Assessment of respiratory health problems among school children due to exposure to air pollutants from cement manufacturing plants

*Dr. S. K. Singh, **Bhagwati Prakash Sharma, Dr.Gautam Lalwani
*Professor, MBM Engg. College, Jodhpur, Rajasthan, India **Phd Scholar,Dept of Civil Engg, India
bpsjod@rediffmail.com

Abstract— **There are only a few studies that have established reference standards for pulmonary function of Indian children. Reference standards for pulmonary function that are reported for Indian children are mainly from particular area or parts of the country.There is a paucity of data on pulmonary function in normal school going Indian children residing near cement plants located in various parts of the country. Therefore, pulmonary function tests (spirometry and peak expiratory flow rates) were carried out in 491 children between 8-18 years of age to derive regression equations to predict pulmonary function. The correlations of forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1) as well as peak expiratory flow rates were established through regression analysis by preparing various models. The functions were regressed over all possible combinations of regressor variables, i.e. between independent variables (like AQI & Exp.Duration) and dependent variables (various indices). It would give a direct relation between damage severity of lungs and pollutants.**

Key words: Pulmonary functions, Regression equations, Prediction equations.

I. Introduction

THERE are only a few studies that have established reference standards for pulmonary function of Indian school going children residing near cement plants. However, more than 100 reference standards are published for pulmonary function in children of different origin. The prevalence of childhood pulmonary diseases especially bronchial asthma is increasing worldwide and this necessitates the need for establishing regression equations for predicting Damage in pulmonary functions in school children studying in schools near cement plants in different parts of the country. The reference standards for pulmonary function that are reported for Indian school going children are mainly from particular parts of the country and there is a paucity of data on pan india basis on pulmonary function in normal Indian children residing near operating cement plants. Pulmonary function is known to vary with various factors and changes in pulmonary functions can occur between children of different origin and children of other regions. Therefore, it is essential to have normal pulmonary function data for children residing near cement plants to interpret accurately the damage in pulmonary functions due to exposure to cement plants pollutants for different exposure duration.. A Research study was, therefore, planned to evaluate the pulmonary function changes due to exposure to cement plant pollutants in school children.

II. Materials and Methods

Pulmonary function studies in children were carried out under relevant protocols approved. Informed consent was obtained from parents and from children . The procedure to be performed was explained in the local language to each child. Prior to pulmonary function testing, each child has assessments and investigations that included detailed history, physical examination through a well developed questionnaire to ascertain that children were free from respiratory symptoms at least three months before testing. Children were excluded from the study if they had structural deformity of the thoracic cage and were suffering from any acute or chronic respiratory or cardiac disease. Although the study population was not truly random, attempts were made to obtain a true representative cross section of normal subjects of school going children and to have a study population representative for the common socio-economic status. To achieve this, children were selected from the local area schools near cement plants. All study subjects were non smokers. All tests were carried out in the morning after breakfast.

III. Pulmonary Function Tests

Pulmonary function tests were carried out in 491 school going children between 8-18 years of age. The tests were carried out in the sitting position and a nose clip was applied. All pulmonary function tests were carried out on a dry-rolling spirometer (Transfer Test model C, P.K. Morgan Ltd. U.K.) and print outs were obtained from a computer. The equipment was calibrated every day. The coefficient of variation was less than 1% for forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1, less than 3% for peak expiratory flow rate (PEFR), forced midexpiratory flow (FMF) and forced expiratory flow at 25% of FVC ($FEF_{25\%FVC}$), less than 5% for forced expiratory flow at 50% of FVC ($FEF_{50\%FVC}$), and 10% for forced expiratory flow at 75% of FVC ($FEF_{75\%FVC}$).

IV. Spirometry

The subject was asked to loosen tight clothing and was seated comfortably. The subject was instructed to take a full breath in, then close the lips around the mouth piece and blow out as hard and fast as possible. Inspiration should be full and unhurried and expiration once begins should be continued without a pause. A minimum exhalation time of 6 seconds was applied to obtain maximal FVC results. The technique was demonstrated to every subject and the result was expressed in litres in body temperature pressure saturated (BTPS). A minimum of three acceptable forced vital capacity (FVC) manoeuvers [11] were obtained. Forced vital capacity and forced expiratory volume in one second (FEV_1) of the best 2 of 3 acceptable tracings should not vary by more than ± 5% of reading or 100 ml whichever is greater. The largest of three acceptable FVC and FEV_1 volumes were recorded, even if the two values did not come from the same curve. The ratio of FEV_1 to FVC was expressed as percentage.

V. MAXIMAL EXPIRATORY FLOW RATES

Maximal expiratory flow-volume loops were recorded by asking the subject to take a deep breath until he breathed in to total lung capacity (TLC) and to wrap his mouth tightly around a mouth piece, and on a given signal to breath out to residual volume, and finally suck it all back again as fast as possible to TLC, taking care to keep his back against the chair-back all of the time. At least three such flow-volume loop (F-V loop) manoeuvres were obtained from each subject. The highest value obtained from any of the three tracings was used for calculation of peak expiratory flow rate (PEFR). Values of forced expiratory flow, $FEF_{25\%FVC}$, $FEF_{50\%FVC}$, and $FEF_{75\%FVC}$ were derived from the single best test and the best test was defined as the one with the largest sum of FEV_1 and FVC.

VI. STATISTICAL ANALYSIS

The entire data from the schools ,school going children were pooled to cover a wide range of variability, if any, and thus, enhance applicability of the results, particularly the prediction equations, to general population of children exposed to similar cement plant pollutants for different exposure duration. Each study variable was analyzed separately.

Significance of difference in various study characteristics between different exposure duartion was tested by applying 't' test after ascertaining homogeneity of variances and normality separately for each segment of exposure. Overall effect of pollutants on these variables was tested by applying analysis of variance (two way classification) after adjusting sum of squares for non-orthogonality due to varying sample size in different exposure category groups of school going children residing near cement plants. Correlations were calculated between the study variables both dependent and independent and the physical characteristics separately for subjects. Their significance from zero was tested by applying 't' test. All the study variables (regressee/dependent variable) were thereafter regressed using least square principle. All possible combinations of regressor (independent) variables were considered to propose prediction equations and those with simplicity, maximum amount of regressee variables sum of squares explained (Rsq) by the equation and least standard deviation from regression S_{y-x} in order of preference, were taken to be the criteria to be proposed for predicting expected study variables. In order to compare our regression equations for FVC and FEV and PEF with those recently published studies, expected values of these variables were determined for mean exposure duration and Air quality index.

The conventional levels of probability, P=0.05 and P=0.01 were taken to be those being significant and highly significant respectively.

VII. RESULTS

Of the 491 children surveyed, technically valid results were obtained from 478 children. . The data from schools, children and cement plants were pooled to cover a wide range of socio-economic strata and thus provide a broader applicability of the prediction equations proposed in this study.

There was definite evidence of significant (P<0.01) interaction shown by analysis of variance results thus indicating diverse trend in different exposure duration under different cement plant pollutants. Different regression models, to establish the relation between independent variables (like air quality index and exposure duration) and dependent variables ie various indices, to give a direct relation between damage severity of lungs and pollutants are shown in regression models 1,2 and 3.

Regression Analysis for IFVC

Regression Model 1

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	AQI, Exdu[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: IFVC

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.299[a]	.089	-.051	.0777108

a. Predictors: (Constant), AQI, Exdur

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.008	2	.004	.637	.545[a]
	Residual	.079	13	.006		
	Total	.086	15			

a. Predictors: (Constant), AQI, Exdur
b. Dependent Variable: IFVC

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.067	.202		-.332	.745
	Exdur	-.002	.006	-.108	-.409	.689
	AQI	.002	.002	.278	1.052	.312

a. Dependent Variable: IFVC

Regression Analysis for IPEF

Regression Model 3

Variables[b]

Model	Variables Entered	Variable Remove	Method
3	Expdur, AQI[a]	.	Enter

a. All requested variables
b. Dependent Variable: IPEF

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
3	.520[a]	.271	.158	.0484633

a. Predictors: (Constant), Expdur, AQI

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
3	Regression	.011	2	.006	2.411	.129[a]
	Residual	.031	13	.002		
	Total	.042	15			

a. Predictors: (Constant), Expdur, AQI
b. Dependent Variable: IPEF

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
3	(Constant)	.075	.126		.596	.562
	AQI	.001	.001	.185	.783	.448
	Expdur	-.007	.004	-.486	-2.052	.061

a. Dependent Variable: IPEF

Regression Analysis for IFEV

Regression Model 2

Variables[b]

Model	Variables Entered	Variables Removed	Method
2	Expdur, AQI[a]	.	Enter

a. All requested variables
b. Dependent Variable: IFEV

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
2	.329[a]	.108	-.029	.0922683

a. Predictors: (Constant), Expdur, AQI

ANOVA[b]

Model		Sum of Square	df	Mean Square	F	Sig.
2	Regression	.013	2	.007	.791	.474[a]
	Residual	.111	13	.009		
	Total	.124	15			

a. Predictors: (Constant), Expdur, AQI
b. Dependent Variable: IFEV

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
2	(Constant)	.349	.240		1.452	.170
	AQI	-.002	.003	-.233	-.891	.389
	Expdur	-.006	.007	-.233	-.888	.391

a. Dependent Variable: IFEV

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