. Though there is plethora of studies on risk factors and incidence of diseases like TB in coal mining countries globally but no such efforts has been done in Pakistan. Keeping this scarcity of knowledge in view, present study was designed to

investigate problem of TB among coal miners in Punjab. Furthermore, it was aimed at probing relevant risk factors so that appropriate measures could be suggested to mitigate their outcomes.

Methods

Present study was carried out to investigate the coal mining associated risk factors of tuberculosis among coal miners of Punjab, Pakistan during 2016. Coal mines of Chkwal district, Khushab district and Mianwali districts were surveyed for collection samples. Samples were processed in lab of department of zoology university of Sargodha while clinical analysis was carried out at university medical and diagnostic center as well as DHQ Sargodha. This study encompasses the role of different risk factors involved in spread and progression of tuberculosis. Clinical diagnosis methods and Cross sectional design was followed for study. The institutional exploration what's more, moral board of trustees endorsed the study and educated assent was gotten from the study subjects before enlistment in the study.

Sampling frame: Three major coal mines of Punjab viz., Chakwal, Khushab and Mianwali were selected for study. A sum of 311 coal workers were divided in to five different grouping viz., coal cutter, shovelers, coal lifters, loaders and mine supervisors.

Serologic Tests: Blood samples were collected from the study subjects and preserved properly. Chromatographic immunoassay technique was used for screening of blood samples [12]. This technique is consisted upon burgundy colored conjugate pad containing recombinant TB antigens conjugated with colloid gold and rabbit IgG-gold conjugates along with nitrocellulose membrane strip which contain two test bands (IgG, IgM) plus a control band while IgM band is pre-coated with monoclonal anti-human IgM for detection of IgM anti-TB, whereas IgG band is pre-coated with reagents for detection of IgG anti-TB. C band contain goat anti rabbit IgG. By applying sample in sample pad of test, capillary action takes place which migrate specimen upward. If IgM anti-TB is present specimen bind to TB conjugates in the form of immune complex. Finally immune complex will captured by pre-coated anti-human IgM antibody, forming reddish-purple band which indicate positive result. Whereas if IgG anti-TB is present specimen will bind to TB conjugates this immune complex will captured by pre-coated reagents on the membrane forming wine-red colored IgG band giving positive result.

Statistical Analysis: Diagnostic test 2 × 2 possibility tables were made. Sensitivity, specificity, positive and negative prescient qualities were recorded. All parameters were assessed with 95% certainty interim utilizing the SPSS statistical software (22.0 V).

Results

Our analysis revealed that out of 311 coal workers, 10.13 % (n=32) workers were having tuberculosis while 89.87(n=279) were without tuberculosis (Fig.1). Area wise distribution showed that majority of workers having tuberculosis were working in the mines of Chakwal (45.238%) followed by Khushab (31.746%) and Mianwali (23.016%) (Fig.2). Furthermore, migrants (89.683%) were more affected by tuberculosis as compared to local workers (10.317%) (Fig.3). Coal Workers who were spending more than 8 hours (57.937%) at their job sites, were more affected by *Mycobacterium tuberculosis* as compared to those who were working for 8 hours or less(42.063%) (Fig.4).

Prevalence of tuberculosis was not same among all job categories as coal cutter (63.492%) were recorded as major affecters of *Mycobacterium tuberculosis* followed by 18.254% coal lifters, 11.111 shovelers, 4.7619% coal loaders and 2.3810% were those involved in mine supervision (Fig.5).

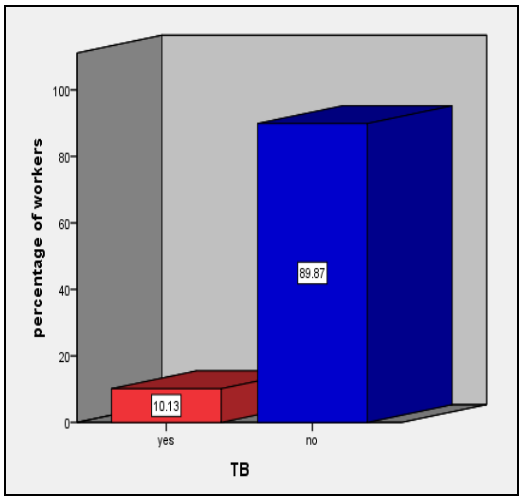

Fig 1: prevalence of tuberculosis among coal miners

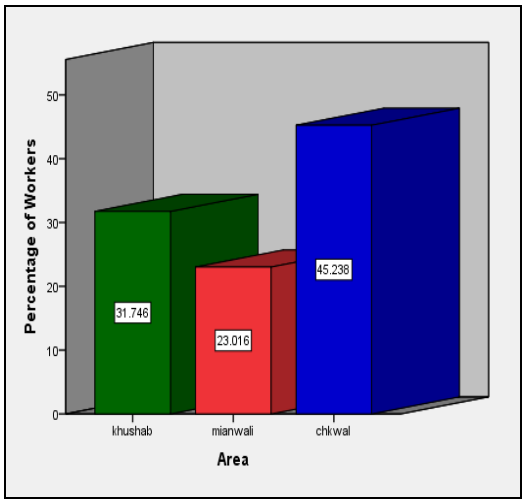

Fig 2: Area wise prevalence of tuberculosis

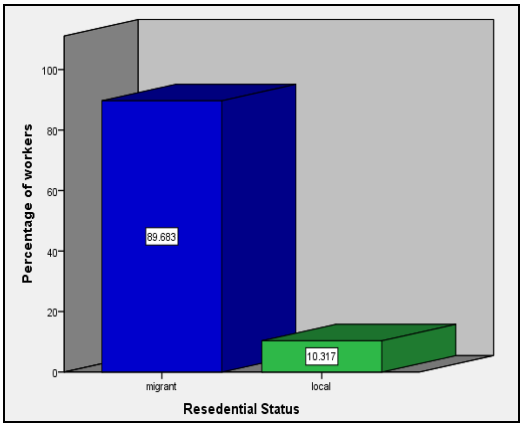

Fig 4: work duration wise prevalence of tuberculosis

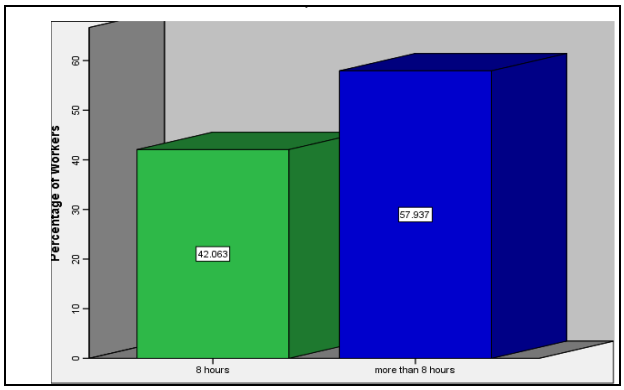

Fig 3: residential status wise prevalence of tuberculosis

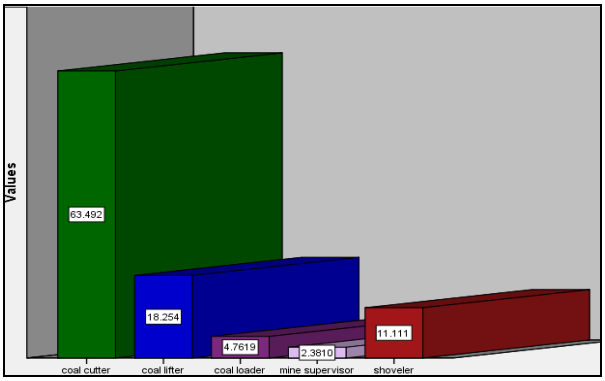

Fig 5: Job category wise prevalence of tuberculosis

Risk factors associated with Tuberculosis among coal miners

Bivariate Chi-square test of independence was applied to find out factors (5% level) that were significantly associated with Tuberculosis. Current study recorded that Residential Area, Use of meat in diet, Way of coughing and sneezing, Sharing of utensils, Work in Confined space, Have milk in diet, Have fruits, Sharing of drinking water bottle/glass, Personal hygiene, Room sharing, Armpits shaving, Niswar sharing, Have Cut in skin, Use alcohol, Eat food at workplace, Smoker, ventilation, Toilet system and Use of niswar were significantly associated risk factors for tuberculosis while type of Cooking Fuel, Working hours and type of water container were not significantly associated with tuberculosis (Table 1).

Regarding the risk factors associated with the tuberculosis, 16 variables were found to be significant for transmission and development of tuberculosis among coal workers (Table 2). Workers who were performing their assigned tasks in confined spaces were found to have higher risk of developing tuberculosis as compared to those who were doing their work in the open spaces (adjusted OR= 12.171 and 95% CI [4.179-35.446]). Another important factor was prolonged duration of work (more than 8 hours), that was 8 times increasing the chances of tuberculosis as compared to those who work for lesser duration (CI=2.970-23.142). Residential status remained most important factor. It was found that chances to develop tuberculosis were about fifteen times greater among those workers who were migrants. Use of niswar among workers was responsible for 5 time increment in *Mycobacterium tuberculosis* development.

Poor sanitary conditions were also responsible for increasing the bacterial incidence as use of (pit- latrine) was increasing the probability of tuberculosis eight times among users (CI=2.450-26.927). Poor personal hygiene was responsible for increasing the tuberculosis at the rate of 6 times as compared to those having good personal hygiene. Improper way of coughing and sneezing was increasing tuberculosis at the rate of 5.554 (CI=1.945-15.856).

Overcrowded quarters (room sharing with more than four persons) were increasing the possibility of tuberculosis significantly with odd ratio (OR) 6.451(CI=1.969-21.133). This suggest that those workers who were sharing room with more than four coworkers have 6 times greater likelihood to develop tuberculosis. Room sharing increase the sharing of personal items (drinking water bottle, utensils, and niswar) with each other and this habit of sharing was significantly contributing in the prevalence of tuberculosis. Chances were 9 times higher for sip from the same water bottle and eat within same utensils (OR=9.045, 95% CI=2.457-33.302 and OR=9.228, 95%CI=2.244-37.937) and 7 times higher for those sharing niswar (OR=7.720, 95% CI=1.424 -41.841).The logistic regression coefficient for smoking had a positive value of 2.095 and odds ratio (OR) 8.122, which is greater than 1 with a 95% CI of 2.450 to 26.927.This suggest that workers who smoke have more than 8 times greater chances to develop tuberculosis than those who do not use it. Alcohol use was also common among workers which was increasing the chances of acquiring tuberculosis at the rate of 3.691 (CI=1.354 to 10.061, $p<0.05$).Poorly ventilated environment of mine was facilitating the transmission of mycobacterium released from infected miner to non-infected ones. It was found that chances were about three times greater to develop tuberculosis among those who were performing their task in those places where there was inadequate ventilation (OR=3.276,CI=1.186-9.054). Workers who were not consuming the milk properly (once a month) were having 3times more chances of contracting tuberculosis.

Table 1: Bivariate Analysis of Risk Factors for Tuberculosis

Variable	Pearson Chi-Square	df	P	Phi& Cramer's V
Residential Area	58.171	1	0.000	0.216
Use meat in diet	56.085	1	0.000	0.212
Way of coughing and sneezing	11.684	1	0.001	0.97
Share utensils	85.592	1	0.000	0.262
Work in Confined space	37.480	1	0.000	0.174
Have milk in diet	65.292	1	0.000	0.229
Have fruits	48.105	1	0.000	0.197
Share drinking water bottle/glass	84.336	1	0.000	0.260
Personal hygiene	36.761	1	0.000	0.172
Room sharing	45.731	1	0.000	0.192
Shave armpits	33.322	1	0.000	0.164
Niswar sharing	19.954	1	0.000	0.127
Have Cut in skin	56.058	1	0.000	0.212

Use alcohol	117.537	1	0.000	0.307
Cooking Fuel	0.899	1	0.343	0.027
Working hours	0.519	1	0.471	0.020
Type of water container	1.259	1	0.262	0.032
Eat food at workplace	15.920	1	0.000	0.113
Smoking status	35.465	1	0.000	0.169
Ventilation	33.182	1	0.000	0.163
Toilet system	73.886	1	0.000	0.244
Use niswar	47.409	1	0.000	0.195

Table 2: Multinomial Regression Analysis of Occupational Risk Factors Associated With Tuberculosis among Coal Workers

Variable	B	S.E	Wald-Statistics	p-value	B	95% C.I for β	
						Lower Bound	Upper Bound
[Residential status=migrant]	2.727	.540	25.457	.000	15.282	5.299	44.076
[use_meat=once a month]	.661	.519	1.626	.202	1.937	.701	5.352
[way of coughing/sneezing=improper]	1.714	.535	10.260	.001	5.554	1.945	15.856
[share utensil=yes]	2.222	.721	9.491	.002	9.228	2.244	37.937
[work in confined space=yes]	2.499	.545	20.995	.000	12.171	4.179	35.446
[have_milk=once a month]	1.181	.575	4.220	.040	3.257	1.056	10.051
[have_fruits=once a month]	.811	.510	2.523	.112	2.249	.827	6.116
[share_drinking_water=yes]	2.202	.665	10.966	.001	9.045	2.457	33.302
[personal_hygiene=poor]	1.814	.471	14.866	.000	6.137	2.440	15.434
[room_sharing=more than four persons]	1.864	.605	9.483	.002	6.451	1.969	21.133
[shave armpit=yes]	.845	.616	1.883	.170	2.329	.696	7.792
[share niswar=yes]	2.044	.862	5.617	.018	7.720	1.424	41.841
[have cut in skin=yes]	-.424	.801	.280	.597	.655	.136	3.147
[use alcohol=yes]	1.306	.512	6.517	.011	3.691	1.354	10.061
[cooking fuel =wood]	-2.836	.586	23.455	.000	.059	.019	.185
[working_hours=more than 8 hours]	2.115	.524	16.305	.000	8.290	2.970	23.142
[ventilation=inadequate]	1.187	.519	5.235	.022	3.276	1.186	9.054
[eat food at workplace=yes]	.078	.471	.027	.869	1.081	.429	2.722
[smoker=yes]	2.095	.612	11.731	.001	8.122	2.450	26.927
[type of water container=open]	.364	.495	.541	.462	1.439	.545	3.800
[type of toilet system=pi-latrine]	2.101	.644	10.634	.001	8.171	2.312	28.881
[use niswar=yes]	1.601	.481	11.080	.001	4.958	1.932	12.729
Constant	-21.722	2.071	110.022	.000			

Estimated Logistic Regression Model for TB = yes

= -21.722 - 2.836*(cooking fuel="wood") + 1.714*(way of coughing/sneezing="improper") -0.424*(have cut in skin="yes") + 0.364*(type of water container="open") + 0.078*(eat_food="yes") + 0.811*(have_fruits="once a month") + 1.181*(have_milk="once a month") + 2.727*(Residential status="migrant") + 1.601*(use_niswar="yes") + 1.814*(personal_hygiene="poor") + 1.864*(room_sharing="more than four") + 2.202*(share_drinking_water="yes") + 2.222*(share_utensil="yes") + 0.845*(shv_armpit="yes") + 2.095*(smoker="yes") + 2.499*(work in confined space="yes") + 2.101*(toilet_system="pit-latrine") + 1.306*(use_alcohol="yes") + 0.661*(use_meat="once a month") + 2.044*(share_niswar) ="yes") + 1.187*(ventilation="inadequate") +2.115*(working_hours="more than 8 hours")

Discussion

Pakistan is the fifth top TB burden country with 0.3-0.5 million cases [13]. Several studies have been carried out to pin point factors responsible for this disease known as child of poverty among different areas of Pakistan but no such study is documented about TB status of coal workers who live and work in such hostile conditions. This is the first study of its kind to explore the TB prevalence rate and identify risk factors associated with this occupation among coal workers of Punjabi mines. Prevalence of TB is 10.3% among coal workers that higher than general population. In this study, we have found multiplex mixture of factors responsible for TB among coal workers. Multinomial regression analysis for overall data revealed sixteen factors that were significantly increasing the rate of Tuberculosis. Migration to and fro from mining sites was increasing the chances among mine workers. Our findings corroborate with crush and Frayne [14], who found circular migrant as culprit for Tuberculosis. He reported that circular migrant provide hindrance in proper diagnosis as well as interrupt chances of treatment. Lurie and Williams [15] reported also higher risk of TB among migrants due to overcrowded housing, poor sanitation and unclean working conditions which are in agreement with ours. Bivariate analysis revealed association of TB with poor dietary habits (less usage of milk, fruits and meat) which endorse Cegielski and McMurray [16], work who reported that undernourished populations are more prone to tuberculosis. Similar findings were reported by Shetty [17]. Poor dietary habits weaken the principle host defense against TB by affecting cell mediated immunity [18]. Confined space and inadequate ventilation also appeared as important factors of current study. Workers who were performing their tasks in confined spaces were 12 times more susceptible to *Mycobacterium tuberculosis*. Trapped indoor bacilli disperse within confined space and remain viable and suspended in the air of these confined spaces for prolonged duration [19, 20]. It was also revealed that inadequate ventilation was increasing the chances of contracting TB up to three times. Charney and Fragala [21] also reported poor ventilation as important facilitator of TB. Sepkowitz [22] and Tornee [23] studies are in agreement with our one who, also reported poor ventilation as

important risk factor of tuberculosis.

Smaller rooms with large number of persons act as hotspot for TB transmission. Sneezing and coughing via inappropriate way escalating the chances of TB up to 5 times. Many workers have reported association of TB with higher number of persons residing in same house/room [23-24]. Room sharing also increases the chances of sharing personal items among coal workers (96% share drinking water, 88.1 % share utensils, and 87.3% share niswar) that exacerbate the chances of contracting TB. When the person infected with TB sneeze and cough without covering their mouth and nose release thousands of tiny droplets nuclei in the smaller enclosed space [24] some of them contain *Mycobacterium tuberculosis* that can victimize non-infected ones. Use of alcohol, niswar and cigarettes among coal workers were significantly increasing the chances of TB. Buskin and his team [25] and Rosenman and Hall [26] also found alcohol and smoking as contributing factors for tuberculosis. Bates and his coworkers [27] also reported higher risk of tuberculosis among cigarette smokers. Nicotine the major component of cigarette is responsible for less clearance of mucosal secretions [28], decreased phagocytic activity of alveolar macrophages [29, 30] and impaired immune response which eventually enhance the vulnerability of individual to tuberculosis [31]. Alcohol is also responsible for immune related changes (Alteration in cytokine production) increasing TB acquiring chances [32].

Longer work duration and Poor personal hygiene was another contributor to TB infection among coal workers which concur with the study conducted by Gustafson [33]. Infected miners when work with non-infected one for longer time in small confined space contribute in transmission of *Mycobacterium tuberculosis*. In this study poor sanitation also appeared as important risk factor for TB. Workers who reported that they use pit-latrine as toilet system were having 8.171 times greater chances of tuberculosis. Coal mines are therefore playing significant role in sustaining the tuberculosis epidemic.

Conclusion

Coal miners are high risk population with respect to tuberculosis. Multiplex of coal mining activities and coal mining environment (small working space, poor ventilation, longer working hours) as well as living conditions of coal miners(small cabins with more persons, sharing of personal items, poor diet) at working sites were playing major role in prevalance of tuberculosis.

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