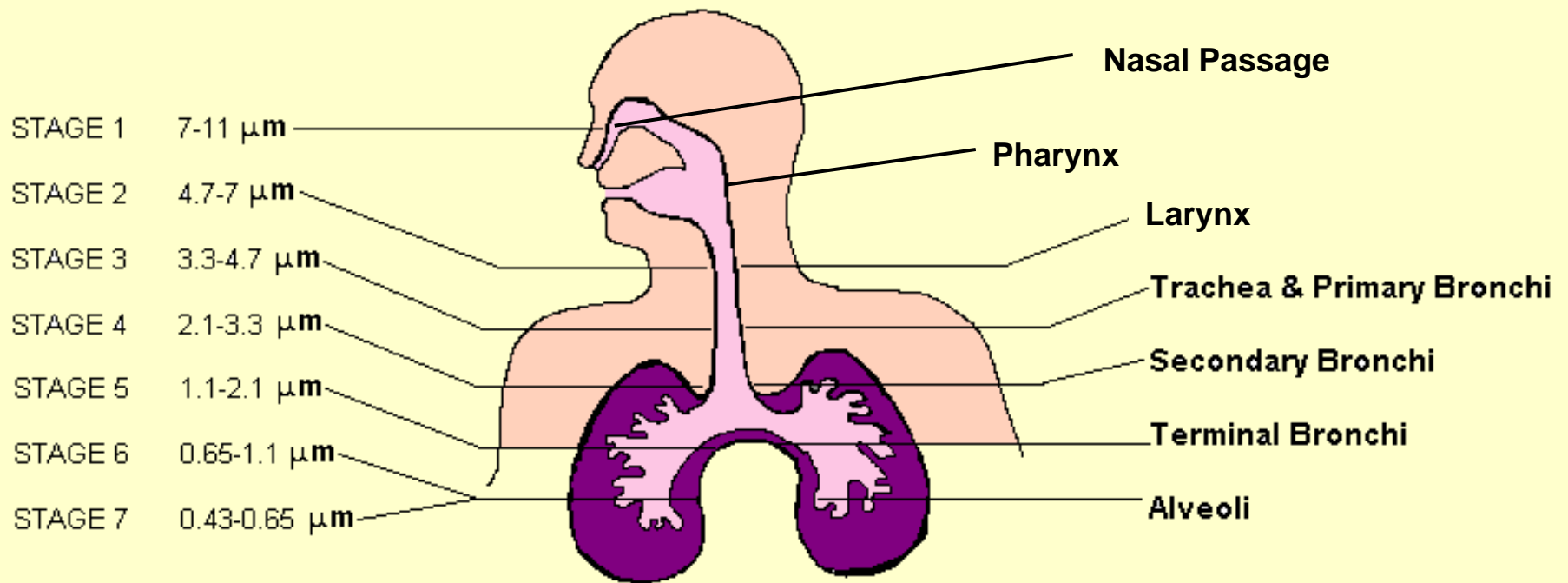## Health Effects of PM Pollution
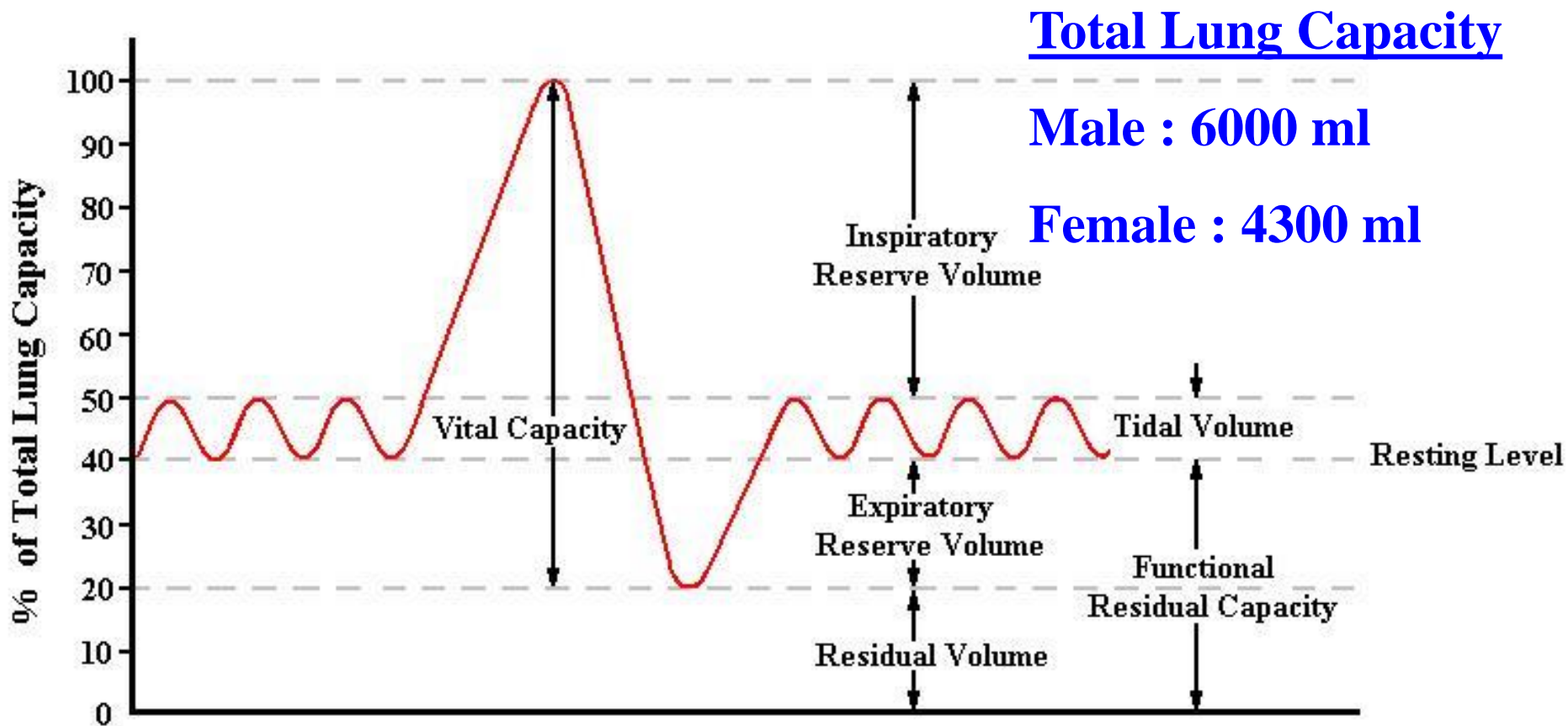
Increase in

- **Mortality**
- **Hospital admissions**
- **Respiratory symptoms (cough etc)**
- **Moderate or worse asthma status**
- **Changes in pulmonary function**
- **Days of work loss**

World Bank Institute (2002)

1

Deposition of Particulate Matter in Respiratory system

STAGE 1	7-11 μm
STAGE 2	4.7-7 μm
STAGE 3	3.3-4.7 μm
STAGE 4	2.1-3.3 μm
STAGE 5	1.1-2.1 μm
STAGE 6	0.65-1.1 μm
STAGE 7	0.43-0.65 μm

Nasal Passage

Pharynx

Larynx

Trachea & Primary Bronchi

Secondary Bronchi

Terminal Bronchi

Alveoli

Terminology Used – Lung Function Parameters

Total Lung Capacity

Male : 6000 ml

Female : 4300 ml

Singh (1999) – Indian Asthma Care Society

Continued…

Flow Volume Loop and Volume Time Curve
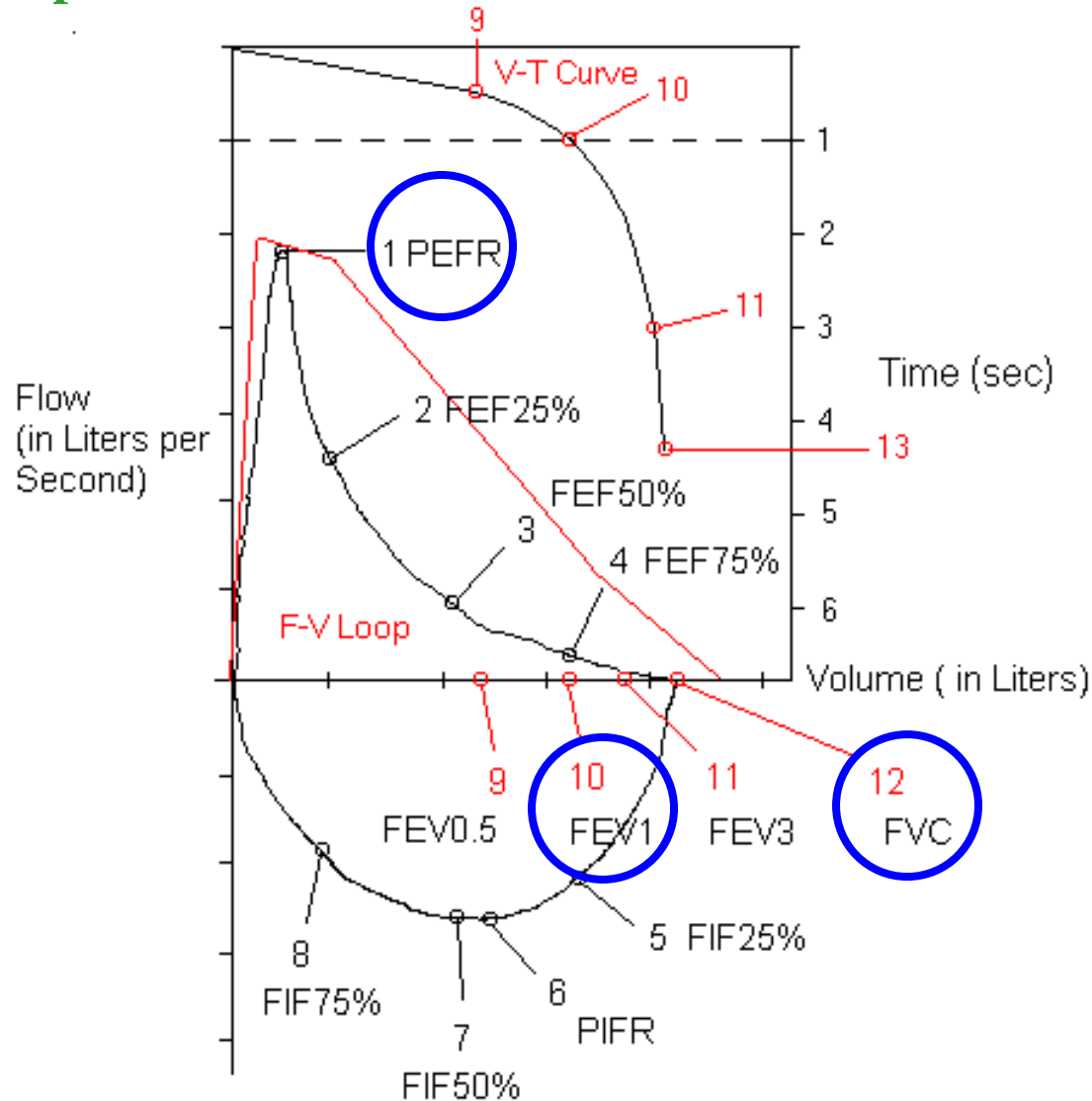
Pulmonary Function Testing

Spirobank G, MIR

Personal Best-PEF Meter

Continued…

PEFR – **Peak Expiratory Flow Rate**

FEV$_1$ – **Forced Expiratory Volume in One Second**

FVC – **Forced Vital Capacity**

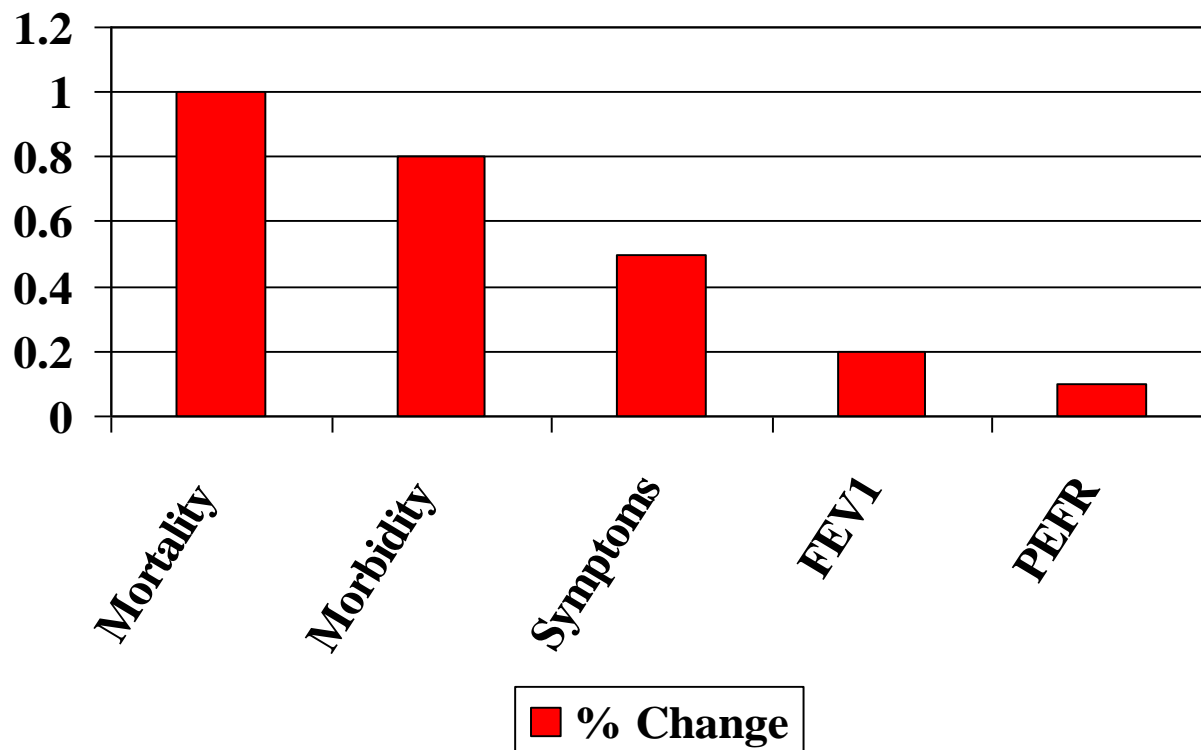☛**Importance of PEFR**

➢Asthma = Troublesome Breathing due to inflammation and constriction of airways

- recommended > 80% of the predicted value
- lower value, aggravation of asthma

Health Effects of PM Pollution

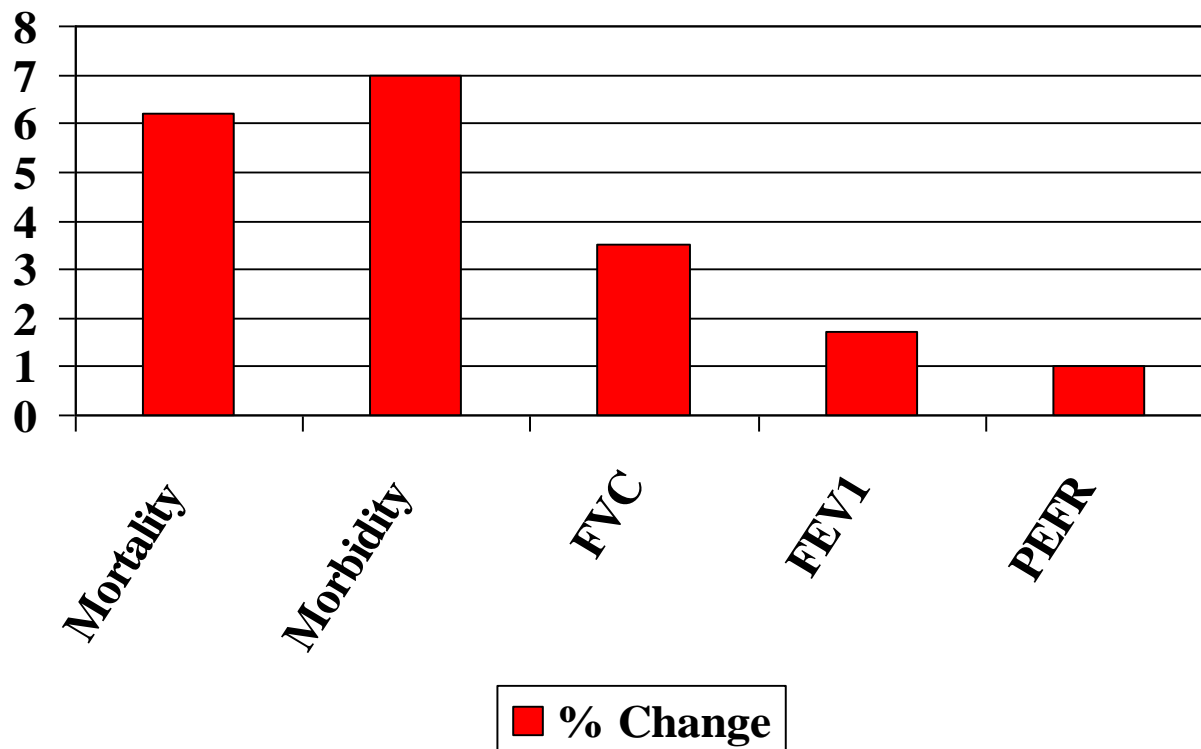**Summary of Acute exposure studies - % change per 10 μg/m³ of change in PM$_{10}$**

Pope and Dockery (1999)

Continued…

Health Effects of PM Pollution

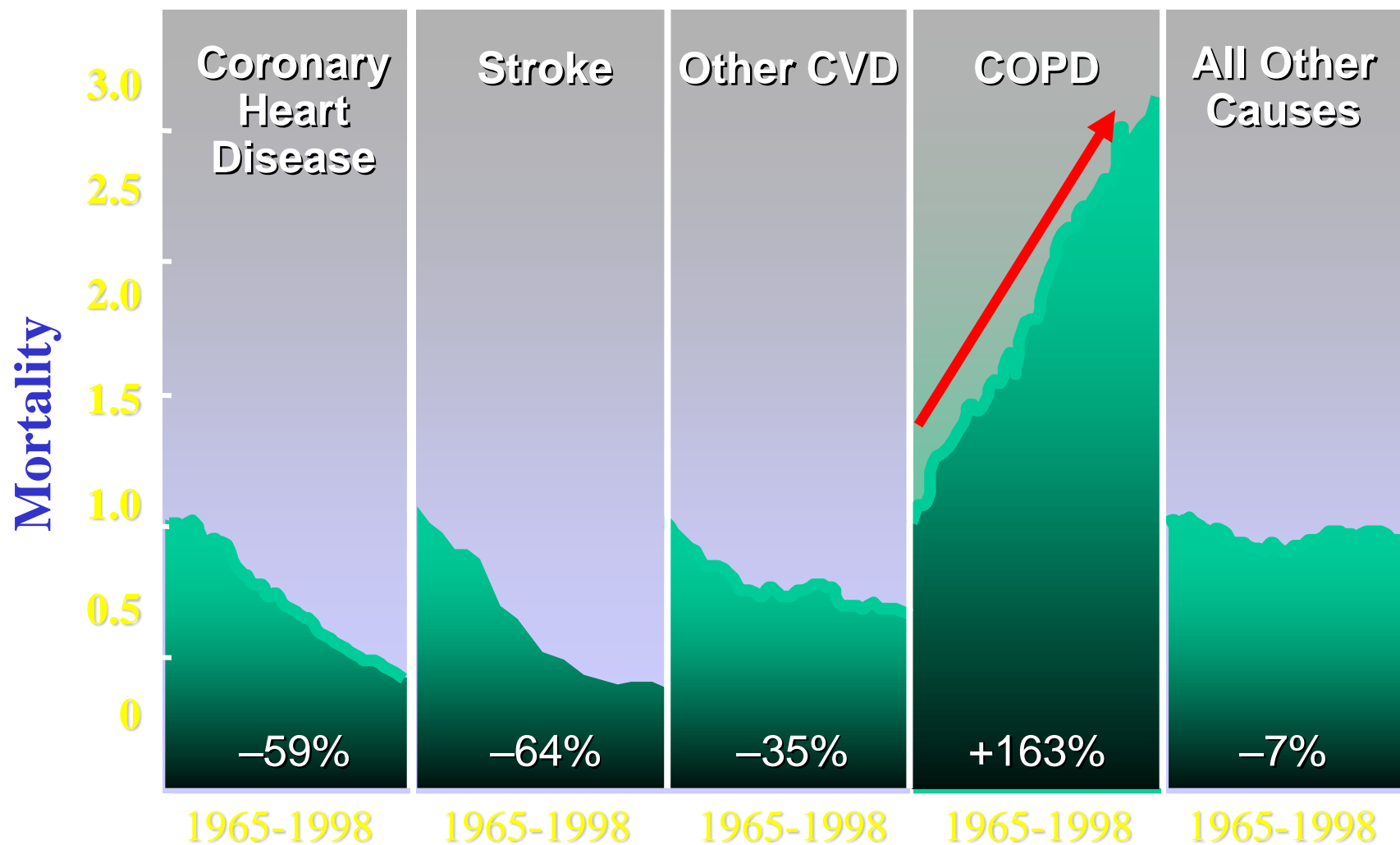**Summary of Chronic exposure studies - % change per 5 µg/m³ of change in $PM_{2.5}$**

Pope and Dockery (1999)

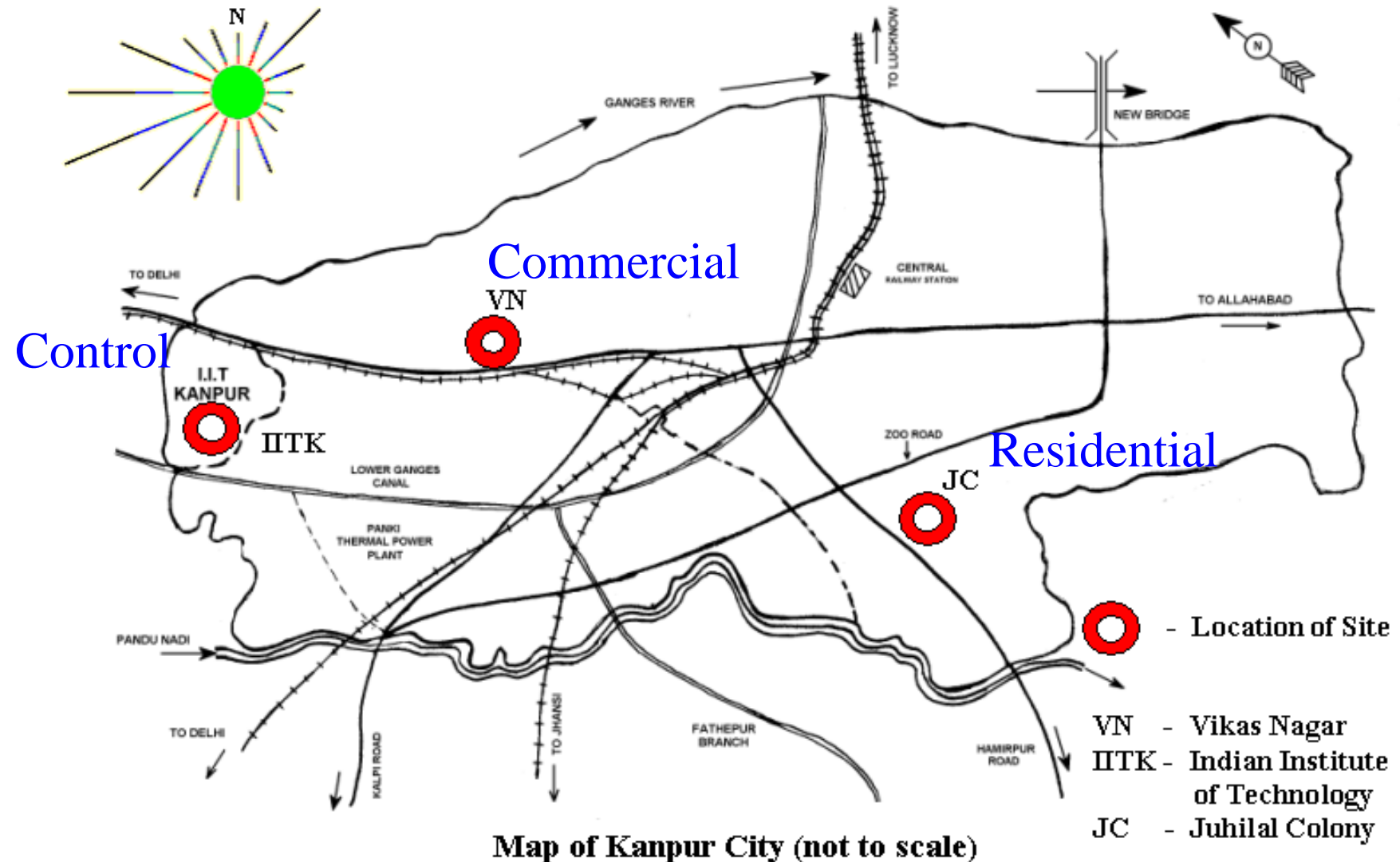☛ **Importance of FEV_1 and FVC in diagnosis**

➢Obstructive Lung Disease = unable to get air out
- $FEV_1/FVC < 70\text{-}75\%$ (70% used in COPD) – low FEV_1
- The lower the ratio, the worse the obstruction

➢Restrictive Lung Disease = unable to get air in
- Low FVC; normal or elevated FEV_1/FVC
- Low TLC

Continued…

Mortality

Coronary Heart Disease	Stroke	Other CVD	COPD	All Other Causes
−59%	−64%	−35%	+163%	−7%
1965-1998	1965-1998	1965-1998	1965-1998	1965-1998

Center for Disease Control and Prevention, US (1999)

10

Study Area and Sites

Map of Kanpur City (not to scale)

VN — Vikas Nagar
IITK — Indian Institute of Technology
JC — Juhilal Colony

Summary of PM$_{10}$ and PM$_{2.5}$ levels at various locations

Air Quality Parameter	Cohort Site		
	Juhilal Colony	**Vikas Nagar**	**IIT Kanpur**
PM$_{10}$ (μg/m^3)	293 $\pm$ 90	295 $\pm$ 57	184 $\pm$ 40
PM$_{2.5}$ (μg/m^3)	85 $\pm$ 30	162 $\pm$ 19	59 $\pm$ 9

- IIT Kanpur site (PM$_{10}$: 132-249 μg/m^3; PM$_{2.5}$: 39-71 μg/m^3)
- Vikas Nagar site (PM$_{10}$: 181-436 μg/m^3; PM$_{2.5}$: 125-188 μg/m^3)
- Juhilal colony (PM$_{10}$: 179-495 μg/m^3; PM$_{2.5}$: 50-153 μg/m^3).
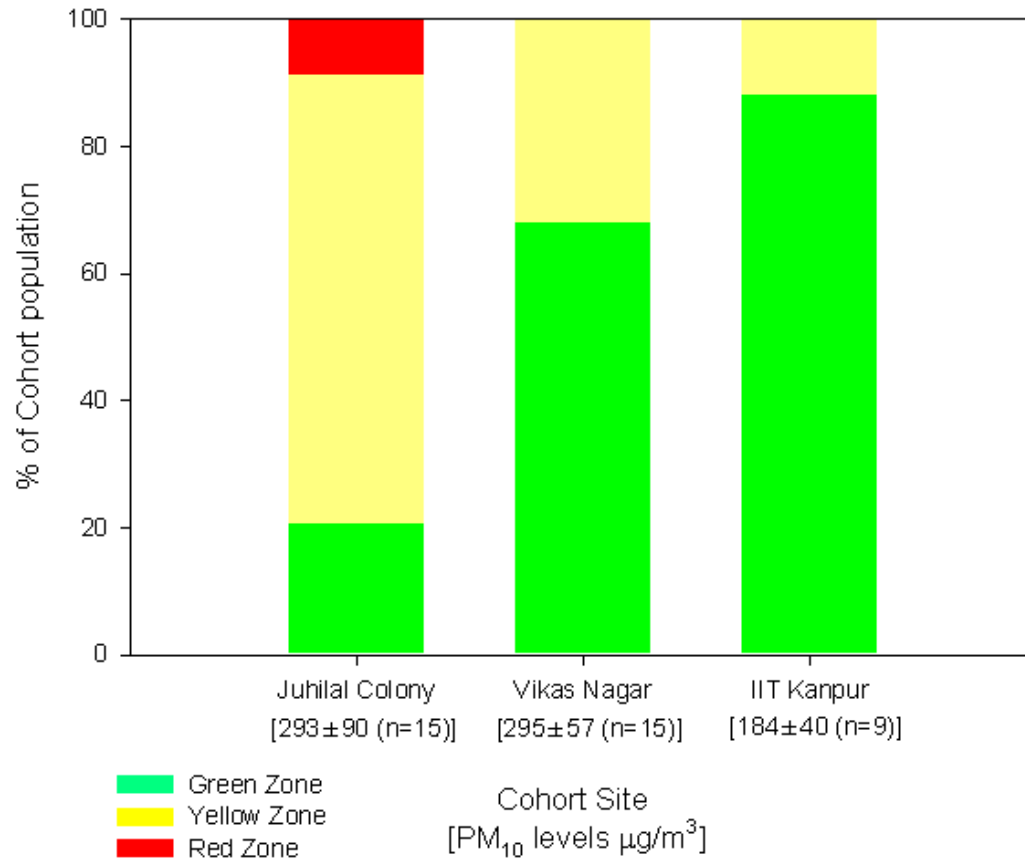
12

Continued…

- Daily PEFR readings were collected for a period of 15 days concurrent to the Air Quality Monitoring for each cohort

- One time complete pulmonary function test were conducted on each individual of cohort with Spirobank-G to observe the general trend in FEV_1 and FVC

Results

Baseline lung status of Cohort Group

Baseline PEFR Values of Cohorts

Green Zone – Observed PEFR value is $\geq$ 80 % of the predicted value of individual; no symptoms of asthma.

Yellow Zone – Observed PEFR value is $\geq$ 50 % & < 80 % of the predicted value; beginning of asthma.

Red Zone - Observed PEFR value < 50 % of the predicted value; needs medical attention.

NIH (1997)

In general Prevalence of Asthma is more in the polluted areas.

Results

Analysis of PEFR Data

It is not advisable to directly examine one to one association between PEFR and PM_{10} and $PM_{2.5}$ of all individual as a group as the absolute value of PEFR of an individual depends on body responses and body parameters like height, age, sex and other confounding factors.

ΔPEF with PM_{10} and $PM_{2.5}$ was checked

1. The mean PEFR (L/min) for each participant was calculated for 15-day period.
2. Individual deviations of daily performance from each participant's mean PEFR were calculated.
3. These deviations were averaged across participants individually to obtain a daily mean deviation, ΔPEF.

Results

	Day1	Day2	..Day15	Mean	Day1	Day2	..Day15
P1	PEF1	PEF2	..PEF15	PEFR	ΔPEF1	ΔPEF2	ΔPEF15
P2	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:
P33	:	:	:	:	:	:	:
				Mean ΔPEF	ΔPEF1	ΔPEF2	ΔPEF15

while looking at ΔPEF, one can look into the variation of PEFR of an individual with respect to his/her mean PEFR performance Suggested by Pope and Dockery (1992)

Results

Correlation between mean ΔPEF and four parameters - PM_{10}, $PM_{2.5}$, PM_{10} (one-day lagged) and $PM_{2.5}$ (one-day lagged)

Parameter	Δ PEF	PM_{10}	$PM_{2.5}$	PM_{10} (One-day lag)	$PM_{2.5}$ (One -day lag)
Δ PEF	1				
PM_{10}	-0.52				
$PM_{2.5}$	-0.30				
PM_{10} (One-day lag)	-0.32	0.45	0.49	1	
$PM_{2.5}$ (One-day lag)	-0.27	0.46	0.88	0.67	1

deposition of larger particles (PM_{10}) takes place in upper part of respiratory system that activates mucus secretion resulting is inflammation & constriction of airways and thus lowering PEFR value

All values are statistically significant ($p < 0.05$) – n = 39

17

Results

PM$_{10}$ vs ΔPEF (ALL)   y = -0.0318x + 9.3025
R^2 = 0.2737

ΔPEF (L/min)

PM$_{10}$ (μg/m^3)

y = -0.0297x + 4.0947
R^2 = 0.0888

ΔPEF vs PM$_{2.5}$ (All)

ΔPEF (L/min)

PM$_{2.5}$ (μg/m^3)

18
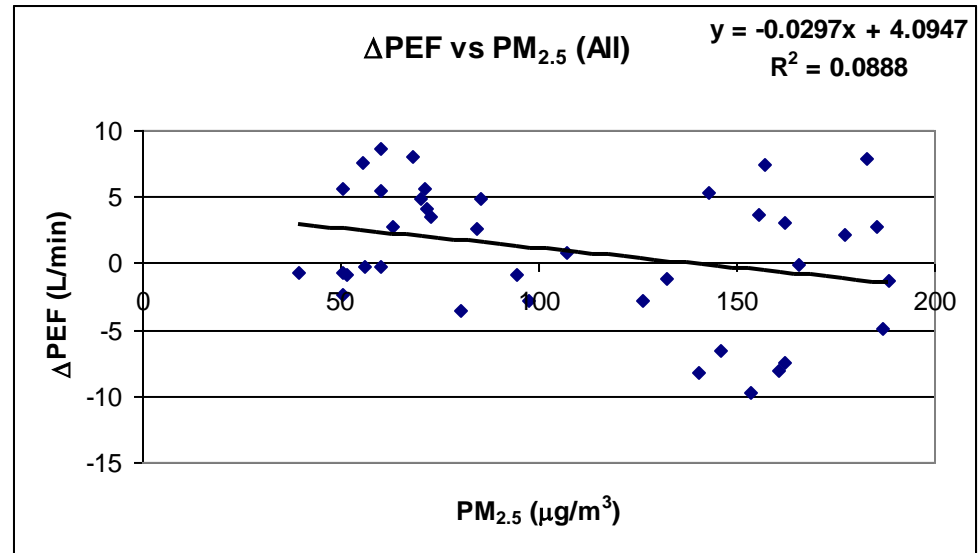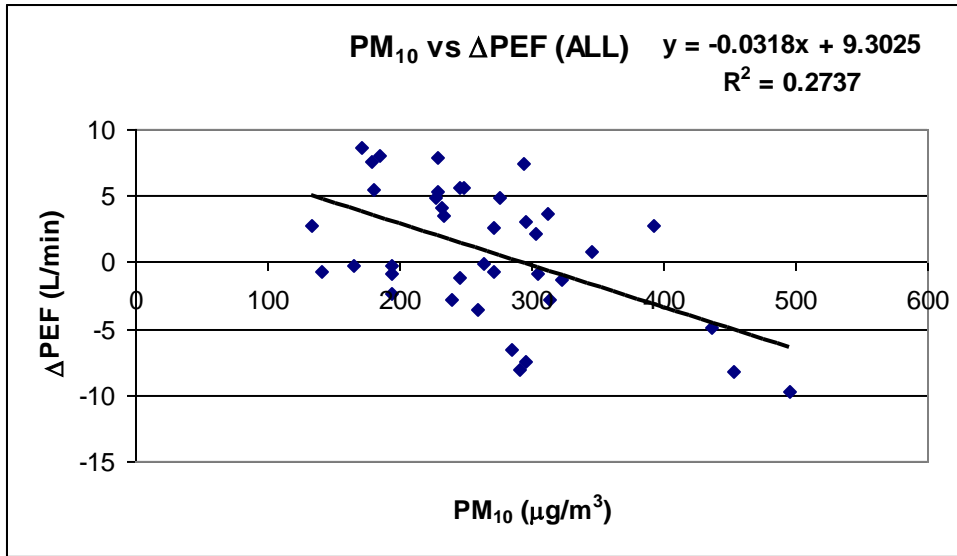
Results

Estimated Regression Coefficients and their Comparison

	This Study		Pope and Dockery (1992)			
	Model I (n=39)	**Model II (n=39)**	**Symptomatic (n = 100)**		**Asymptomatic (n=100)**	
			Model I	**Model II**	**Model I**	**Model II**
PM$_{10}$ (concurrent day, μg/m3)	**-0.0318 (9.025)**	**-**	**-0.0175 (0.6006)**	**-**	**-0.0110 (-3.606)**	**-**
PM$_{2.5}$ (concurrent day, μg/m3)	**-**	**-0.0297 (4.0947)**	**-**	**-**	**-**	**-**
PM$_{10}$ (5-day moving average)	**-**	**-**	**-**	**-0.0359 (2.0934)**	**-**	**-0.0254 (-2.504)**

Value in parenthesis is the intercept. (n represents number of sampling days)

Variation of ΔPEF with PM_{10} and $PM_{2.5}$

PM₁₀, ΔPEF vs Time (Cohort - VN Site)
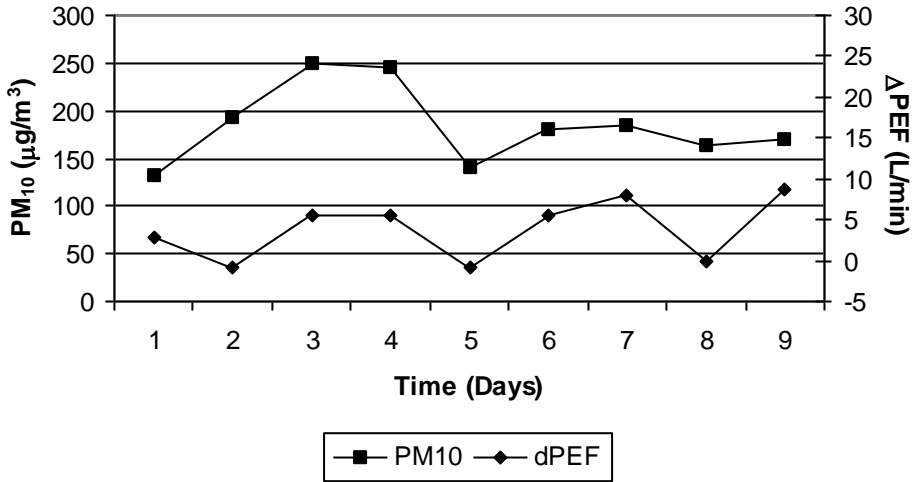
Change in daily PM_{10} levels and mean ΔPEF at VN

PM₂.₅, ΔPEF vs Time (Cohort - VN Site)

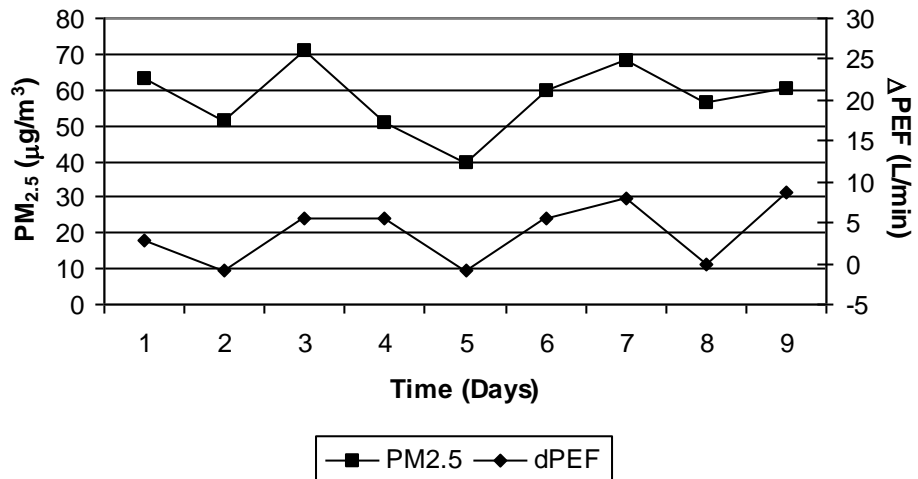**Change in daily $PM_{2.5}$ levels and mean ΔPEF at VN**

Variation of ΔPEF with PM_{10} and $PM_{2.5}$

PM$_{10}$, ΔPEF vs Time (Cohort- JC Site)

Change in daily PM_{10} levels and mean ΔPEF at JC

PM$_{2.5}$, ΔPEF vs Time (Cohort - JC Site)

Change in daily $PM_{2.5}$ levels and mean ΔPEF at JC

Variation of ΔPEF with PM_{10} and $PM_{2.5}$

Change in daily PM_{10} levels and mean ΔPEF at IITK

Change in daily $PM_{2.5}$ levels and mean ΔPEF at IITK

22
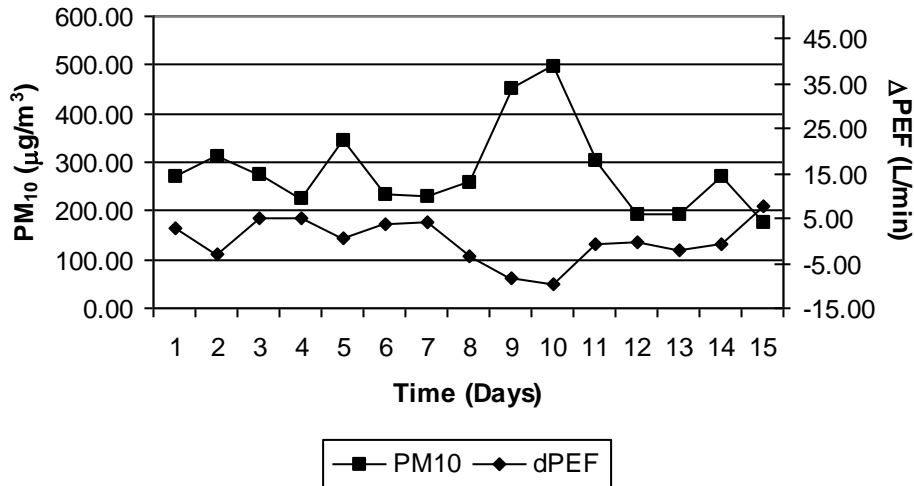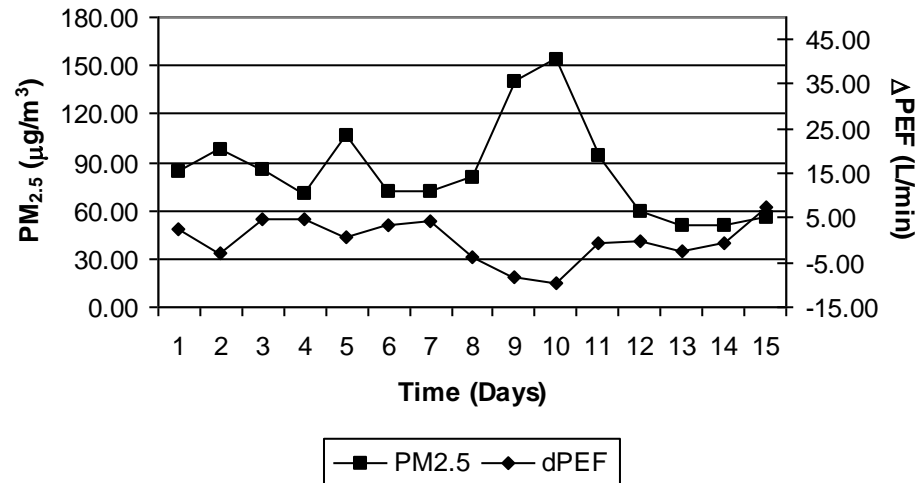
Variation in Observed FEV$_1$, FVC from Reference
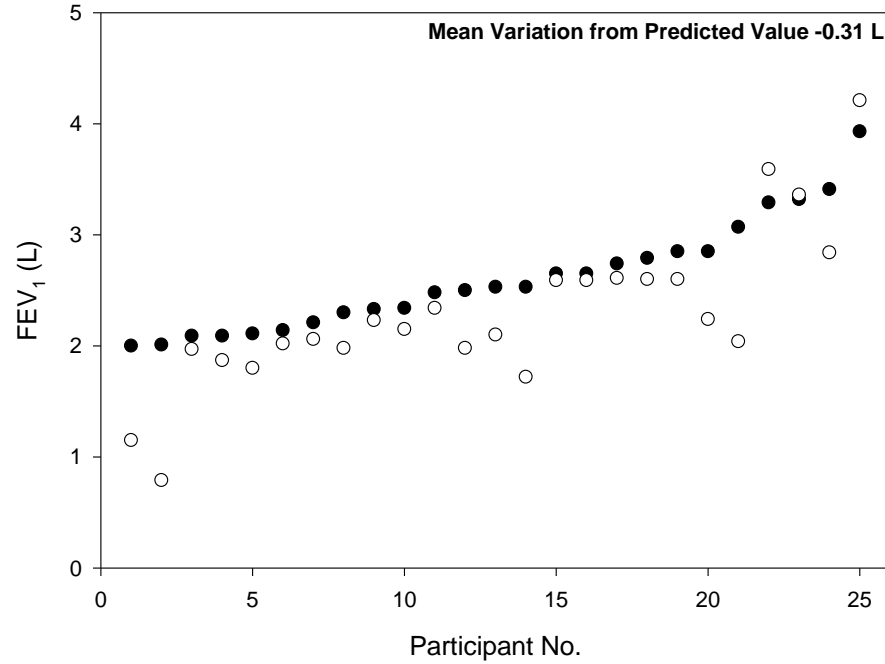

Vikas Nagar (VN) Cohort
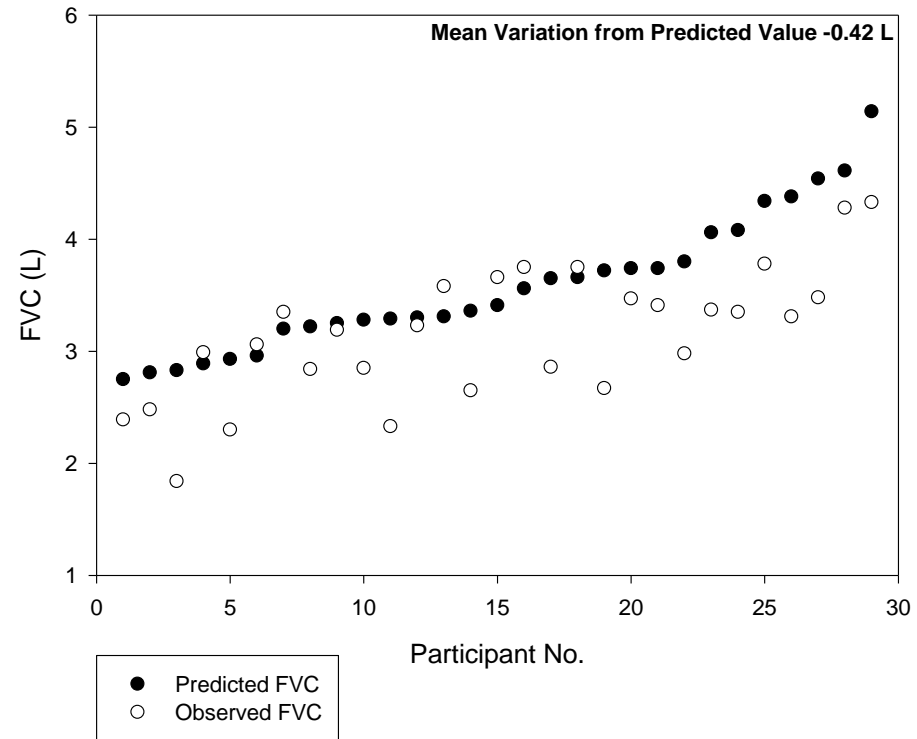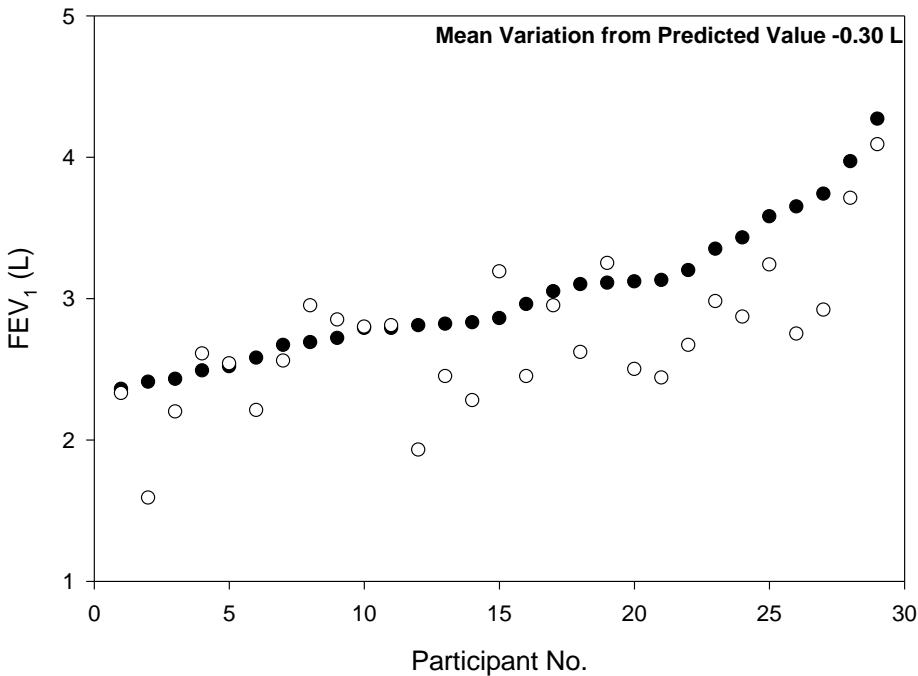
Vikas Nagar Cohort

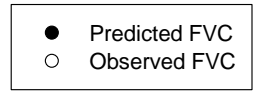# Variation in Observed FEV$_1$, FVC from Reference

Juhilal Colony (JC) Cohort
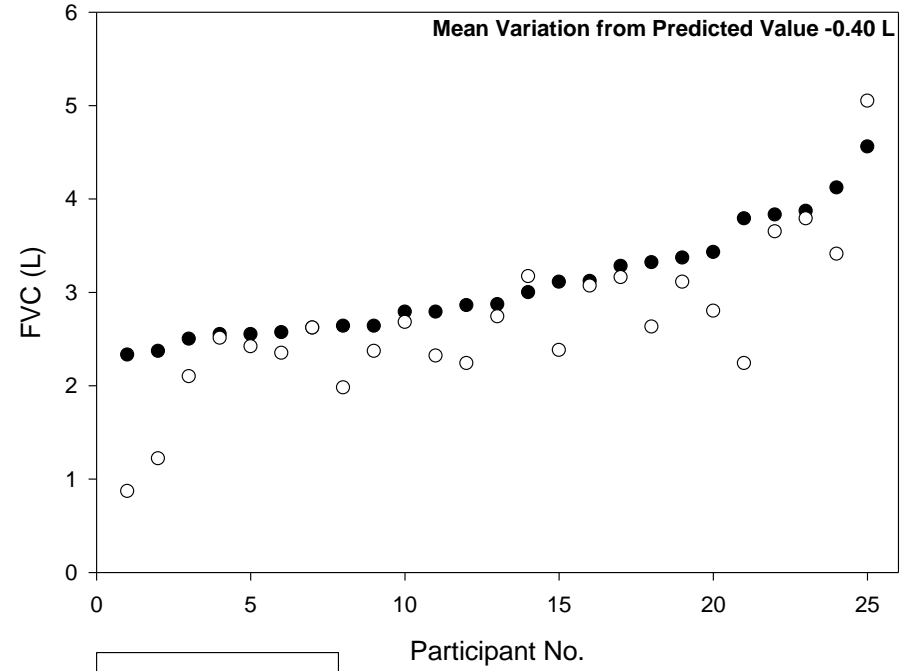
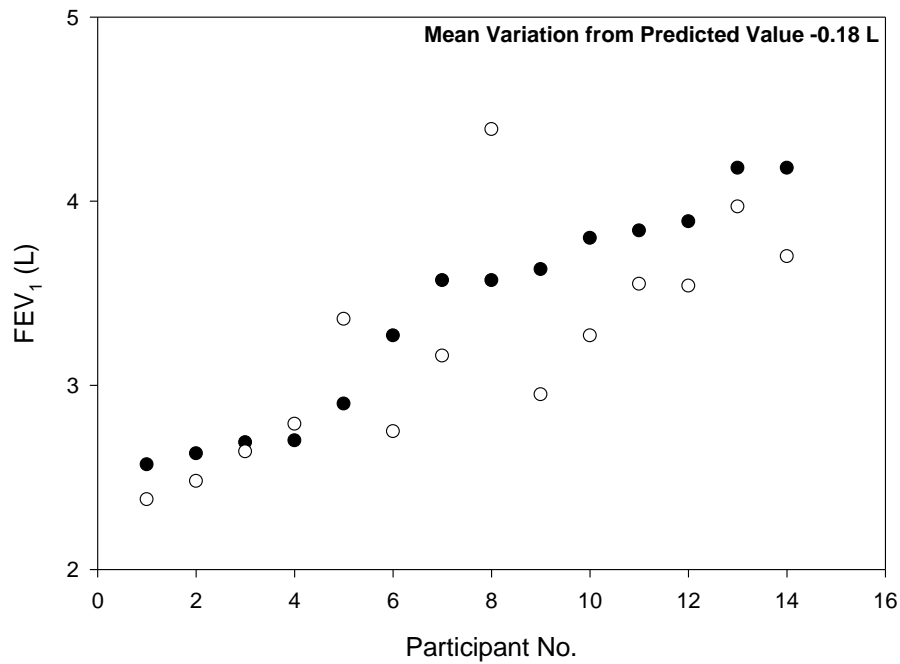**Juhilal Colony Cohort**

Variation in Observed FEV$_1$, FVC from Reference

IIT Kanpur (IITK) Cohort

IIT Kanpur Cohort