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Effect of Respirable Suspended Particulate Matter on Blood Pressure of Sand Stone Mine Workers: A case study

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Abstract: *The workers were selected for the study from various stone quarries around Jodhpur city of Rajasthan state in India. The selection of workers was based upon the exposure duration, type of work, socioeconomic factor, and previous diseases. The workers having hereditary respiratory & cardiovascular problems were not taken for study. Only male workers have been considered in this study .The workers were divided in three categories depending upon the type of their work and exposure to particulate concentration. These categories are: Labour (particulate concentration category-1), Dresser (particulate concentration category-2), and Driller (particulate concentration category-3). Similarly the exposure duration is divided in four categories: category –1 (exposure duration 0-5 years), category –2 (exposure duration 5-10 years), category –3 (exposure duration 10-15 years), category –4 (exposure duration >15 years). Concentration of Respirable particulate matter for different activities (drilling, dressing, general quarry environment) were measured with the help "Respirable High volume sampler". The blood pressure of the workers were measured with the help of Multi-Parameter Monitor. It is clear from the observation & analysis that increase in exposure duration and RSPM concentration is responsible for increase in SBP/ DBP. It is clear from the statistical analysis that two independent variables "Exposure Duration and Particulate Concentration" jointly account for the variation in ISBP upto 80.5% and remaining 19.5 % variation is due to other reasons. It also indicates that these two independent variables jointly account for the variation in IDBP upto 95.9 % and remaining rest 4.1 % variation is due to other reasons. study indicates that increase in DBP is closely associated with the exposure duration and exposure concentration.*

Key Words*: Exposure duration, Exposure concentration, Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Respirable Suspended Particulate matter (RSPM)*

I. Introduction:

The sand stone is obtained from underground by a process of digging, blasting or cutting. Very small mines are called quarries from which stone is excavated by open mining .Mining of stone involves both machines and manual work. The drilling and dressing is done using hand chisels and hammers. Many mines/quarries now have mining machinery, such as compressors, drilling machines for drilling and blasting, cranes for lifting big blocks, and dampers and trucks for transport. Once the stone is obtained it is further processed for the next stage of production. Particulate air pollution has been linked to mortality and morbidity and affects cardiovascular system. Mine /Quarry Workers are exposed to particulate matter of different concentration and size, which leads to deterioration of their pulmonary and cardiovascular functions. Epidemiological studies by Dockery and Pope, (1994); &Pope, et al., (1995) explained a dose-response relationship between exposure to PM10 and respiratory morbidity and mortality are established [12,13]. Oxman et al., (1993) suggested that numerous epidemiological studies have supported the association between respiratory impairment and occupational exposure to dust [14]. In a study by Ghotkar, et al., (1995),the prevalence of respiratory morbidity among stone quarry workers was 32.5%, based on radiological study; the severity of pulmonary function impairment was significantly associated with increasing age, duration of exposure to dust, smoking status and presence of chronic obstructive airways disease on radiological study [11].Mengesha et al., (1998) revealed that the occupationally related lung diseases (are most likely due to the deposition of dust in the lung and are influenced by the type of dusts, the period of exposure, the concentration and the size of the airborne dust in the breathing zone [10] .Borja-Aburto et al., (1998); Burnett et al., (1999); Morris, (2001) suggested that adverse effects of air pollution include an increase in cardio-vascular and respiratory deaths among elderly people as well as increased hospital admissions for heart and respiratory diseases [9,7,6].Ibald-Mulli et al., (2001); Linn et al., (1999), analysed effects of air pollution on blood pressure in a population based sample as well as in a panel of asthmatic subjects found an increase in systolic blood pressure with elevated concentrations of particulates[5,8].Brook et al., (2004) published its first scientific statement of American Heart Association (AHA) regarding air pollution and cardiovascular disease. He

discussed that short term exposure to particulate matter air pollution contributes to acute cardiovascular morbidity and mortality and exposure to elevated PM level over the long term can reduce life expectancy by a few years [3]. Singh et al., (2007), assessed the reduction in forced vital capacity of lungs of sand stone quarry workers exposed to high respirable suspended particulate concentration. He found that exposure duration and exposure concentrations are main factors responsible to damage respiratory tract of worker [4].According to Bellavia et al., (2013), Short-term exposures to fine (<2.5 lm aerodynamic diameter) ambient particulate-matter (PM) have been related with increased blood pressure (BP) in controlled-human exposure and community-based studies[2]. Kumar et al., (2014), performed pulmonary function test on quarry workers and control population and found that reduction of pulmonary function values were positively correlated with duration of their work. [1].

Most of the researchers have carried out the study on a particular concentration of a RSPM or FPM (Fine particulate matter) and its effect on blood pressure. All most in all the study researchers have considered either pollutant concentration as variable or exposure duration as a variable and extent of damage were reported as increase of blood pressure. Assessment of increase of blood pressure is not done in relation to the exposure duration and exposure concentration both as variables. In this study effort has been made to quantify of increase in blood pressure by considering exposure duration and exposure concentration of RSPM as variables.

II. Methodology & Observations:

The sandstone quarrying/ mining process is done manually and mechanically but the involvement of workers in both the cases is significant. There are three types of workers, in the quarrying process:

a. Driller : These sets of workers are employed for blasting, and drilling operations
b. Dresser: These are the workers employed for doing finer work, by chiseling , cutting or dressing the stone pieces for decorative works.
c. Labours: These sets of workers are employed for loading & unloading operations and are exposed to normal quarry environment.

(1) The workers were selected for the study from various stone quarries around Jodhpur city of Rajasthan state in India. The selection of workers was based upon the exposure duration, type of work, socioeconomic factor, and previous diseases. The workers having hereditary respiratory & cardiovascular problems were not taken for study. Only male workers have been considered in this study .

The workers were divided in three categories depending upon the type of their work and exposure to particulate concentration. These categories are: Labour (particulate concentration category-1), Dresser (particulate concentration category-2), and Driller (particulate concentration category-3). Similarly the exposure duration is divided in four categories: category –1 (exposure duration 0-5 years), category –2 (exposure duration 5-10 years), category –3 (exposure duration 10-15 years), category –4 (exposure duration >15 years). Concentration of Respirable particulate matter for different activities (drilling, dressing, general quarry environment) were measured with the help "Respirable High volume sampler". The blood pressure of the workers were measured with the help of Multi-Parameter Monitor.

(2) RSPM concentration was measured during various activities in the mines and average concentration of RSPM for various activities are given in table-2.

(3) The systolic blood pressure (SBP) and diastolic blood pressure (DBP) of mine workers exposed to different concentration of RSPM and control population are given in table-1

(4) indices were calculated for Systolic blood pressure and Diastolic blood pressure and are represented as ISBP (percentage increase in systolic blood pressure in fraction) and IDBP (percentage increase in diastolic blood pressure in fraction) respectively. As it is very difficult to calculate increase of blood pressure in absolute term. These indices were calculated from equations given below and are given in table -3.

$$ISBP = (SBP-120) / 120$$
$$IDBP = (DBP-80) / 80$$

Where :

SBP = Measured value of Systolic blood pressure

DBP = Measured value of Diastolic blood pressure

Table-1
Category of workers and exposure duration

Category of Workers	Exposure Duration in Years	Number Of Workers	Exposure Category
Labour (120)	0-5	30	1
	5-10	27	2
	10-15	36	3
	>15	27	4
Dresser (125)	0-5	32	1
	5-10	27	2
	10-15	36	3
	>15	30	4
Driller (125)	0-5	33	1
	5-10	30	2
	10-15	28	3
	>15	34	4
Control workers	----------	36	------

Table-2
Particulate concentration for different activities

S.N.	Activity	Respirable suspended Particulate matter (RSPM) Concentration	Concentration category
1	Normal Quarry Environment	460.00 μg/m³	1
2	Dressing	970.00μg/m³	2
3	Drilling	1890.00μg/m³	3

Table- 3 Mean values of indices
(Increase of exposure duration and concentration and Increase in Blood Pressure)

S.N	No .Of Obs.	Worker Category	Exposure Duration (Yrs)	Exposure Duration Category	Exposure Concentration	Exposure concentration Category	Mean IDBP	Mean ISBP
1	30	Labour	0-5	1	460.00 μg/m³	1	0.163	0.305
2	27	Labour	5-10	2	460.00 μg/m³	1	0.177	0.327
3	36	Labour	10-15	3	460.00 μg/m³	1	0.179	0.326
4	27	Labour	>15	4	460.00 μg/m³	1	0.185	0.326
5	32	Dresser	0-5	1	970.00 μg/m³	2	0.18	0.361
6	27	Dresser	5-10	2	970.00 μg/m³	2	0.184	0.326
7	36	Dresser	10-15	3	970.00 μg/m³	2	0.205	0.364
8	30	Dresser	>15	4	970.00 μg/m³	2	0.213	0.377
9	33	Driller	0-5	1	1890.00 μg/m³	3	0.195	0.338
10	30	Driller	5-10	2	1890.00 μg/m³	3	0.215	0.382
11	28	Driller	10-15	3	1890.00 μg/m³	3	0.221	0.397
12	24	Driller	>15	4	1890.00 μg/m³	3	0.232	0.419
13	36	Control Population					0.146	0.309

III. Statistical Analysis:

For ISBP (Model 1)

The dependent variable ISBP is denoted by 'Y_s'. Independent variables EXDUR (i.e. Exposure Duration category) and PCAT (i.e. Particulate Concentration Category) are denoted by 'X1' & 'X2' respectively. Using data from table -3.The regression analysis is done & analyzed data are given in table -4

Table - 4
Statistical Parameters for EXCAT, PCAT & ISBP (ANOVA)

Model	R	R Square	Std. Error of the Estimate	F-Value		df		Coeff.	t
1	0.897	0.805	.016960	18.574	Regression Residual Total	2 9 11	Constant EXCAT PCAT	.257 .032 .014	15.163 5.253 3.090

a. Dependent variable: ISBP
b. Independent variables :EXCAT (X1), PCAT (X2)

F test

H_o: $\beta_1 = \beta_2 = 0$ against H_1: not all $\beta_k = 0$: (k= 1, 2)

ANOVA table-4 gives the value of calculated 'F' i.e. F = 18.574 and
$F_{k, n-k-1, \alpha}$ = 4.26 (critical value from standard tables).
Here, $F_{calculated} > F_{k, n-k-1, \alpha}$
Hence, reject H_0 at α (= 0.05) level of significance, therefore, significance of individual β's be tested by 't - test'.

t- Test

H_0: $\beta_j = 0$ against H_1: $\beta_j \neq 0$: (j = 1,2)
The calculated values for 't - statistics' for β_1 and β_2 are given in ANOVA table-4.
t (for β_1) = 5.253
t (for β_2) = 3.090
The value of $t_{n-k-1, \alpha/2}$ = 2.26
Here $t > t_{n-k-1; \alpha/2}$; therefore reject H_0.
Hence, $\beta 1 \neq 0$ and $\beta_2 \neq 0$
As the estimated b_0, b_1 and b_2 are
b_0 = 0.257, b_1 = 0.032 and b_2 = 0.014 .
Thus, estimated multiple regression equation for ISBP can be expressed as:

$$Y_S = 0.032\ X_1 + 0.014\ X_2 + 0.0257.$$

Where Y_s = ISBP; X_1 = Exposure duration category; X_2 = Particulate Concentration category.

For IDBP (Model 2)

The dependent variable IDBP is denoted by 'Y_D'.Independent variables EXDUR (i.e. Exposure Duration category) and PCAT (i.e. Particulate Concentration Category) are denoted by 'X1' & 'X2' respectively. Using data from table -3. the regression analysis is done & the analyzed data are given in table -5

Table - 5
Statistical Parameters for EXCAT,PCAT & IDBP (ANOVA)

Model	R	R Square	Std. Error of the Estimate	F-Value		df		Coeff	t
2	.979	.959	.004734	105.090	Regression Residual Total	2 9 11	Constant EXCAT PCAT	.131 .020 .010	27.583 11.874 8.317

a. Dependent variable: IDBP
b. Independent variables :EXCAT (X1), PCAT (X2)

F test

H_o : $\beta_1 = \beta_2 = 0$ against H_1 : not all $\beta_k = 0$:(k= 1, 2)
ANOVA table-5 gives the value of calculated 'F' i.e. F = 105.090 and
$F_{k, n-k-1, \alpha}$ = 4.26 (critical value from standard tables).
Here, $F_{calculated} > F_{k, n-k-1, \alpha}$
Hence, reject H_0 at α (= 0.05) level of significance, therefore significance of individual β's be tested by 't - test'.

t- Test

H_0: $\beta_j = 0$ against H_1: $\beta_j \neq 0$: (j = 1,2)
The calculated values for 't - statistics' for β_1 and β_2 are given in ANOVA table-5.
t (for β_1) = 11.874
t (for β_2) = 8.317
The value of $t_{n-k-1, \alpha/2}$ = 2.26
Here $t > t_{n-k-1; \alpha/2}$; therefore reject H_0.
Hence, $\beta_1 \neq 0$ and $\beta_2 \neq 0$
As the estimated b_0, b_1 and b_2 are
b_0 = 0.131
b_1 = 0.020
b_2 = 0.010
Thus, estimated multiple regression equation for IDBP can be expressed as:

$$Y_D = 0.020\ X_1 + 0.010\ X_2 + 0.131$$

Where, Y_D = IDBP, X_1 = Exposure duration category and X_2 = Particulate Concentration category

Analysis indicates that increase in has positive correlation with exposure duration and exposure concentration of RSPM. It indicates that two independent variables Exposure Duration and Particulate Concentration jointly account for the variation in ISBP upto 80.5% and remaining 19.5 % variation is due to other reasons. It also indicates that two independent variables Exposure Duration and Particulate Concentration jointly account for the variation in IDBP upto 95.9 % and remaining rest 4.1 % variation is due to other reasons. It indicates that increase in DBP is closely associated with the exposure duration and exposure concentration.

IV. Conclusion:

Sand stone mine workers are exposed to high concentration RSPM and these particles are deposited in the respiratory tract of workers. Toxicology depends upon the size of particles and chemical composition of the particles. Deposition of various small size particles in the lungs adversely affect the working of lungs and it affect working of cardiovascular system.

Based on the study done the important conclusions drawn are :

1 Increase in DBP or SBP is associated with exposure duration and exposure concentration of RSPM.
2 It is concluded that if exposure duration is increasing, DBP & SBP is increasing. Similarly if exposure concentration of RSPM is increasing, DBP & SBP is increasing
3 The multiple regression equation developed to relate the increase in DBP/ SBP with the increase of exposure duration & concentration are

$Y_S = 0.032\ X_1 + 0.014\ X_2 + 0.0257$

$Y_D = 0.020\ X_1 + 0.010\ X_2 + 0.131$

Workers working in the sand stone mine in which working environment is highly polluted are inhaling excess amount of RSPM and are suffering from various types of respiratory diseases and at the same time their blood pressure is also increasing. As the exposure duration is increasing , problem is becoming severe. Hence in all the mines attempts is to be made to provide clean working environment to save the life of workers.

References:

[1]. Kumar C.H.K.; Reddy N.M.; Singh M.S.B.; KrishnaB.; Sasikala P.; Shravya Keerthi G.; Siva Kumar A.V.; Kareem S.K.(2014), Deterioration of pulmonary function in stone quarry workers. Biomedical Research, Vol 25(2) pp 261-266

[2]. Bellavia A.; Urch B.; Speck M.; Brook R.D.; Scott J.A.; Albetti B.; Behbod B.; North M.; Valeri L.; Bertazzi P.A.; Silverman F.; Gold D.; Baccarelli A.A. (2013), DNA Hypomethylation, Ambient Particulate Matter, and Increased Blood Pressure: Findings From Controlled Human Exposure Experiments. Journal of the Americal Heart Association, DOI: 10.1161/JAHA.113.000212

[3]. Brook, R.D., (2008). Cardiovascular effects of air pollution. Clin. Sci. (Lond), 115: 175-187

[4]. Singh, S.K.; Chowdhary, G.R.; Chhangani,V.D.; Purohit, G. (2007), Quantification of Reduction in forced vital capacity of sand stone quarry workers. International Journal of Environmental Research and Public Health , Vol.4(4), pp.269-300.

[5]. Ibald-Mulli, A., Steiber, J., Wichmann, E., Koenig, W., Peters, A., (2001). Effects of air pollution on blood pressure: a population based approach. Am. J. Public Health 91, 571–577

[6]. Morris, R.D.,(2001). Airborne particulates and hospital admissions for cardiovascular disease: a quantitative review of the evidence. Environ.Health Perspect. 109, 495–500

[7]. Burnett, R.T., Smith-Doiron, M., Stieb, D., Cakmak, S., Brook, J.R., (1999). Effects of particulate and gaseous air pollution on cardio-respiratory hospitalizations. Arch. Environ. Health 54, 130–139

[8]. Linn, W., Gong, H., Clark, K., Anderson, K.,(1999). Day to day particulate exposure and health changes in Los Angeles area residents with severe lung disease. J. Air Waste Manage. Assoc. 49, 108–115

[9]. Borja-Aburto, V.H., Castillejos, M., Gold, D.R., Bierzwinski, S., Loomis, D., (1998). Mortality and ambient fine particles in southwest Mexico City, 1993–1995. Environ. Health Perspect. 106, 849–855

[10]. Mengesha, YA, Bekele A. (1998),. Relative chronic effects of occupational dust on respiratory indices and health of workers in three Ethiopian factories. Am J Ind Med;34:373-80

[11]. Ghotkar VB, Maldhure BR, Zodpey SP (1995), Involvement of lung and lung function tests in Stone quarry workers. Ind J Tub ;42:155-60

[12]. Pope, C., Bate, D.V. and Razienne, M.E. (1995). Health effects of Particulates in air pollutant: Time for re-assessment? Environmental Health perspective. 103: 472- 475

[13]. Dockery, D., Pope, C. (1994). 'Acute respiratory effects of particulate air pollution'. Annual Review of Public Health. Vol.15, pp.107-132

[14]. Oxman AD, Muir DCF, Shannon HS, et al (1993. Occupational dust exposure and chronic obstructive pulmonary disease. A systematic review. Am Rev Respir Dis;148:38-48