Report

on

“Assessment of impact of air pollution among school children in selected schools of Dhaka city”

Department of Environment,
Department of Occupational & Environmental Health,
NIPSOM and
Directorate General of Health Services

Project Title : Assessment of impact of air pollution among school children in selected schools of Dhaka city

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1. Introduction

Air is indispensable for the survival of all living organisms on earth, including human beings. Air quality has deteriorated both due to human activities, and natural. Among the air pollutants Particulate matter (PM) is a matter of concern. It is an consists of a mixture of particles that can be solid, liquid or both, are suspended in the air and represent a complex mixture of organic and inorganic substances. These particles categorized according to their aerodynamic diameter called particle size as because this size is the important determinant of their effect on human health as well as the time they spend in the atmosphere.

- The coarse fraction is called PM_{10} (particles with an aerodynamic diameter smaller than 10 μm), which may reach the upper part of the airways and lung.
- Smaller or fine particles are called $PM_{2.5}$ (with an aerodynamic diameter smaller than 2.5 μm); these are more dangerous because they penetrate more deeply into the lung and may reach the alveolar region.

The major PM components are sulfate, nitrates, ammonia, sodium chloride, carbon, mineral dust and water. Particles may be classified as primary or secondary depending on their formation mechanism.

Primary particles are directly emitted into the atmosphere through man-made (anthropogenic) and natural processes. Anthropogenic processes include combustion from car engines (both diesel and petrol); solid-fuel (coal, lignite and biomass) combustion in households; industrial activities (building, mining, manufacturing of cement, ceramic and bricks, and smelting); erosion of the pavement by road traffic and abrasion of brakes and tyres; and work in caves and mines.

The main sources of total anthropogenic emissions of primary PM10 are road traffic (10–25%), stationary combustion (40–55%) and industrial processes (15–30%). However, the contribution of road traffic to ground-level urban concentrations and to human exposure would be considerably larger than the contribution of road traffic to emission [1-2].

Recently, air pollution has received priority among environmental issues in Asia, as in other parts of the world. Exposure to air pollution is the main environmental threat to human health in many towns and cities. Motor vehicles have been found to pollute the air through tailpipe exhaust emissions and fuel evaporation, contributing $PM_{2.5}$, other air pollutants. Motor vehicles represent the principal source of air pollution in many communities, and concentrations of traffic pollutants are greater near major roads.[3]

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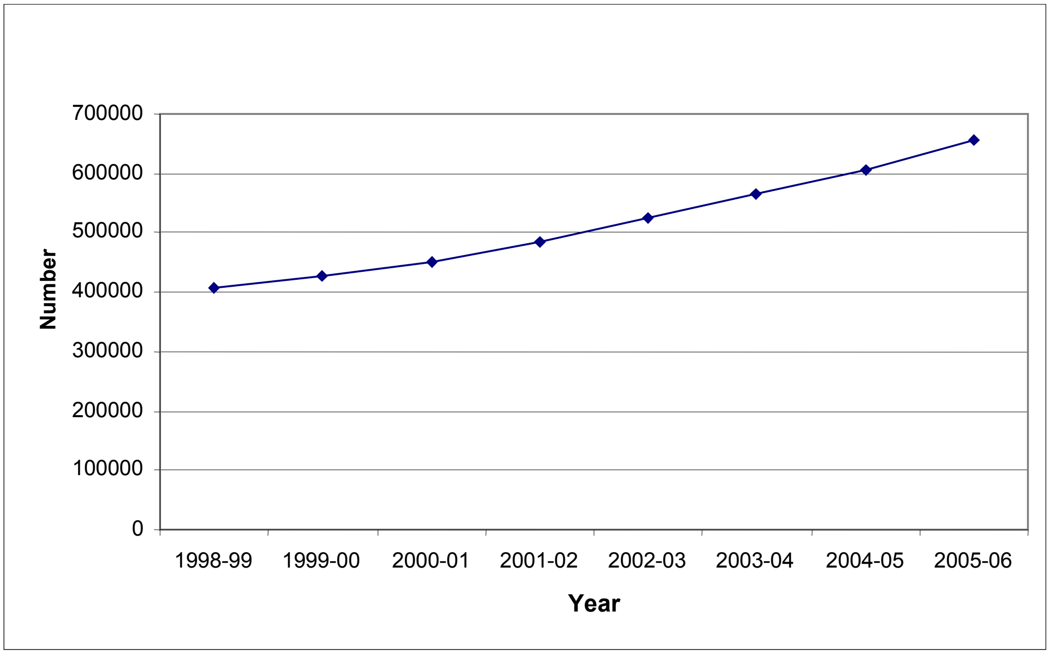
Several studies conducted in Europe, including the central European study on air pollution and respiratory health [4], have indicated that the PM2.5 constitutes, on average, about 70% of the PM10 mass. The seasonal variability of PM10 was entirely accounted for by the changes in PM2.5 concentration. Particulate emission is mainly responsible for increased death rate and respiratory problems for the urban population. PM increases the risk of respiratory death in infants under 1 year, affects the rate of lung function development, aggravates asthma and causes other respiratory symptoms such as cough and bronchitis in children; PM2.5 seriously affects health, increasing deaths from cardiovascular and respiratory diseases and lung cancer. Increased $PM_{2.5}$ concentrations increase the risk of emergency hospital admissions for cardiovascular and respiratory causes; and PM_{10} affects respiratory morbidity, as indicated by hospital admissions for respiratory illness[2,4-9]. Fine particles ($PM_{2.5}$) are emitted from combustion processes (especially diesel-powered engines, power generation, and wood burning) and from some industrial activities. Coarse particles (diameter between 2.5 and 10 µm) include windblown dust from dirt roads or soil and dust particles created by crushing and grinding operations. Toxicity of particles may vary with composition[10-11]. Particle pollution contributes to excess mortality and hospitalizations for cardiac and respiratory tract disease[12-15].

In children, particulate pollution affects lung function[16-17] and lung growth[18]. Children are more vulnerable to the adverse effects of air pollution than are adults. Eighty percent of lung alveoli are formed postnatally, and changes in the lung continue through adolescence[7]. Children have increased exposure to many air pollutants compared with adults because of higher minute ventilation and higher levels of physical activity. Because children spend more time outdoors than do adults, they have increased exposure to outdoor air pollution[2,7]. PM among other criteria pollutants (ozone, sulfur dioxide, nitrogen dioxide) have respiratory effects in children and adults, including increased respiratory tract illness, asthma exacerbations, and decreased lung function (eg, changes in peak flow)[8,9,18].

Air quality in Dhaka is a serious issue in view of the magnitude of its health and economic impacts. In the last few decades, the city has experienced huge population growth and rapid industrial, commercial, business, residential and infrastructure development.

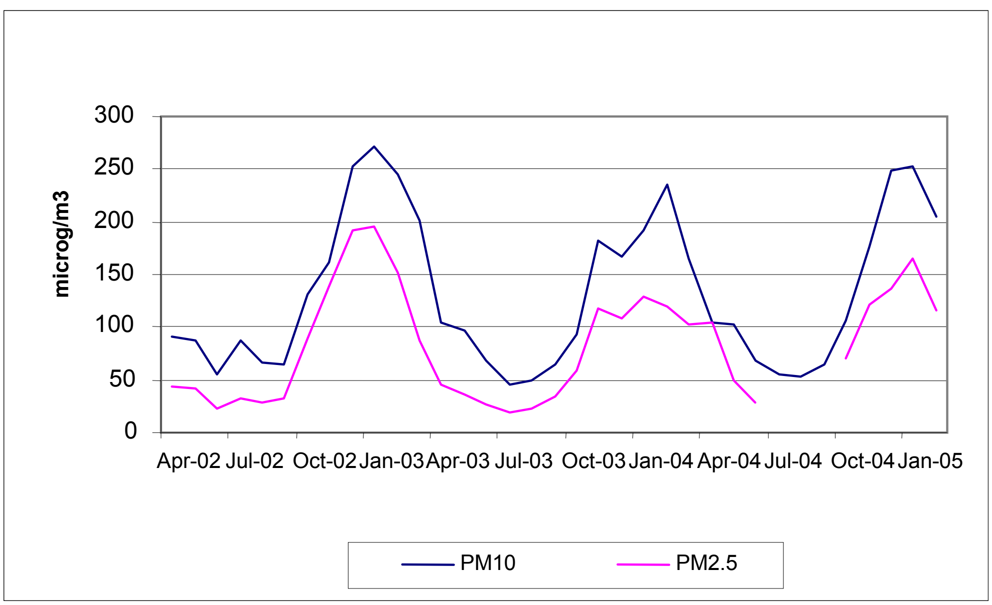
As a result, the major components of the city environment both physical and social are greatly impacted leading to more or less continuous deterioration. Urbanization is an inherent part of the process of economic development in Bangladesh, and its rate can be indicated by the large population growth in urban areas. With increased urbanization, the number of vehicles is also increasing rapidly, and contributing to more and more air pollution. Dust pollution due to road diggings, constructions and other development activities further aggravate the air pollution situation in cities. In order to accommodate the growing population, the construction of multi-storied buildings is increasing rapidly. Due to rapid and unplanned urbanization the total number of vehicles has increased enormously. Most of the cars, jeeps, auto-rickshaws, motorcycles, etc., ply in the cities. This has really led to a deterioration of air quality, particularly in Dhaka[19]. The increasing number of transportation vehicles and their improper management and operation are responsible for degradation of the air quality. There is no doubt that air pollution affecting human health in Bangladesh, especially in Dhaka City[20,21].

Fig.1: Registered motor vehicles in Bangladesh



The main air quality problem in Dhaka is the high level of particulate matter. Both PM10 and PM 2.5 levels are high[22], being much above the proposed safety standards especially during the dry winter season. Both PM_{10} and $PM_{2.5}$ starts increasing in October, peaks in

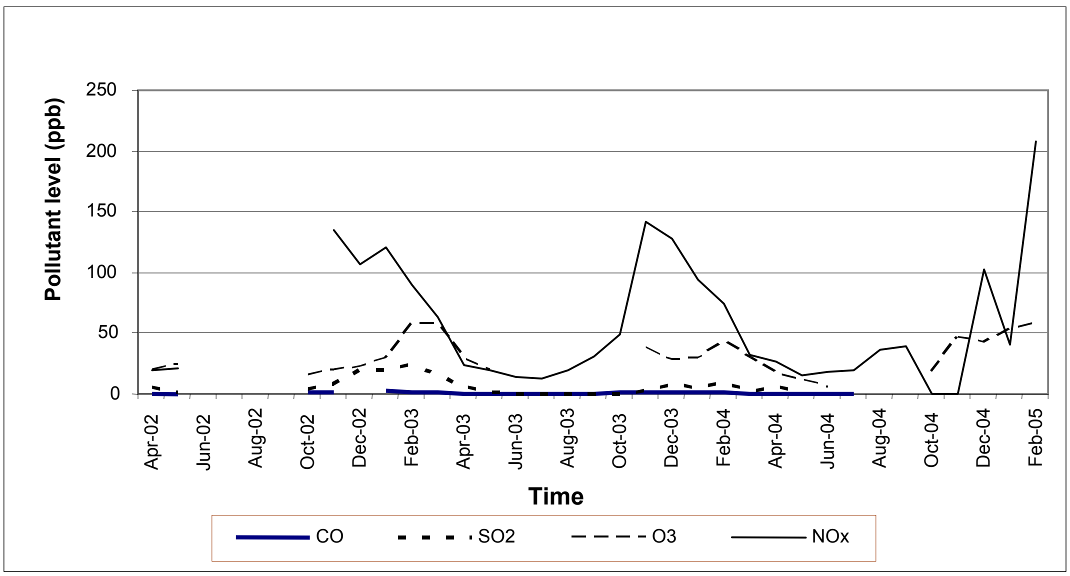
Fig.2: Average Particulates during April 2002 – February 2005



between December and February thereafter starts declining and is low in between April and October..

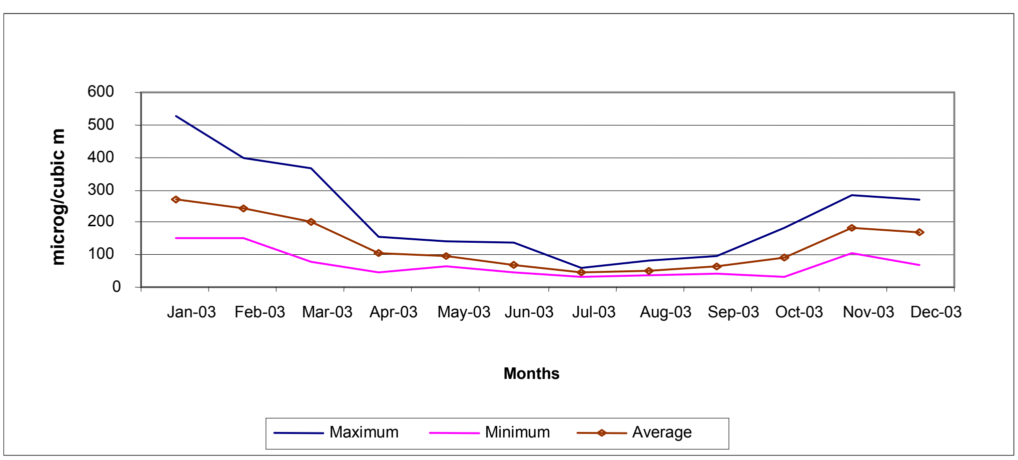
The air quality standards are different for residential, industrial, commercial, and sensitive areas. According to various studies the worst affected areas in Dhaka city include: Hatkhola, Manik Mia Avenue, Tejgaon, Farmgate, Motijheel, Lalmatia, and Mohakhali. Surveys conducted between January 1990 and December 1999 showed that the concentration of suspended particles goes up to as high as 3000 micrograms per cubic meter (Police Box Farmgate Station, 1999 December), although the allowable limit is 400 micrograms per cubic meter[19].

Fig.3: Average Emissions during April 2002 – February 2005



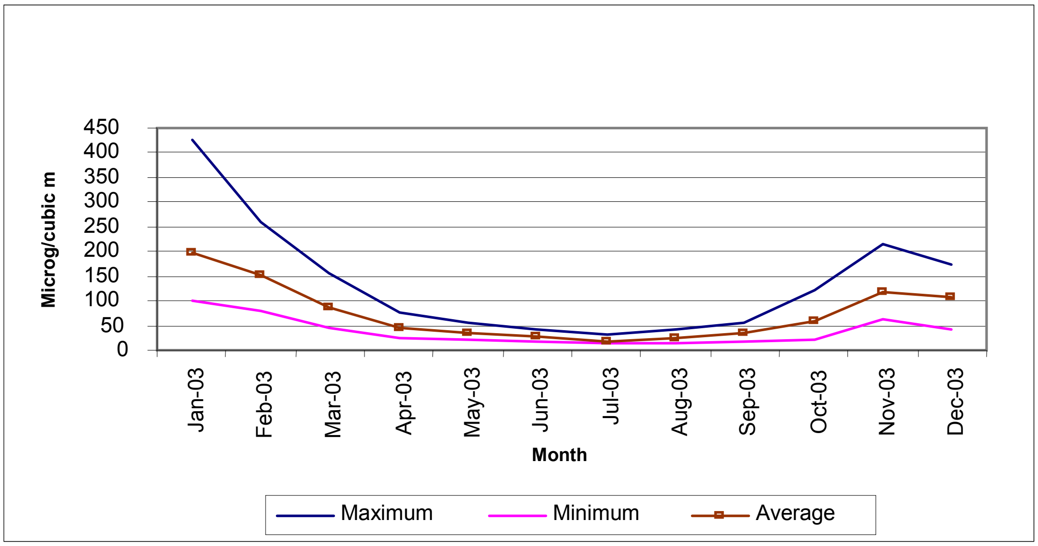
AQMP data from a continuous air monitoring station installed at Sangsad Bhaban area (a relatively cleaner area) with comparatively low vehicular traffic load shows the state of

Fig.4: Monthly PM 10 level at Shangshad Bhavan area of Dhaka in 2003



different air pollution parameters during the period 2002-2005 (Fig 3) and the year 2003 (Fig 4 -5)[23-27]. Even in the Sangshad Bhaban area the PM 10 and PM 2.5 was observed to be low during the period April to October

Fig.5: Monthly PM 2.5 level at Shangshad Bhavan area of Dhaka in 2003



There is still a lack of formal studies showing the linkages between air pollution concentration and health impacts in most of the Asian Countries as well as Bangladesh. In this backdrop, an assessment on impact of air pollution among school children of Dhaka City has been initiated jointly by the United Nations Environment Programme (UNEP), RRCAP, Stockholm Environment Institute (SEI) of Sweden, Department of Environment and Department of Occupational & Environmental Health of Bangladesh under the Male Declaration sub-activity 4.1.2., to determine health effects of air pollution through a cross sectional study by assessing whether the concentrations of particulates and socio-economic differences alters the relationship between particles and respiratory symptoms and lung function in children in Dhaka City. The findings of the study will address uncertainties and strengthen inferences of causality and develop a dose-response association.

2. Objective of the study

To determine whether air pollution in terms of the concentrations of particulates alters the relationship between particles and respiratory symptoms and lung function (PEFR) in children in Dhaka City.

3. Methods and Materials

The study consisted of a baseline survey followed by the assessment of health impact of air pollution among school children.

3.1. Phase I: Baseline Survey

The base line survey was to get the socioeconomic and respiratory illness data from the student with a target to identify and enroll the asthmatic students who are supposed to be selected finally in the "Health Impact Study".

The baseline survey was carried out in three schools situated in the central part of Dhaka city (well known areas of air pollution). The schools were Dhanmondi Boy's School (DBS), Tejgaon Girl's School (TGS) and Civil Aviation School (CAS). The schools are located within one kilometer of the central Air Quality Monitoring Station of the Department of Environment. It was assumed that the AQMP data of this station would represent the air quality state of the selected schools. All students (around 1800) of class V, VI, VII, VIII & IX of these schools (their age range was from 9-16 years) were targeted as participants for the baseline survey.

Before implementation of the baseline survey several preliminary meeting were arranged with the school authority to motivate them to participate, cooperate and fix an appropriate time period for conducting the two phases of the study. It was found that considering the study objectives and required period of the study the school authority agreed to initiate the study in the month of February. Class Teachers of all the selected classes were recruited to act as supervisors for base line data collection. Training program were organized for the teachers to aware them the objective, methodology and their terms of reference in the study.

For the purpose of the survey based on 'The International Study of Asthma and Allergies in Childhood (ISAAC)' questionnaire (Ref: ISAAC International Data Centre, Auckland, New Zealand, July 2000. http://isaac.auckland.ac.nz) a modified structured English version ***questionnaire*** was prepared. The questionnaire was then translated into Bengali, to confirm the correctness of the Bengali translation the Bengali version was again retranslated into English. After necessary correction the Bengali Questionnaire was pre-tested in a school.

The Questionnaire had 3 parts:
Part-I had introductory information. *Part II*: had socioeconomic data, *Part-III* had Respiratory health related data. The questionnaire with a request letter was delivered to

all the students through the respective class teachers and was asked to take it to their home and fill in with the assistance of their parents. The request letter contained statements of request to cooperate the study, study rational, study objectives and instruction for proper filling up of the questionnaire. The letter also contained the address and telephone number of the investigators for any query or clarification during filling up the questionnaire.

A separate ***check list*** for recording the present state of respiratory health, relevant medical history and findings of clinical examination of respiratory system of the participating students was also prepared.

To encourage highest response rate, a gift (Pencil box/geometry box etc.) for each participating students and a General gift item- a large screen Television set for each of the participant school was declared.

Thereafter, in the 1st week of February 2007 the structured pre-tested ***questionnaire*** was distributed to all students (around 1800) of class V, VI, VII, VIII & IX of the selected schools through their class teachers with instructions to return the filled in questionnaire to the respective class teachers on the following week. Out of the 1800 targeted students, 1618 students ultimately submitted the filled in questionnaire and were considered as participants of the study. The response rate was around 80%. Of the participating students, 720 were from DBS, 600 from TGS and 500 from CAS.

Subsequently each participating student underwent evaluation of the present state of respiratory health that included clinical examination of the respiratory system and history taking by six trained doctors. Six doctors with two of them in each school were deployed.

Data obtained in the baseline survey was analyzed to identify students with history or clinical evidence of Asthma. The students who gave history of wheeze at any time in the last one year or a patient of diagnosed Asthma with or without medication and if one is designated as an Asthma patient identified by the medical examination conducted during the Base line survey were taken as Asthmatic subjects. Ultimately 388 asthmatic subjects were identified.

3.2. Phase II: Health impact study

Study subjects

From the 388 asthmatic subjects identified in the Base Line Survey students whose father was smokers and who did not provided smoking history were excluded. After exclusion all the 214 students who qualified to be a participant of the study were invited to undertake self Peak Expiratory Flowmetery test twice each day for six weeks. Ultimately of the 197 asthmatic subjects, who consented to be participant of the Health Impact Study, 120 asthma students were selected randomly.

Enrolling Healthy Control was difficult because most of the healthy subjects did not want to come to the school comparatively early in the morning and undertake long six weeks PEFR testing, which they considered unnecessary and troublesome. From the available non-asthma students who agreed to participate, 60 healthy subjects were selected as controls.

Ultimately a total of 180 students were selected for the study. The distribution of asthmatic subjects and control subjects by schools are shown in the table below.

School wise Asthmatic and Control subjects

Schools	Asthmatics	Controls
Dhanmondi Boy's School	60	30
Tejgaon Girl's School	30	15
Civil Aviation School	30	15

Data collection procedure:

Respiratory Data:
For recording Peak Expiratory Flow Rate a Peak Flow Meter named DATOSPIR PEAK – 10, made in Spain (www.SIBELMED.COM) was used.

For the entire period of data collection in 2^{nd} phase, formatted colored Record Sheets for each student were used for recording the PEFR readings. The sheets contained a tabular form of PEFR readings started from 100 to 720 both for morning and afternoon in each row with date. One card contained column for two weeks, as such for each student three cards were filled for six weeks.

Pink colored sheet was used for the Asthmatic subjects and Green colored for the Controls (non-asthmatic). Individual cards contained a unique serial number, school name, class of the school, name and roll number of the student. In addition all the students were provided with a Dairy to make daily note(s) of any illness, particularly respiratory symptoms like sore throat, runny nose, hoarseness, cough, phlegm, wheezing, fever, ear pain or discharge; hospital admission, physician consultation and additional medications if required in any occasion.

Class teachers of all sections of Class V, VI, VII, VIII & IX and designated technicians were trained up by the Principal and Co-Investigators of the study at the National Institute of Preventive and Social Medicine (NIPSOM) with emphasis on supervision of the daily diary writing, standard technique of Peak Expiratory Flow Rate (PEFR) measurement and recording of PEFR finding.

A roster for PEFR measurement of selected students in identified classes was prepared with the assistance of the Headmaster of each school who ensured the accomplishment of the schedule. One technician assigned for each school supervised the daily data collection and ensured quality assurance of PEFR measurement.

The use of Peak Flow Meter was demonstrated to selected study participants in small groups (individual classes) by the designated trained teachers and technician. And each participating student was provided with a Peak Flow Meter.

PEFR was measured by the student themselves under the supervision of the assigned teachers and technician twice per day; once in the morning shortly before the classes began and again when the classes for the day ended. Morning measurements were recorded before taking of any airway medication. Each measurement was replicated three times in the standing position, and the highest reading was recorded. The reading was done by putting a dot mark in the PEFR record sheet under the marked PEFR reading for that occasion. The reading was recorded by the teacher. The principal investigator and co-investigators frequently visited the schools for any guidance and quality collection of data.

The PEFR measurement was initiated on the last week of February 2007. Daily measurements were taken for a total of 6 weeks during the school time. But because of practical situation(s) like school examinations, summer vacation and school closure for SSC examination, continuous data collection was not possible. Ultimately accommodating for these events, data collection was carried out during last week of February; 2nd,3rd 4th weeks of April; and 1st & 2nd week of June.

As per objective of the study to get a correlation of increased particulate in atmosphere and occurrence of respiratory symptoms (if any), we wanted to collect the data from school children during the peak dust (PM10 & PM 2.5) periods of dry season. Typically in Bangladesh the dry period starts in November. During the period of November to February the dust level usually remains high compared to other months of the dry season.

To collect data for 35 days it took up to third week of June'07. During this 35 days data collection the students had exposure to higher level of dusts only for 4-5 days of February and in other days the particulate level in the air remained unusually low. But for attaining the objective this few days of exposure data was seemed not sufficient and would not be representative of typical particulate exposure period. In this situation few more days of data collection was contemplated during period of higher ambient dusty period. To get the same sample of students we had to decide data collection within November 07 otherwise majority of the study samples might be missed because of their promotion and school change. We therefore, undertook a further 7 days' data collection during the month of November 2007.

Data of Particulate and Weather:
Corresponding data about particulates (PM10 and 2.5) of relevant period was collected from the Air Quality Management Project (AQMP) of the Department of Environment. Relevant metrological data (maximum, minimum and average daily temperature, relative humidity and wind speed) was obtained from the Department of Metrology.

Statistical analysis:
A variety of statistical tests were used including chi-square tests to evaluate group data, student t-test and analysis of variance to test the difference between group means, correlation analyses, Curvilinear regression and Multiple regression analyses to establish which variables had a significant effect on PEFR. Repeated measures analyses were also

undertaken to evaluate the changes in the morning and afternoon PEFR over time and also stratified by asthma status. A significant result was defined by a p value of <0.05.

4. Results

4.1. Phase 1: Baseline Survey observations

The baseline survey targeted around 1800 students of class V, VI, VII, VIII and IX of Dhanmondi Boy's School (DBS), Tejgaon Girl's School (TGS) and Civil Aviation School (CAS). All students of these classes were provided with a structured questionnaire with instructions to fill it in consultation with their parents and return it to their respective class teacher. Out of the 1800 targeted students a total of 1618 students submitted the filled in questionnaire, thus the response rate of the baseline survey was around 89%. Out of the total 1618 participants 60.5% were female. The participants of the baseline questionnaire survey were mostly Muslim (93.5%), hindus, buddhists, and Christians accounted for the remaining participants.

Table 1: Selected Socio demographic status of School Children

Socio demographics		Frequency	Percent
School name	DBS	639	39.5
	CAS	422	26.1
	TGS	557	34.4
Gender	Male	639	39.5
	Female	979	60.5
Religion	Islam	1513	93.5
	Hinduism	100	6.2
	Buddhism	3	0.2
	Christianity	2	0.1
Class	V	418	25.8
	VI	347	21.4
	VII	267	16.5
	VIII	289	17.9
	IX	297	18.4

Students of class V & VI accounted for 25.8% and 21.4% of those who participated in the base line survey (Table 1).

Table 2: Class wise Age and Gender distribution of School Children

Class	Gender	No	Mean age (±SD)	Difference

Class V	Male	206	10.25 (±0.86)	NS
	Female	212	10.40 (±0.89)	F=3.140 p=0.077
Class VI	Male	124	11.10 (±0.93)	NS
	Female	223	11.26 (±0.82)	F=2.663 p=0.104
Class VII	Male	102	12.20 (±0.82)	NS
	Female	165	12.28 (±0.78)	F=0.554 p=0.457
Class VIII	Male	98	13.11 (±0.90)	NS
	Female	191	13.05 (±0.71)	F=0.289 p=0.591
Class IX	Male	109	13.80 (±0.89)	NS
	Female	188	13.73 (±0.75)	F=0.425 p=0.515

In the individual classes there was no difference (p>0.05) in the mean ages in either of the sexes (Table 2).

Table 3: Distribution of Respiratory Problems

Respiratory Problems	**Response**	No.	**%**	Total Response
Wheezing sound in respiration	yes	268	19.6	1369 (84.6%)
	no	1101	80.4	
Sound in respiration in last 1 year	yes	158	59.0	268 (100%)
	no	110	41.0	
No. of attacks of wheezing in past 1 year	1-3 times	126	79.7	158 (59%)
	4-12 times	24	15.2	
	>than 12 times	8	5.1	
Sleep disturbed for wheezing	never	63	39.9	158
	once in a week	64	40.5	
	> one in a week	31	19.6	
Severe wheezing	yes	67	42.4	158
	no	91	57.6	
Child suffered from asthma	yes	235	16.5	1425 (88.1)
	no	1190	83.5	
Chest sounded wheezy during or after exercise (play)	yes	114	8.2	1396 (86.3)
	no	1282	91.8	
Cold cough at night	yes	358	26.4	1357 (83.9)
	no	999	73.6	

Amongst the total 1618 respondents 84.6% responded to the query if their child ever had wheezing or whistling in the chest in the past. Of them who responded 19.6% (268) confirmed such an event, and among them 59.0% (158) of the children had experienced such an event during the past year. Among them most (79.7%) had about less than 4 attacks and another 15.2% had about 4 to 12 attacks of wheezing in the past year. Amongst the children had experienced attacks of wheeze in the past year 19.1% had sleep disturbances in more than one night each week and another 40.5% it occurred in about 1 night a week. About 42% (67) who had wheezing in the past year it was severe enough to limit the child's speech to one or more words between breaths. Children with asthma accounted for 16.5% (235) of those who responded to the query if their child ever had asthma (1425). About 8% (114) of the children during or after exercise or playing had experienced a wheeze and about 26.4% (358) had dry cough at night not associated with common cold or fever in the past 12 months. (Table 3).

Table 4: Distribution of Respiratory Problems not due to general cold/fever

Respiratory Problems not due to general cold/fever	Response	No.	%	Total
Ever sneezing not due to general cold/fever	yes	567	40.6	1396 (86.3)
	no	829	59.4	
In last 1 year sneezing not due to general cold/fever	yes	486	85.7	567 (35.0)
	no	81	14.3	
Eye itching with nose problem	yes	346	71.2	486 (30.0)
	no	140	28.8	
Study and play disturbed in last year	never	161	33.8	477
	little	269	56.4	
	much disturbed	38	8.0	
	most disturbed	9	1.9	
Allergy related fever	yes	172	12.5	1380 (85.3)
	no	1208	87.5	

Amongst the total 1618 respondents 86.3% (1396) responded to the query if their child ever had a problem with sneezing, running or blocked nose despite not having clod or flu. Among those who responded 40.6% (567) mention of such experience. Among these 567 children 85.7% (486) had such an experience during the past 12 months. Among those who had at least an episode of the problem of sneezing, running or blocked nose despite not having clod or flu 71.2% (386) had additionally experienced itchy watery eyes. Among those children who had an episode of the problem of sneezing, running or blocked nose despite not having clod or flu in the past 12 months about 98% (477) responded to the query as to how much did the nose problem in the past 12 months interfere with the child's daily activities like studies and playing. Among them about 90% (430) did experience little or no problem. Out of the 1380 (85.3%) among the total 1618 respondents, 12.5% (172) children had ever experienced allergic fever.(Table 4)

Table 5: Distribution of Allergic Manifestations Other than Respiratory Problems

Other than Respiratory Problems	Response	No	%
Frequent rash in last 6 months (1319)	yes	267	20.2
	no	1052	79.8
Rash at least once in last one year (267)	yes	241	90.3
	no	26	9.7
Rash in elbow, knee, heel, throat, eye, ear (249)	yes	170	68.3
	No	79	31.7
Rash automatically cured in last one year (246)	yes	153	62.2
	no	93	37.8
Night sleep disturbed for rash in last one year(260)	never	153	58.8
	once in a week	66	25.4
	> once in a week	41	15.8
Child suffered from eczema (1395)	yes	136	9.7
	no	1259	90.3

Amongst the total 1618 respondents 81.5% (1319) responded to the query if their child in the past 6 months ever had an itchy rash that came and went. Of them about 20% (267) confirmed that their child had experienced such a problem. Amongst those who in the past 6 months had experienced an itchy rash that came and went 249 (93.2%) responded to the query about specific location of the itchy rash, of them 68.3% confirmed that the rash had appeared in locations that included the fold of the elbow, back of the knee, front of the ankle or around the neck, ears or eyes. Of those who had experienced an itchy rash that came and went during the past 6 months 50.3% (153) had experienced such rash in the past 1 year. Amongst those who mentioned that their child had experienced itchy rash 246 responded to the query if the rash had disturbed the child's night sleep in the past year, of 41.2 % (107) confirmed that their child have had such an experience. 9.7% (136) mentioned that their child also suffered from eczema (Table 5).

Table 6: Smoking status among the children's household

Smoking status		N	%	Total
Any smoker among the house hold	Yes	574	39.8	1443 (89.2%)
	No	869	60.2	
Smoking in the house	Yes	285	49.7	574 (39.8%)
	No	289	50.3	

The response rate for the query whether some one in the household of the child is a smoker was 89.2%. Among those who responded 39.8% (574) mentioned that they had a smoker in the household and among the smokers 49.7% (285) mentioned that the smoker smokes within the house (Table 6).

Table 7: Asthma status according to study physicians' diagnosis

Asthma diagnosed by study physician	Response regarding child ever suffered from Asthma		Total
	Yes	No	
Yes	234 (63.6%)	134 (36.4%)	368 (25.8)
No	1 (0.1%)	1056 (99.9%)	1057
Total	235 (16.5%)	1190 (83.5%)	1425

Among the 1425 children for whom the response to the query if child ever had asthma was obtained 16.5% (235) reported of having asthma. On the other hand, among these 1425 children 25.8% (368) were diagnosed by study physician as having asthma. And previously diagnosed asthmatic children accounted for about 63.6% of the children diagnosed of having asthma (Table 7).

Table 8: Asthma status according to smoker in the house

Asthma status	Smoker in the house		Total
Children suffering from asthma	Yes	No	
Yes	158 (42.9%)	210 (57.1%)	368
No	416 (38.7%)	660 (61.3%)	1076
Total	574 (39.8%)	870 (60.2%)	1444

Among the 574 house hold with smoker 158 (42.9%) respondents' children were reported to be suffering from asthma (Table 8).

Table 9: Gender distribution of Asthmatic children Without smoker in the house

Class	Gender		Total
	Male	Female	
V	40 (59.7%)	27 (40.3%)	67
VI	21 (58.3%)	15 (41.7%)	36
VII	13 (43.3%)	17 (56.7%)	30
VIII	21 (52.5%)	19 (47.5%)	40
IX	19 (51.4%)	18 (48.6%)	37
Total	114 (54.3%)	96 (45.7%)	210

Among the 210 asthmatic children who did not have a smoker in the household, 54.3% (114) was male and 45.7% (96) were female (Table 9).

4.2. Phase II: Health Impact Study Observations

4.2.1. Introduction:

This chapter provides information about how the sample was selected and on the basic socio-demographic and other characteristics of the patients. It then goes on to test for homogeneity in socio-demographic and other variables between the groups.

Of the 1800 students of three schools of Dhaka City, 1618 students have responded to the baseline screening process. Students, who initially attended for assessment, 368 met the clinical criteria (presence of asthma). Of these, 210 students became eligible for the study as they were identified with asthma and there were no smoker at the house-hold level. Finally, out of these 210 students, who agreed to participate the study, a simple randomization was done to select 120 asthmatic students for the study. Another 60 students without asthmatic problem were included in the study after matching them with their age and sex and also they had provided their consent to participate in the study.

4.2.2. Socio-demographic characteristics:

A total of 180 students were included in the study, of which 90 were male and 90 were female. 90 male students were enrolled in the study from the Dhanmondi Boys High School (DBS), of which 60 students were with asthma and 30 were non-asthmatic students. Female students joined from Tejgaon Girl's high School (TGS) and Civil Aviation Girl's high School (CAS) and 60 were with asthmatic problems and 30 students did not have any asthmatic problems. Distribution of students by their sex and schools were presented in a tabulated form in Table 10 and 11.

Table 10: Status of Asthma students by their Gender

Gender of the student	**Status of Asthma**		**Total**
	No Asthma	With Asthma	
Male	30	60	90
Female	30	60	90
Total	60	120	180

Table 11: Status of Asthma of the student by their School

School	Status of Asthma		Total
	No asthma	With Asthma	
DBS	30	60	90
TGS	15	30	45
CAS	15	30	45
Total	60	120	180

Other socio-demographic characteristics of the sample are presented in Table 12 and 13. Age ranged from 09 to 16 years and mostly between 10 to 14 years (about 90%). Students were included from Class five to class nine but more than half were from early two classes (Class five and six). Comparisons were made between the asthmatic and non-asthmatic groups, the results of these analyses are presented in Tables 12 and 13 and no significant differences were found among these two groups.

Table 12: Status of Asthma of the student by their Age

Age of the student in years	Status of Asthma		Total	χ^2	p
	No asthma	With Asthma			
9	1	3	4	4.99	ns
10	12	16	28		
11	14	25	39		
12	7	20	27		
13	8	25	33		
14	12	22	34		
15	5	5	10		
16	1	4	5		
Total	60	120	180		

Table 13: Status of Asthma of the student by their Academic Level

Academic Level	Status of Asthma		Total	χ^2	p
	No asthma	With Asthma			
Class-V	17	28	45	2.04	ns
Class-VI	15	31	46		
Class-VII	11	20	31		

Class-VIII	6	21	27		
Class-IX	11	20	31		
Total	60	120	180		

The height of the students ranged from 126.0 cm to 182.0 cm with a mean of 149.77 cm and SD of 10.07 cm. Weight ranged from 24.0 kg to 90.0 kg with a mean of 45.51 kg and SD of 11.76 kg.

At the beginning of the study, the Pulmonary Expiratory Flow Rate in the Morning (PEFR-M) ranged from 150 L/min to 320 L/min, with a mean 237.72 L/min and SD was 34.80 L/min. The Pulmonary Expiratory Flow Rate in the Afternoon (PEFR-A) was little lower with a range from 150 L/min to 310 L/min, mean 218.44 L/min and the SD was 38.98 L/min.

4.2.3. Relationship of Pulmonary Expiratory Flow Rate (PEFR) with other variables at the beginning of the study:

An exhaustive analysis was performed to explore the relationship of PEFR of morning and afternoon of the respondents to the socio-demographic characteristics, anthropometric measurements and other variables. No significant differences were observed for in the Morning (PEFR-M) and Pulmonary Expiratory Flow Rate in the Afternoon (PEFR-A) with any of the respondent characteristics namely age, sex, academic level or admitted schools and also for the prevailing health problems. An expected significant relationship was observed with the PEFR-Morning reading (F= 7.09 and p=0.001) where the students with inhaler use had 37.62 L/min lower PEFR reading than the no-medicine user students.

4.2.4. Testing for homogeneity based on the asthma status:

The final set of comparisons was made for checking the homogeneity and was presented in Tables 3.5. No significant differences between the asthmatic and non-asthmatic groups with respect to the socio-demographic characteristics and anthropometric measurements were found. Significant differences were observed only for Pulmonary Expiratory Flow Rate in the Morning (PEFR-M) and Pulmonary Expiratory Flow Rate in the Afternoon (PEFR-A). The PEFR-Morning mean of the asthmatic students group was lower than the non-asthmatic group (p=<0.001) and which also continued to be lower in the afternoon PEFR reading (p=<0.001). In the morning of the first day of data collection, PEFR was 57.17 L/min lower among the asthmatic students and this symptom was more intense in the afternoon with a 67.33 L/min lower PEFR reading than the non-asthmatic students. From these findings, it could be concluded that the data set was homogenous with respect to the socio-demographic and anthropometric variables. It could also be opined that the PEFR readings in the morning and in the afternoon were consistent with the study objectives and hypothesis.

Table 14: Status of Asthma of the student by their Anthropometry and PEFR

Variables of interest	Asthma status	Mean	Standard Deviation	t-test for Equality of Means				
				t- value	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Height of the student	No asthma	149.17	10.548	-0.564	0.573	-0.900	-4.049	2.249
	With Asthma	150.07	9.857					
Weight of the student	No asthma	45.53	12.213	0.022	0.982	0.042	-3.639	3.723
	With Asthma	45.49	11.586					
PEFR-Morning	No asthma	275.83	18.892	16.444	0.000	57.167	50.307	64.027
	With Asthma	218.67	23.369					
PEFR-Afternoon	No asthma	263.33	19.193	18.874	0.000	67.333	60.293	74.373
	With Asthma	196.00	24.059					

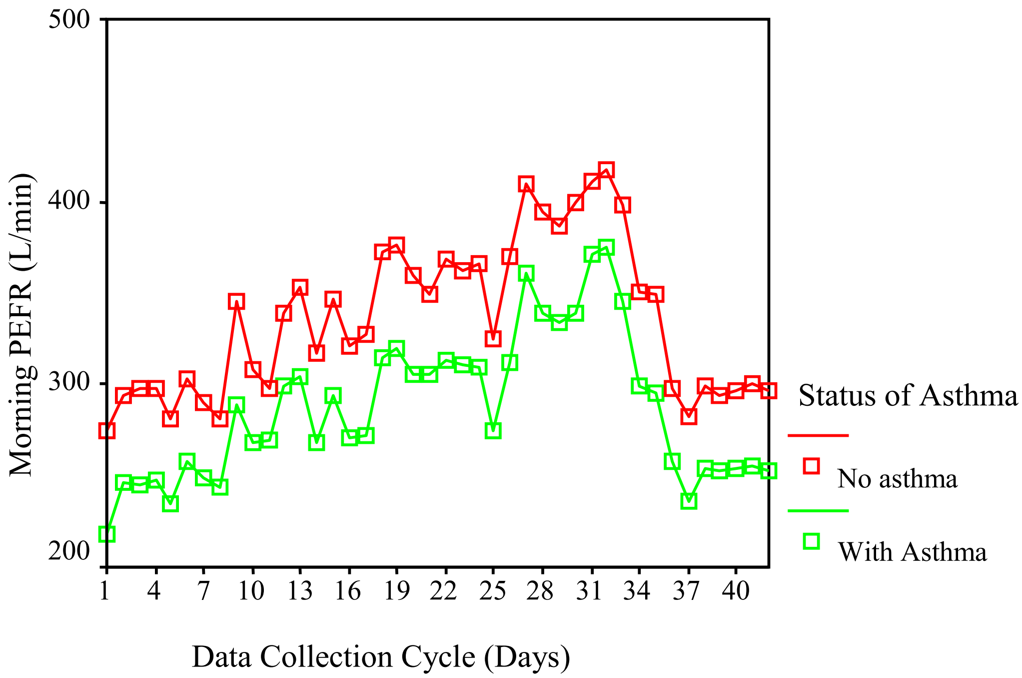
4.2.5. Impact on Pulmonary Expiratory Flow Rate (PEFR):

4.2.5.1. Impact of Asthma on morning PEFR:

Repeated measures analyses of variance were used to examine the changes of morning PEFR during the data collection period among the asthmatic and non-asthmatic students (Figure-1). The result showed that there was significant within subject variation in the morning PEFR over the study period of time (F= 307.93, p=<0.001). A significant interaction effect was also observed between the morning PEFR and asthma status (F= 2.20, p=<0.05) which tells us that morning PEFR significantly differs depending on asthma status. The variation of morning PEFR among the asthmatic and non-asthmatic groups of students was consistently different over the study period of time (F= 149.15, p=<0.001). It was obvious from the graph that the morning PEFR reading of asthmatic students was generally significantly higher than the non-asthmatic students over the study period of time. There was a sharp rise of morning PEFR in both the groups within 25^{th} to 35^{th} day of data collection which represented the data collection for the month of June.

The 24th day of data collection was in April and the 36th day of data collection was in November.

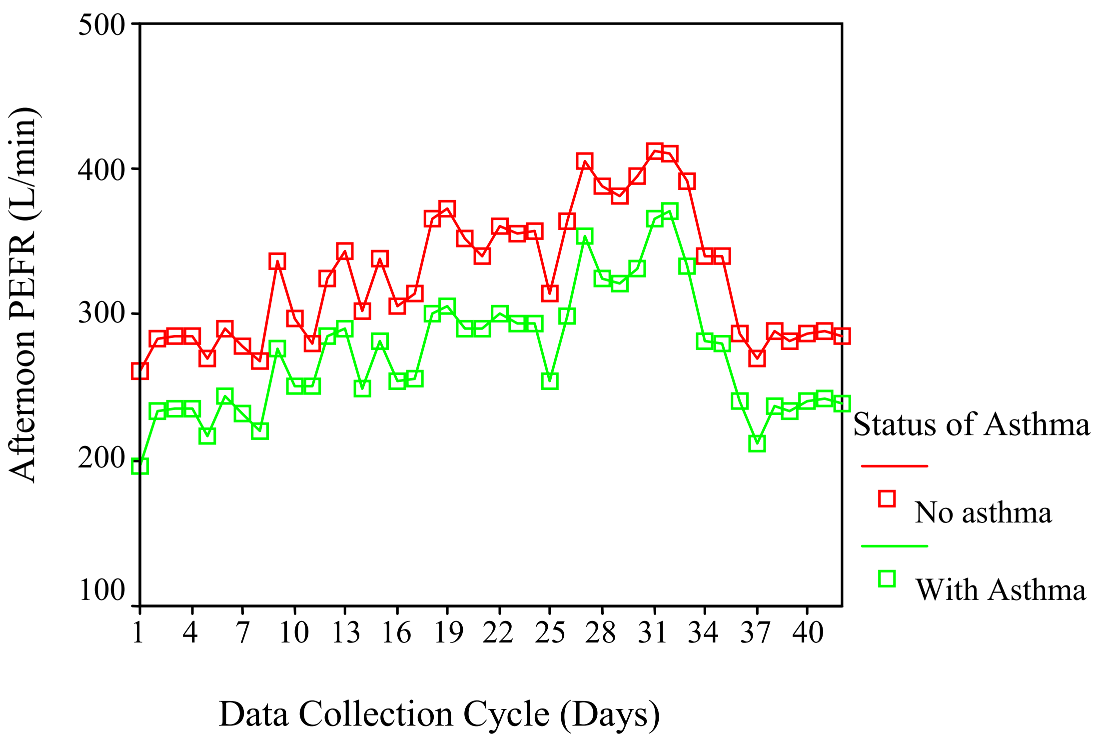
Fig: 6- Change in morning PEFR in relation to asthma status



4.2.5.2. Impact of Asthma on afternoon PEFR:

Repeated measures analyses of variance were used to examine the changes of afternoon PEFR during the data collection period among the asthmatic and non-asthmatic students (Figure-6). The result showed that there was significant within subject variation in the afternoon PEFR over the study period of time (F= 333.72, p=<0.001). A significant interaction effect was also observed between the afternoon PEFR and asthma status (F= 2.67, p=<0.01) which tells us that afternoon PEFR significantly differs depending on asthma status. The variation of afternoon PEFR among the asthmatic and non-asthmatic groups of students was consistently different over the study period of time (F= 176.64, p=<0.001). It was obvious from the graph that the afternoon PEFR reading of asthmatic students was generally significantly higher than the non-asthmatic students over the study period of time. There was a sharp rise of afternoon PEFR in both the groups within 25th to 35th day of data collection which represented the data collection for the month of June. The 24th day of data collection was in April and the 36th day of data collection was in November.

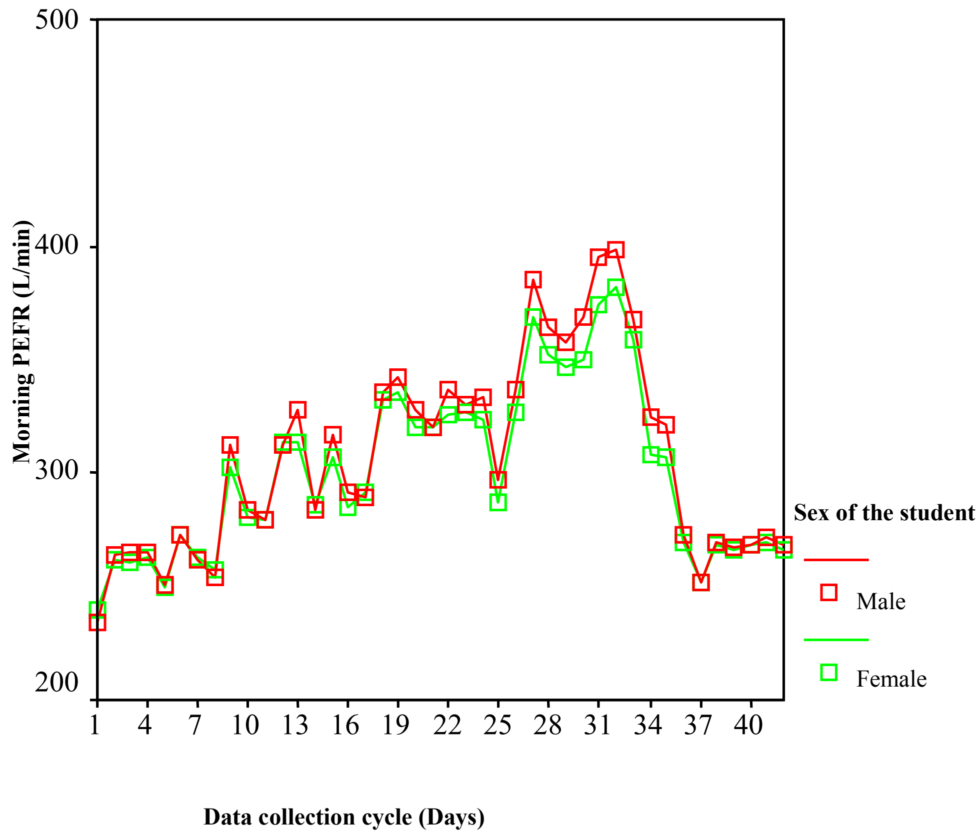
Fig: 7- Change in afternoon PEFR in relation to asthma status



4.2.5.3. Impact of Gender on morning PEFR:

Repeated measures analyses of variance were used to examine the changes of morning PEFR during the data collection period among male and female students (Figure-7). The result showed that there was significant within subject variation in the morning PEFR over the study period of time (F= 338.71, p=<0.001). A significant interaction effect was also observed between the morning PEFR and gender (F= 2.31, p=<0.05) which tells us that gender of the student significantly influenced the morning PEFR. But the variation of morning PEFR was not consistently different among the male and female students over the study period of time.

Fig: 8- Change in morning PEFR according to their sex

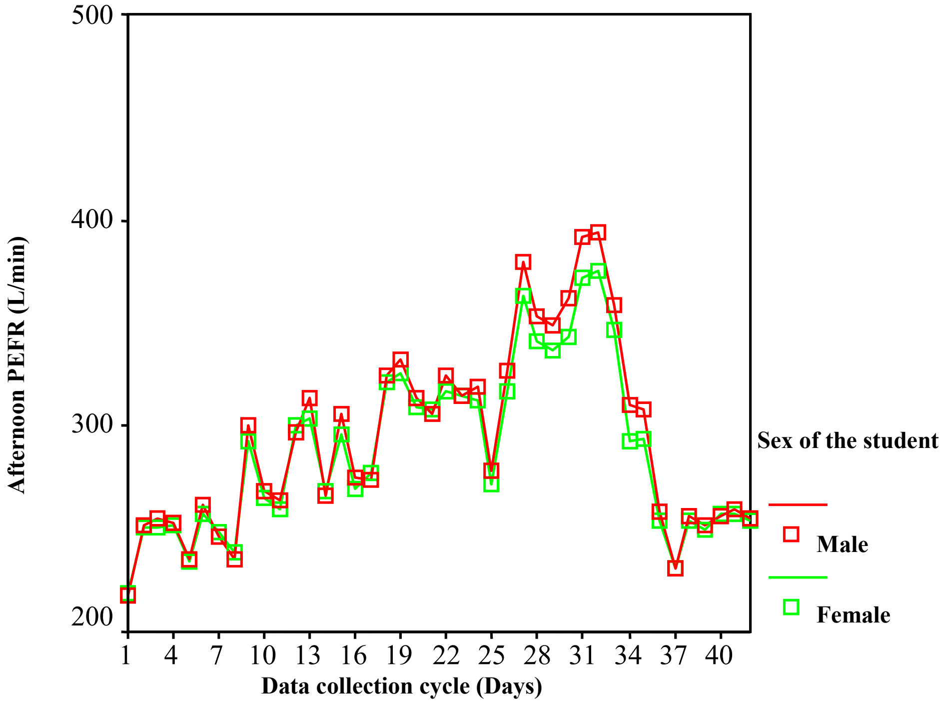


4.2.5.4. Impact of Gender on afternoon PEFR:

Repeated measures analyses of variance were used to examine the changes of afternoon PEFR during the data collection period among male and female students (Figure-8). The result showed that there was significant within subject variation in the afternoon PEFR over the study period of time (F= 366.05, p=<0.001). A significant interaction effect was also observed between the afternoon PEFR and gender (F= 2.08, p=<0.05) which tells us that gender of the student significantly influenced the afternoon

PEFR. But the variation of afternoon PEFR was not consistently different among the male and female students over the study period of time.

Fig: 9- Change in afternoon PEFR according to their sex



4.2.6 The relationship between PEFR with the particulate matter concentration, daily temperature and humidity status:

Curvilinear regression analysis were performed to examine the relationship of the Pulmonary Expiratory Flow Rate (PEFR) of morning and afternoon time and the difference of PEFR between the morning and afternoon reading with the particulate matter concentration, daily average, minimum and maximum temperature and humidity status.

Curvilinear regression analysis showed that morning PEFR had a curvilinear relationship with the concentration of particulate matter 10 (PM10) (linear term= -1.274 p=<0.001 and quadratic term = +0.0023, p=<0.001) and explained a significant amount of variance of PEFR of morning (43.42%). Afternoon PEFR and the difference between the morning and afternoon reading of PEFR had showed the similar type of curvilinear relationship with the concentration of particulate matter 10 (PM10) (linear term= -1.362 p=<0.001, quadratic term = +0.0024, p=<0.001 and linear term= +0.087 p=<0.001, quadratic term = -0.001, p=<0.001 respectively) and explained 44.76% and 5.70% of variance of PEFR of afternoon and the difference PEFR respectively.

All relationship were similar for the PM2.5 concentration with the three PEFR data with little lower beta value but similar high level of significance (<0.001) as PM10 concentration.

Both significant linear and quadratic relationships were observed for the daily average temperature, daily maximum and also the minimum temperature with the PEFR reading of the morning and afternoon but only the linear relationship existed for the difference between the morning and afternoon reading of PEFR. The minimum temperature of the day could explain the highest amount of variance of morning PEFR among the temperature related variables (19.31%).

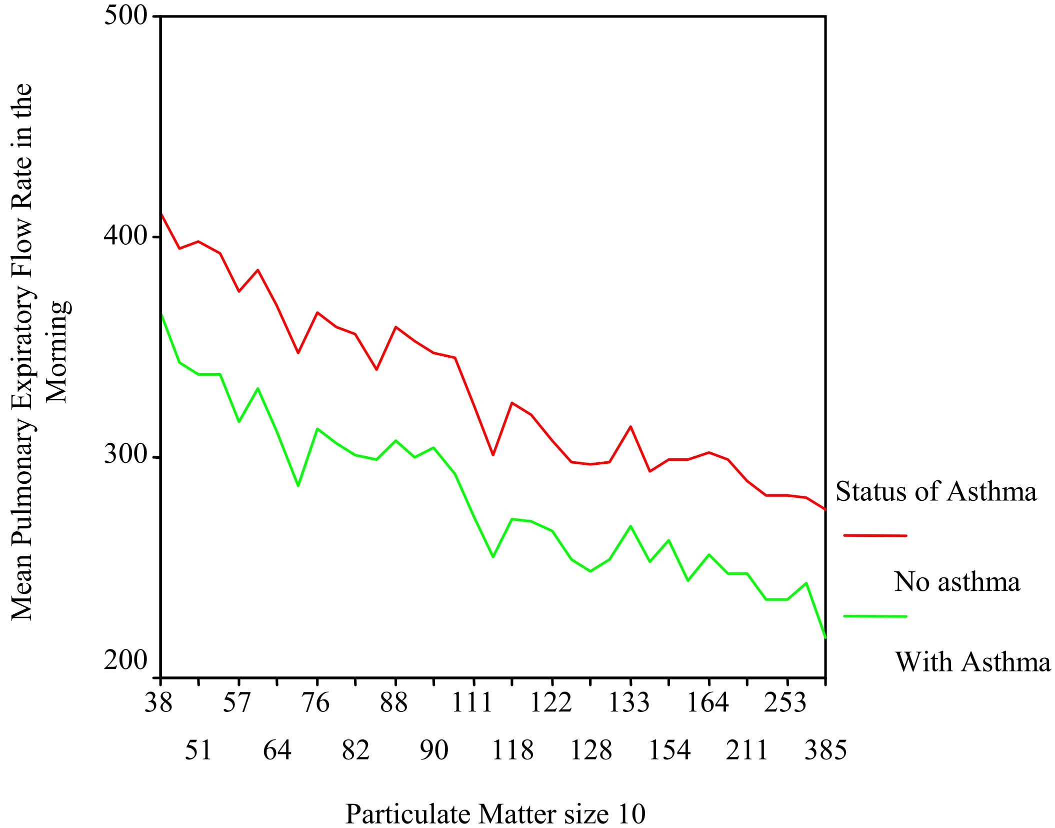
Average humidity of the day had significant linear relationship in linear term and significant quadratic relationship in quadratic term with all three PEFR data but there were highly significant curvilinear relationship existed between the minimum humidity of the day and the morning and afternoon PEFR (linear term= +2.344, p=<0.001 and quadratic term = -0.0055, p=<0.001 and linear term= +2.412, p=<0.001, quadratic term = -0.005, p=<0.001 respectively) and explained 26.13% and 25.93% of variance of morning and afternoon PEFR respectively. Maximum humidity status maintained only linear relationship with all three PEFR data.

4.2.6.1 Morning PEFR with the PM10 concentration

The analyses revealed highly significant differences in morning PEFR in relation to the asthma status of the respondent, where non-asthmatic students had a significantly higher mean morning PEFR than the asthmatic students (F Change value =323.11; p=<0.001).

There was highly significant effect of PM10 concentration on morning PEFR and was alone accounted for 58.4% variance of the morning PEFR (with an F change value of 2624.20; p= <0.001). When the asthma status was included in the model, there was a significant but modest increase in adjusted R^2 value to 60.10%. Standardized coefficient beta indicated that the increase in one standard deviation of PM10 concentration while holding the asthma status constant would reduce the morning PEFR by 1.07 standard deviations.

Fig: 10- Relationship of morning PEFR with the PM10 concentration by asthma status

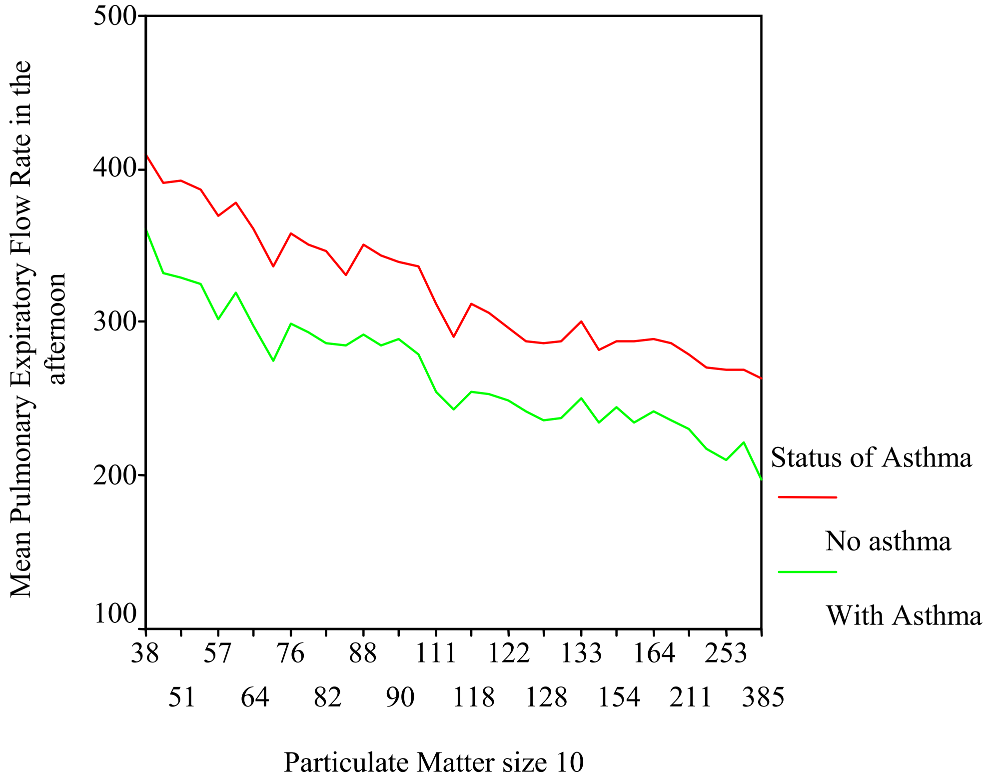


4.2.6.2 Afternoon PEFR with the PM10 concentration

The analyses revealed highly significant differences in afternoon PEFR in relation to the asthma status of the respondent, where non-asthmatic students had a significantly higher mean afternoon PEFR than the asthmatic students (F Change value =380.48; p=<0.001).

There was highly significant effect of PM10 concentration on afternoon PEFR and was alone accounted for 60.9% variance of the afternoon PEFR (with an F change value of 2913.29; p= <0.001). When the asthma status was included in the model, there was a significant but modest increase in adjusted R^2 value to 62.7%. Standardized coefficient beta indicated that the increase in one standard deviation of PM10 concentration while holding the asthma status constant would reduce the afternoon PEFR by 1.07 standard deviations.

Fig: 11- Relationship of afternoon PEFR with the PM10 concentration by asthma status

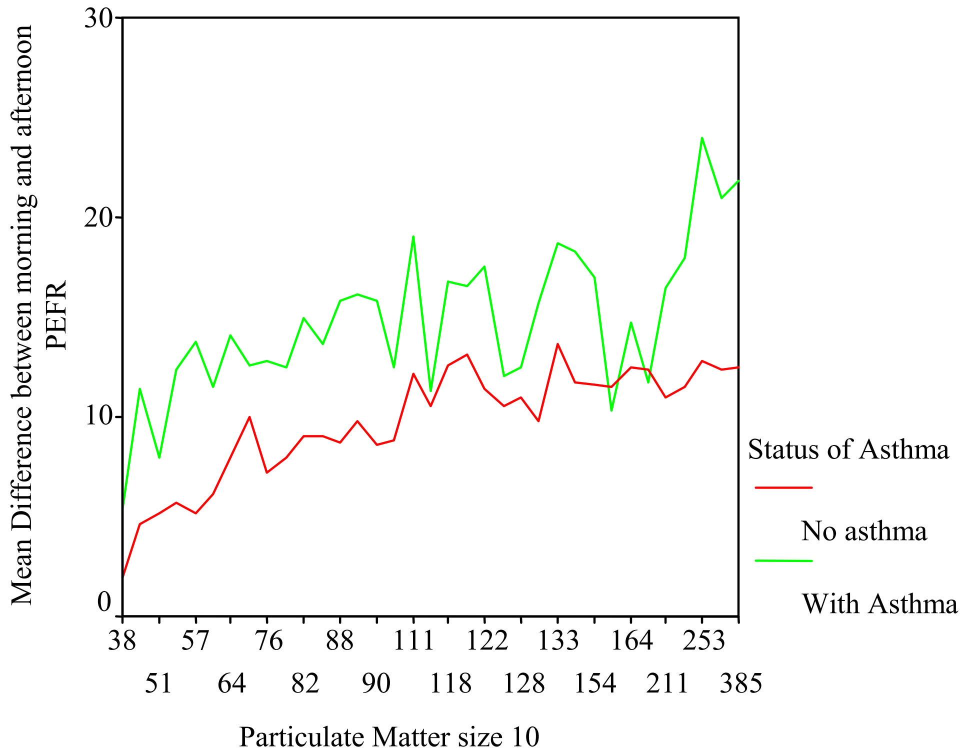


4.2.6.3 Difference between morning and afternoon PEFR with the PM10 concentration:

The analyses revealed highly significant effect of asthma status of the respondent on the difference between morning and afternoon PEFR, where non-asthmatic students had a significantly higher mean afternoon PEFR than the asthmatic students (F Change value =39.61; p=<0.001).

There was highly significant effect of PM10 concentration on the difference between morning and afternoon PEFR and was accounted for 9.30% variance of the difference PEFR (with an F change value of 191.35; p= <0.001). When the asthma status was included in the model, there was a significant but very little increase in adjusted R^2 value to 9.70%. Standardized coefficient beta indicated that the increase in one standard deviation of PM10 concentration while holding the asthma status constant would increase the difference in PEFR by 0.317 standard deviations.

Fig: 12- Relationship of difference between morning and afternoon PEFR with the PM10 concentration by asthma status

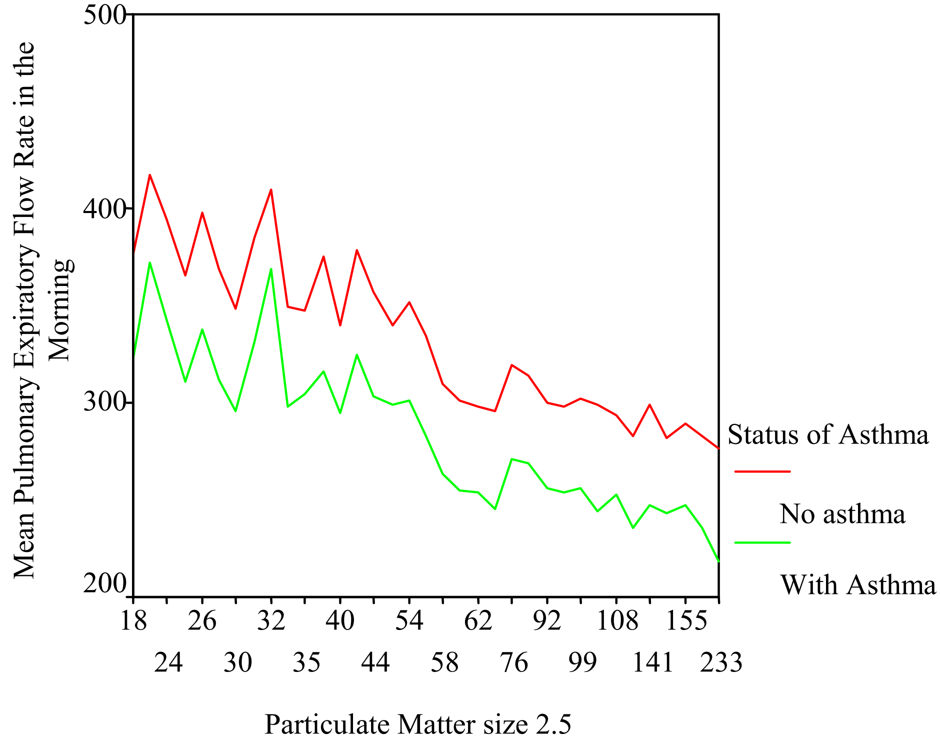


4.2.6.4 Morning PEFR with the PM2.5 concentration

The regression analyses revealed highly significant differences in morning PEFR in relation to the asthma status of the respondent, where non-asthmatic students had a significantly higher mean morning PEFR than the asthmatic students (F Change value =395.36; p=<0.001).

There was highly significant effect of PM2.5 concentration on morning PEFR and was alone accounted for 48.7% variance of the morning PEFR (with an F change value of 1776.57; p= <0.001). When the asthma status was included in the model, there was a significant 2.60% increase in adjusted R^2 value to 51.30%. Standardized coefficient beta indicated that the increase in one standard deviation of PM2.5 concentration while holding the asthma status constant would reduce the morning PEFR by 0.73 standard deviations.

Fig: 13- Relationship of morning PEFR with the PM2.5 concentration by asthma status

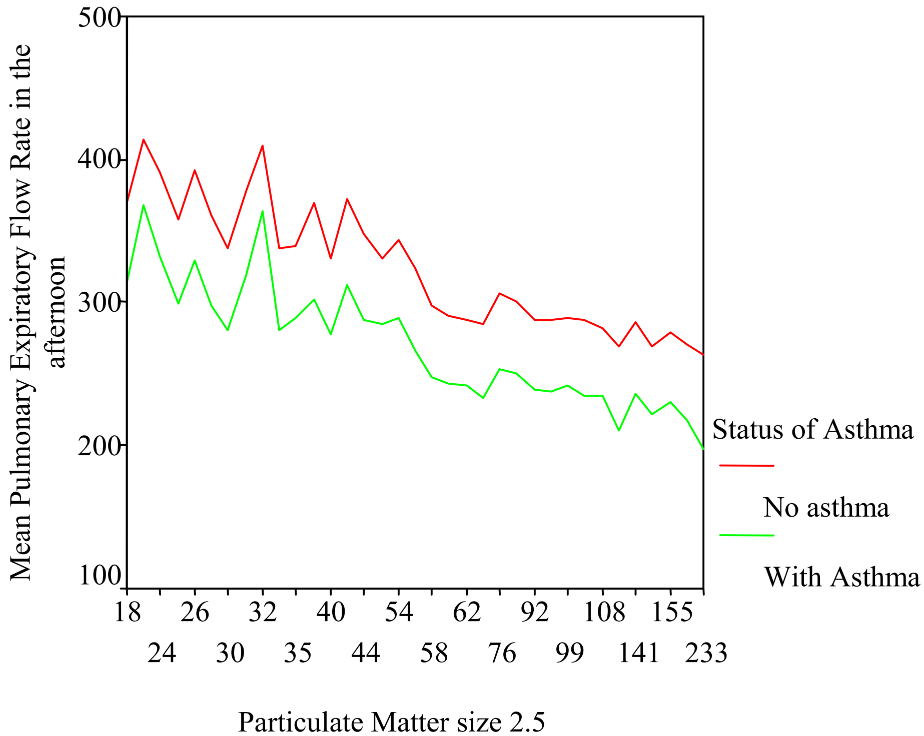


4.2.6.5 Afternoon PEFR with the PM2.5 concentration

The analyses revealed highly significant differences in afternoon PEFR in relation to the asthma status of the respondent, where non-asthmatic students had a significantly higher mean afternoon PEFR than the asthmatic students (F Change value =448.68; p=<0.001).

There was highly significant effect of PM2.5 concentration on afternoon PEFR and was alone accounted for 50.50% variance of the afternoon PEFR (with an F change value of 1910.51; p= <0.001). When the asthma status was included in the model, there was a significant 2.80% increase in adjusted R^2 value to 53.30%. Standardized coefficient beta indicated that the increase in one standard deviation of PM2.5 concentration while holding the asthma status constant would reduce the afternoon PEFR by 0.718 standard deviations.

Fig: 14- Relationship of afternoon PEFR with the PM2.5 concentration by asthma status

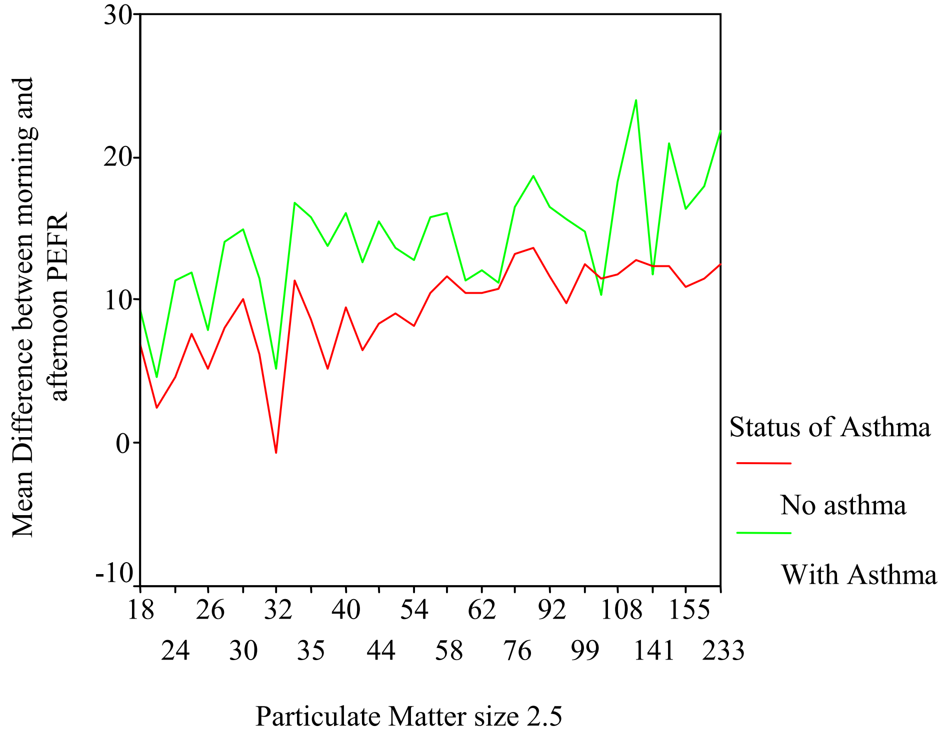


4.2.6.6 Difference between morning and afternoon PEFR with the PM2.5 concentration:

The analyses revealed highly significant effect of asthma status of the respondent on the difference between morning and afternoon PEFR, where non-asthmatic students had a significantly higher mean afternoon PEFR than the asthmatic students (F Change value =52.23; p=<0.001).

There was highly significant effect of PM2.5 concentration on the difference between morning and afternoon PEFR and was accounted for 7.20% variance of the difference PEFR (with an F change value of 145.78; p= <0.001). When the asthma status was included in the model, there was a significant but very little increase in adjusted R^2 value to 7.80%. Standardized coefficient beta indicated that the increase in one standard deviation of PM2.5 concentration while holding the asthma status constant would increase the difference in PEFR by 0.145 standard deviations.

Fig: 15- Relationship of difference between morning and afternoon PEFR with the PM2.5 concentration by asthma status

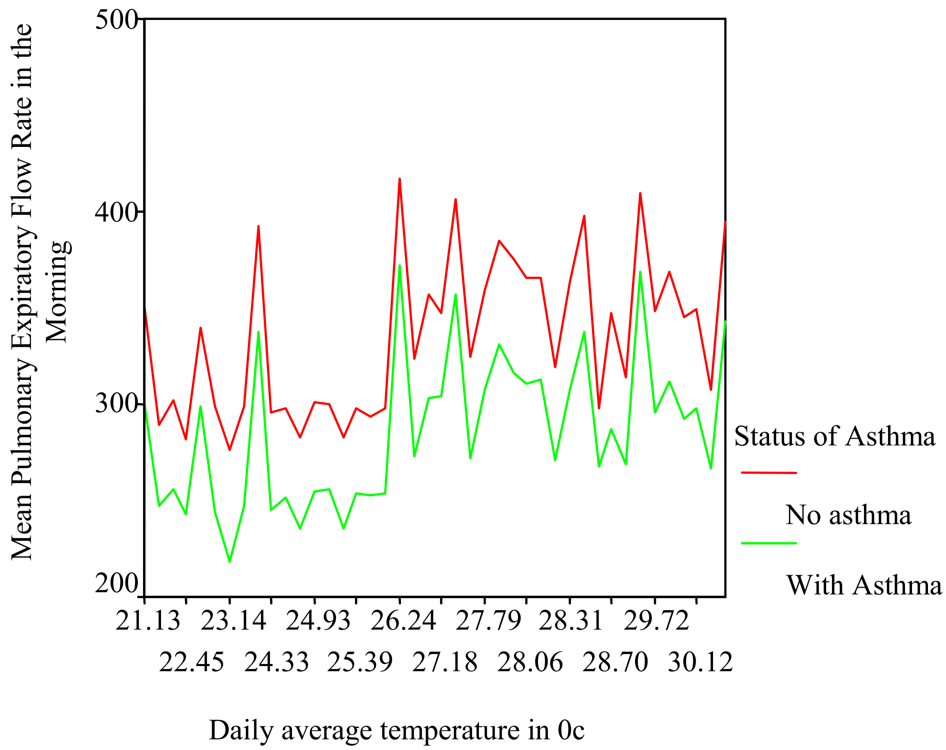


4.2.7.1 Morning PEFR with the daily average temperature

There was highly significant effect of daily average temperature on morning PEFR and was alone accounted for 29.1% variance of the morning PEFR (with an F change value of 1027.19; p= <0.001). When the asthma status was included in the model, there was a significant increase in adjusted R^2 value to 29.20% (with and F Change value of 9.48; p=0.002 for asthma status).

Standardized coefficient beta indicated that the increase in one standard deviation of daily average temperature while holding the asthma status constant would reduce the morning PEFR by 0.50 standard deviations.

Fig: 16- Relationship of morning PEFR with the daily average temperature by asthma status

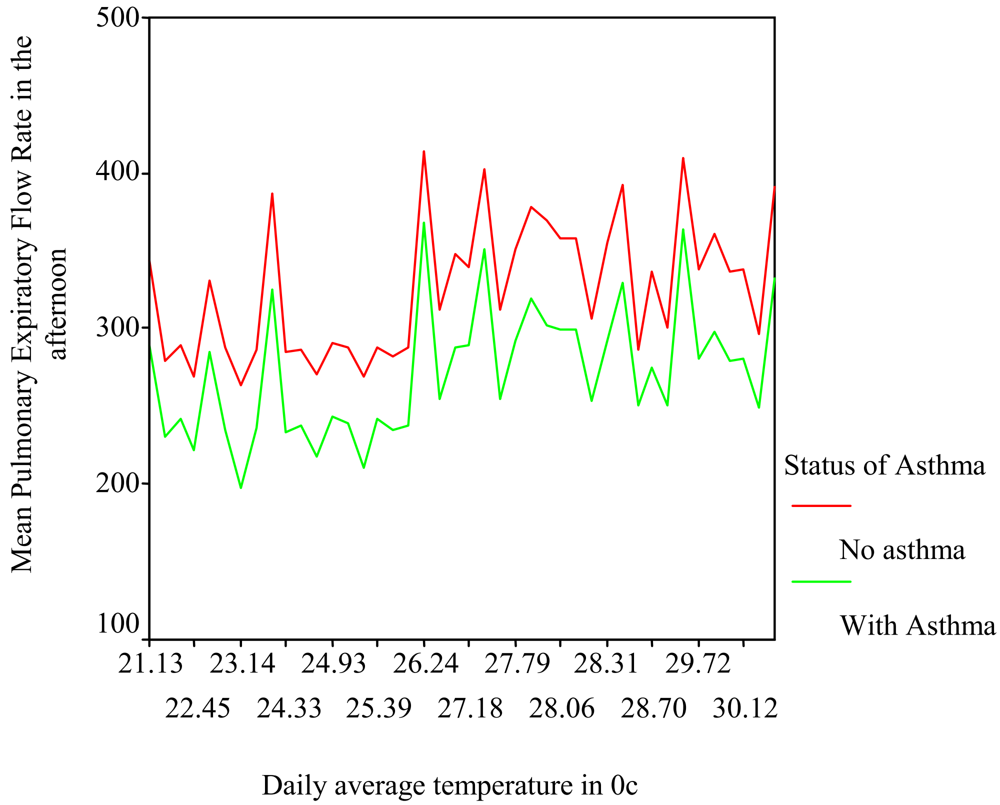


4.2.5 Afternoon PEFR with the daily average temperature

There was highly significant effect of daily average temperature on afternoon PEFR and was alone accounted for 29.9% variance of the morning PEFR (with an F change value of 1069.09; p= <0.001). When the asthma status was included in the model, there was a significant increase in adjusted R^2 value to 30.00% (with and F Change value of 8.80; p=0.003 for asthma status).

Standardized coefficient beta indicated that the increase in one standard deviation of daily average temperature while holding the asthma status constant would reduce the afternoon PEFR by 0.46 standard deviations.

Fig: 17- Relationship of afternoon PEFR with the daily average temperature by asthma status

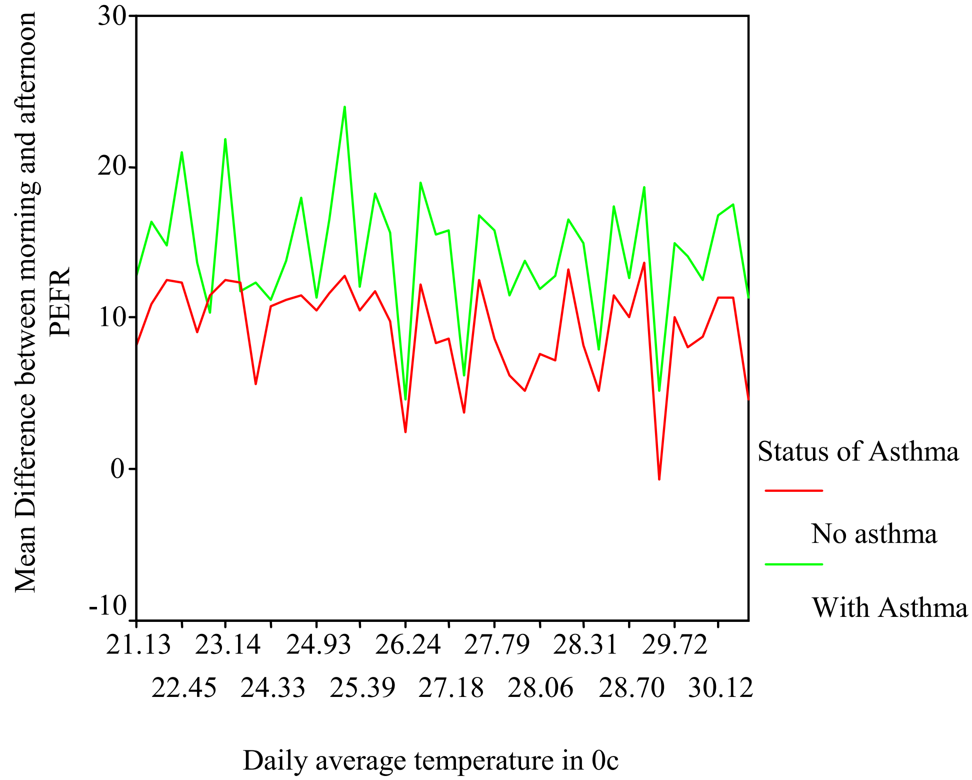


4.2.7.2 Difference between morning and afternoon PEFR with the daily average temperature:

There was highly significant effect of daily average temperature on the difference between morning and afternoon PEFR but accounted for only 4.30% variance of the morning PEFR (with an F change value of 112.25; p= <0.001). There was no significant effect of asthma status on the difference PEFR.

Standardized coefficient beta indicated that the increase in one standard deviation of daily average temperature while holding the asthma status constant would reduce the difference between morning and afternoon PEFR by 0.07 standard deviations.

Fig: 18- Relationship of difference between morning and afternoon PEFR with the daily average temperature by asthma status

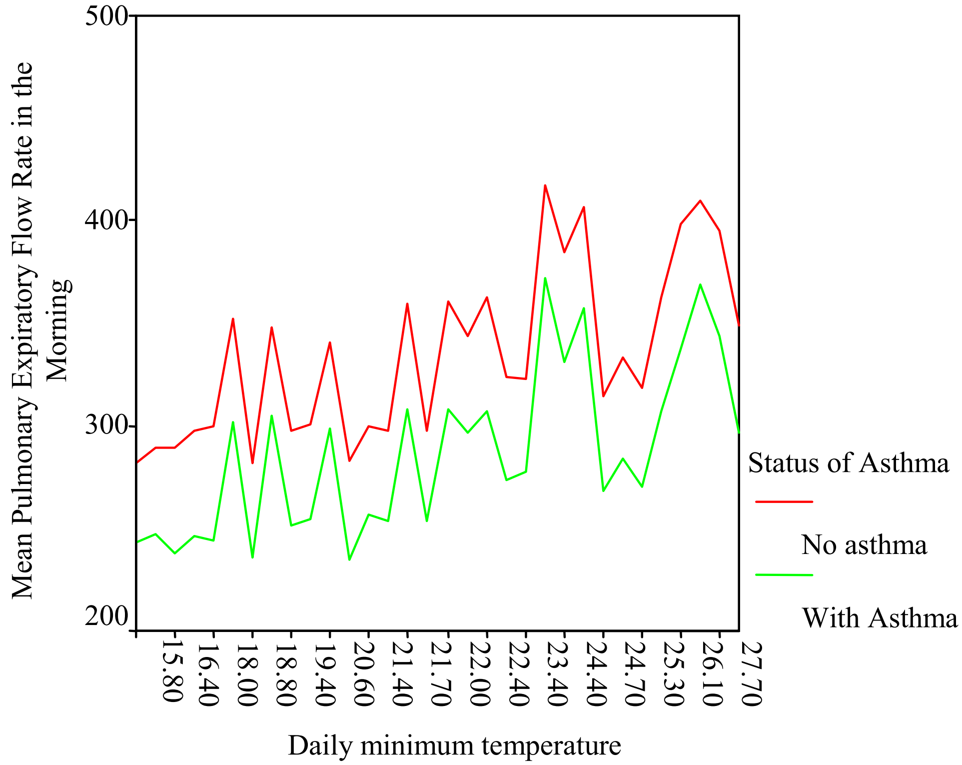


4.2.7..3 Morning PEFR with the daily minimum temperature

There was highly significant effect of daily minimum temperature on morning PEFR and was alone accounted for 36.30% variance of the morning PEFR (with an F change value of 1064.97; p= <0.001). The asthma status of the student had no significant explanatory capacity on morning PEFR, when included in the model with the daily minimum temperature.

Standardized coefficient beta indicated that the increase in one standard deviation of daily minimum temperature while holding the asthma status constant would increase the morning PEFR by 0.70 standard deviations.

Fig: 19- Relationship of morning PEFR with the daily minimum temperature by asthma status

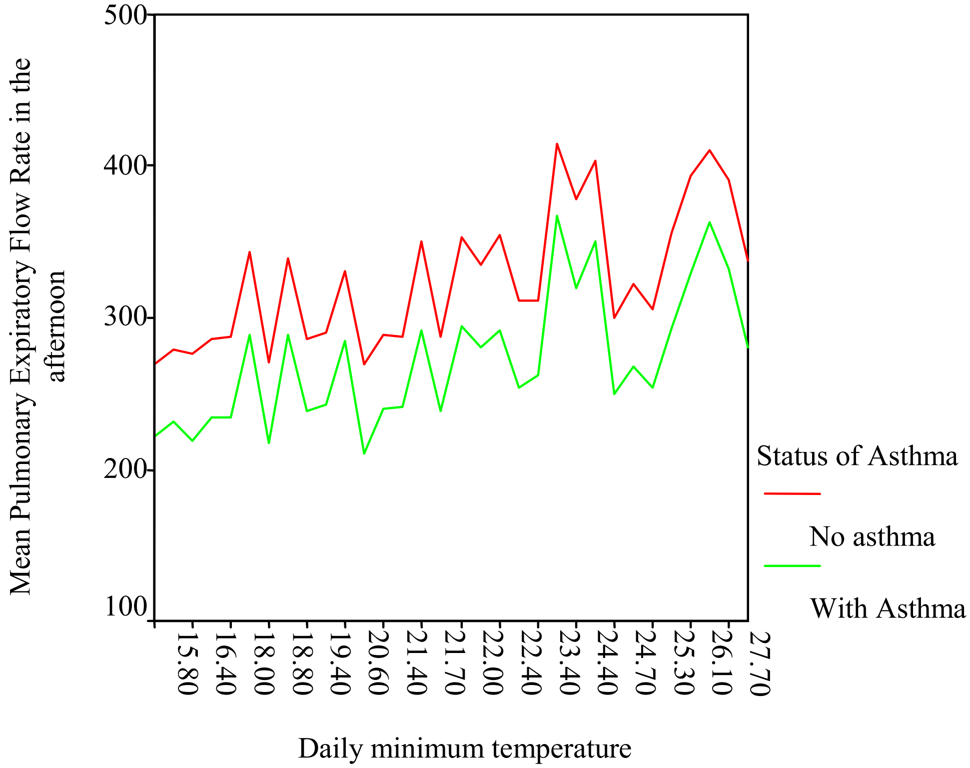


4.2.7..4 Afternoon PEFR with the daily minimum temperature

There was highly significant effect of daily minimum temperature on afternoon PEFR and was alone accounted for 37.30% variance of the morning PEFR (with an F change value of 1112.12; p= <0.001). The asthma status of the student had no significant explanatory capacity on afternoon PEFR, when included in the model with the daily minimum temperature.

Standardized coefficient beta indicated that the increase in one standard deviation of daily minimum temperature while holding the asthma status constant would increase the afternoon PEFR by 0.69 standard deviations.

Fig: 20- Relationship of afternoon PEFR with the daily minimum temperature by asthma status

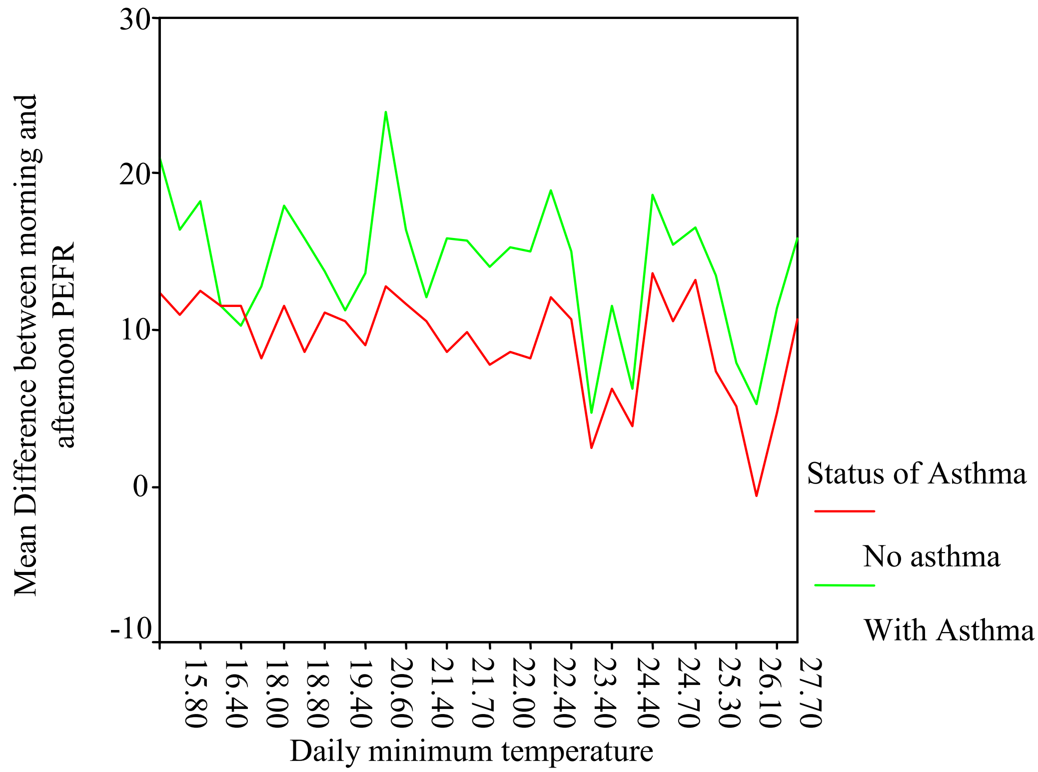


4.2.7.5 Difference between morning and afternoon PEFR with the daily minimum temperature:

There was highly significant effect of daily minimum temperature on the difference between morning and afternoon PEFR but accounted for only 5.00% variance of the morning PEFR (with an F change value of 98.72; p= <0.001). There was no significant effect of asthma status on the difference PEFR.

Standardized coefficient beta indicated that the increase in one standard deviation of daily minimum temperature while holding the asthma status constant would reduce the difference between morning and afternoon PEFR by 0.16 standard deviations.

Fig: 21- Relationship of difference between morning and afternoon PEFR with the daily minimum temperature by asthma status

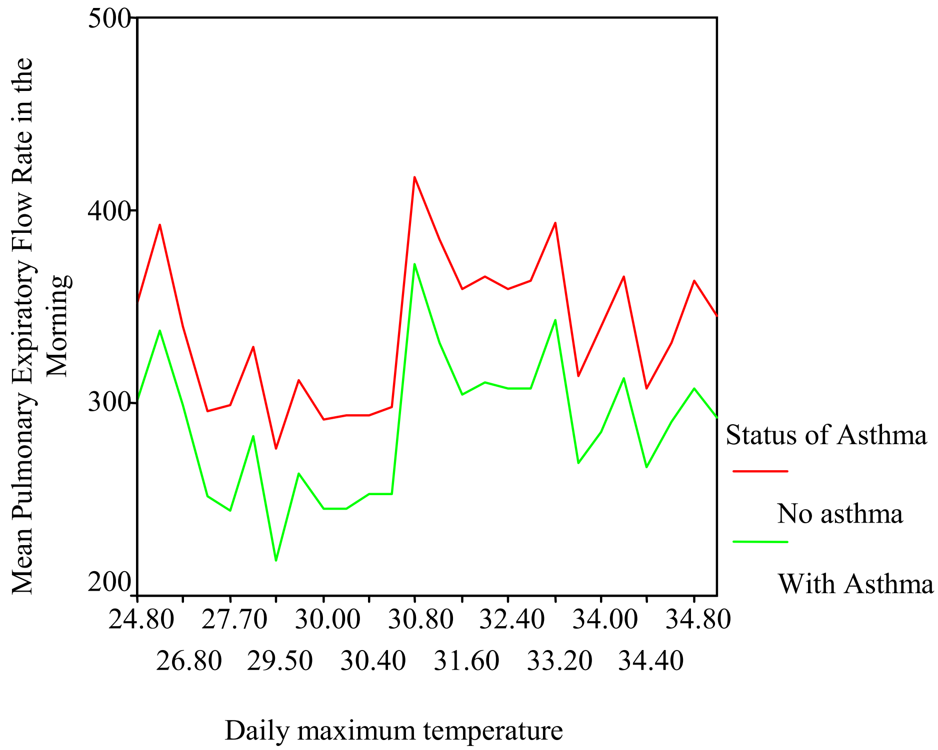


4.2.7.6 Morning PEFR with the daily maximum temperature

There was highly significant effect of daily maximum temperature on morning PEFR and was alone accounted for 21.70% variance of the morning PEFR (with an F change value of 693.42; p= <0.001). When the asthma status was included in the model, there was a significant raise of adjusted R^2 value to 21.80% (with and F Change value of 7.20; p=0.007 for asthma status).

Standardized coefficient beta indicated that the increase in one standard deviation of daily maximum temperature while holding the asthma status constant would decrease the morning PEFR by 2.55 standard deviations.

Fig: 22- Relationship of morning PEFR with the daily maximum temperature by asthma status

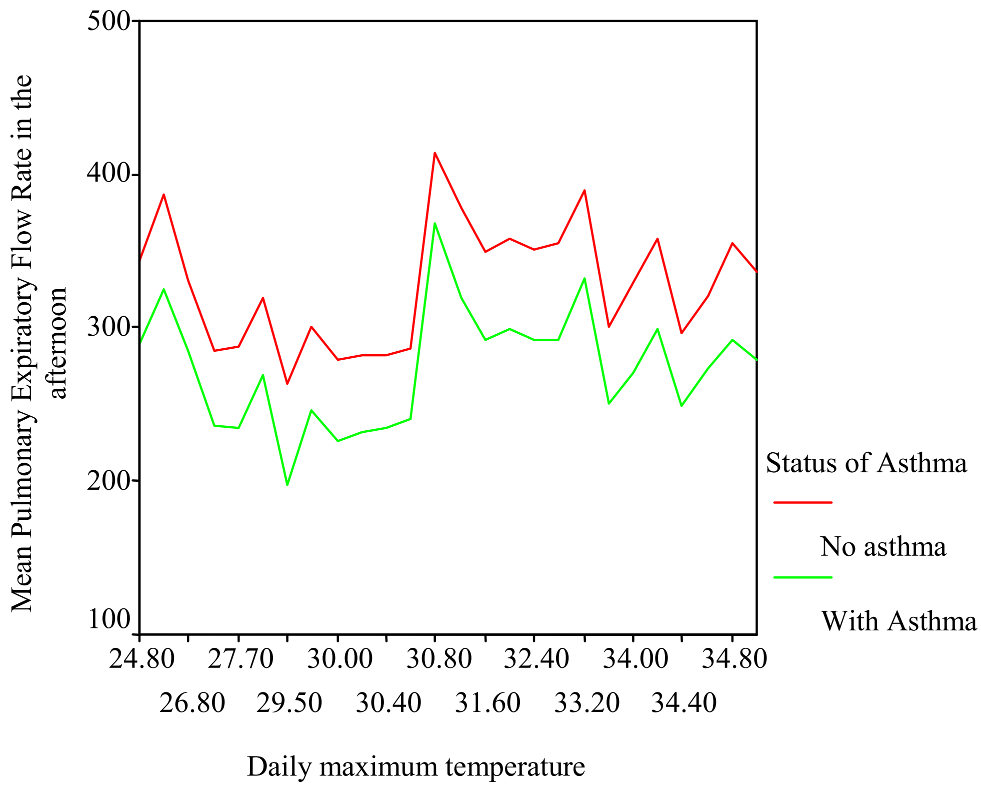


4.2.7.7 Afternoon PEFR with the daily maximum temperature

There was highly significant effect of daily maximum temperature on afternoon PEFR and was alone accounted for 22.5% variance of the morning PEFR (with an F change value of 729.16; p= <0.001). When the asthma status was included in the model, there was a significant increase in adjusted R^2 value to 22.60% (with and F Change value of 5.97; p=0.015 for asthma status).

Standardized coefficient beta indicated that the increase in one standard deviation of daily maximum temperature while holding the asthma status constant would decrease the afternoon PEFR by 2.43 standard deviations.

Fig: 23- Relationship of afternoon PEFR with the daily maximum temperature by asthma status

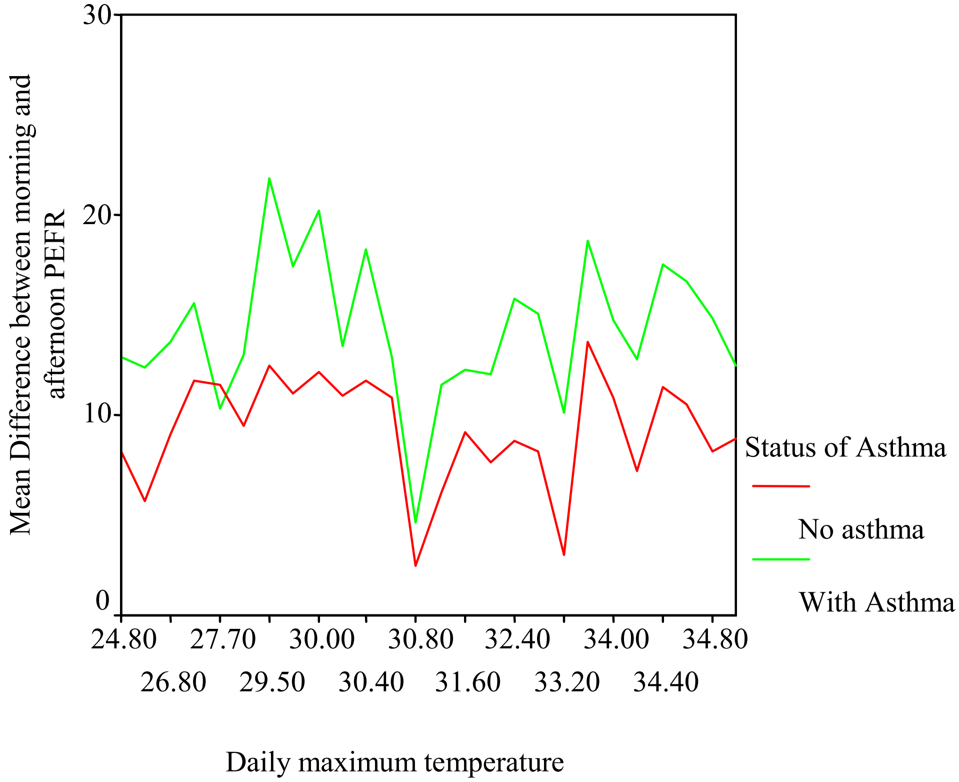


4.2.7.8 Difference between morning and afternoon PEFR with the daily maximum temperature:

There was highly significant effect of daily maximum temperature on the difference between morning and afternoon PEFR but accounted for only 3.90% variance of the morning PEFR (with an F change value of 102.24; p= <0.001). There was no significant effect of asthma status on the difference PEFR.

Standardized coefficient beta indicated that the increase in one standard deviation of daily maximum temperature while holding the asthma status constant would reduce the difference between morning and afternoon PEFR by 0.096 standard deviations.

Fig: 24- Relationship of difference between morning and afternoon PEFR with the daily maximum temperature by asthma status

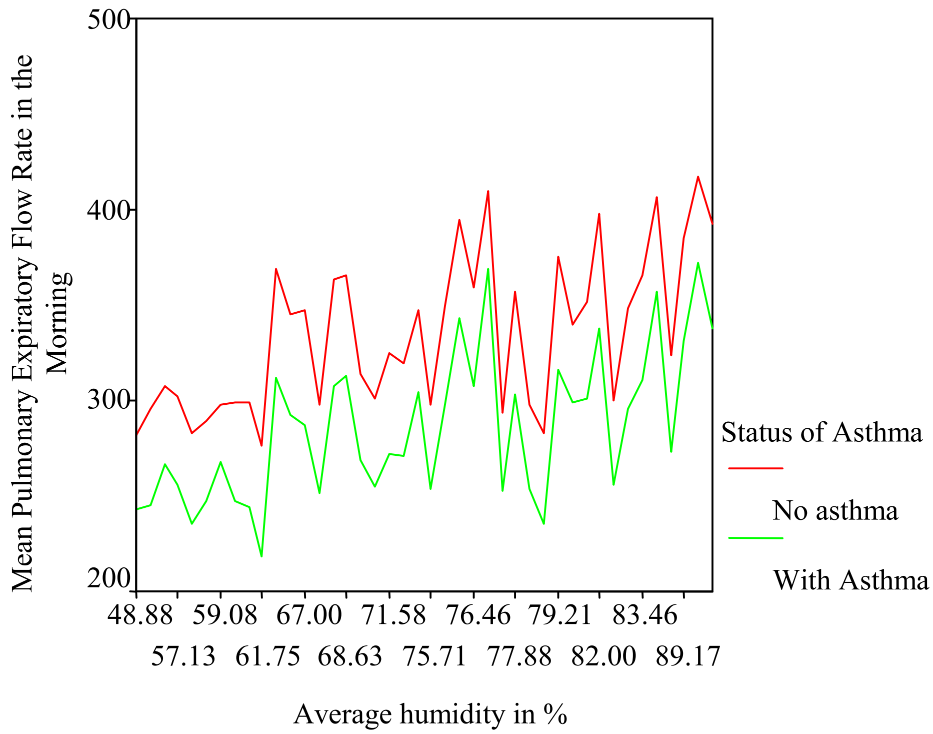


4.2.7.9 Morning PEFR with the daily average humidity

There was highly significant effect of daily average humidity on morning PEFR and was alone accounted for 19.10% variance of the morning PEFR (with an F change value of 1772.47; p= <0.001). When the asthma status was included in the model, there was a significant raise of adjusted R^2 value to 36.00% (with and F Change value of 1984.13; p=<0.001 for asthma status).

Standardized coefficient beta indicated that the increase in one standard deviation of daily average humidity while holding the asthma status constant would increase the morning PEFR by 0.44 standard deviations.

Fig: 25- Relationship of morning PEFR with the daily average humidity by asthma status

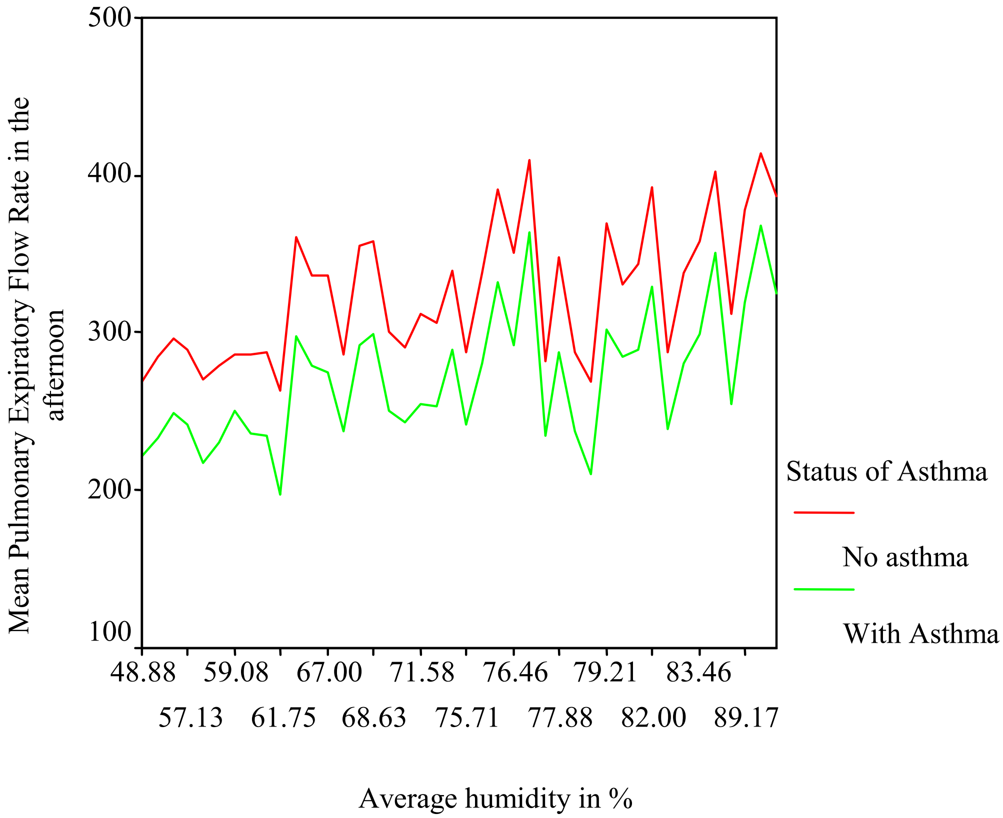


4.2.7.10 Afternoon PEFR with the daily average humidity

There was highly significant effect of daily average humidity on afternoon PEFR and was alone accounted for 19.10% variance of the morning PEFR (with an F change value of 1768.14; p= <0.001). When the asthma status was included in the model, there was a significant increase in adjusted R^2 value to 37.30% (with and F Change value of 2184.79; p=<0.001 for asthma status).

Standardized coefficient beta indicated that the increase in one standard deviation of daily average humidity while holding the asthma status constant would increase the afternoon PEFR by 0.44 standard deviations.

Fig: 26- Relationship of afternoon PEFR with the daily average humidity by asthma status

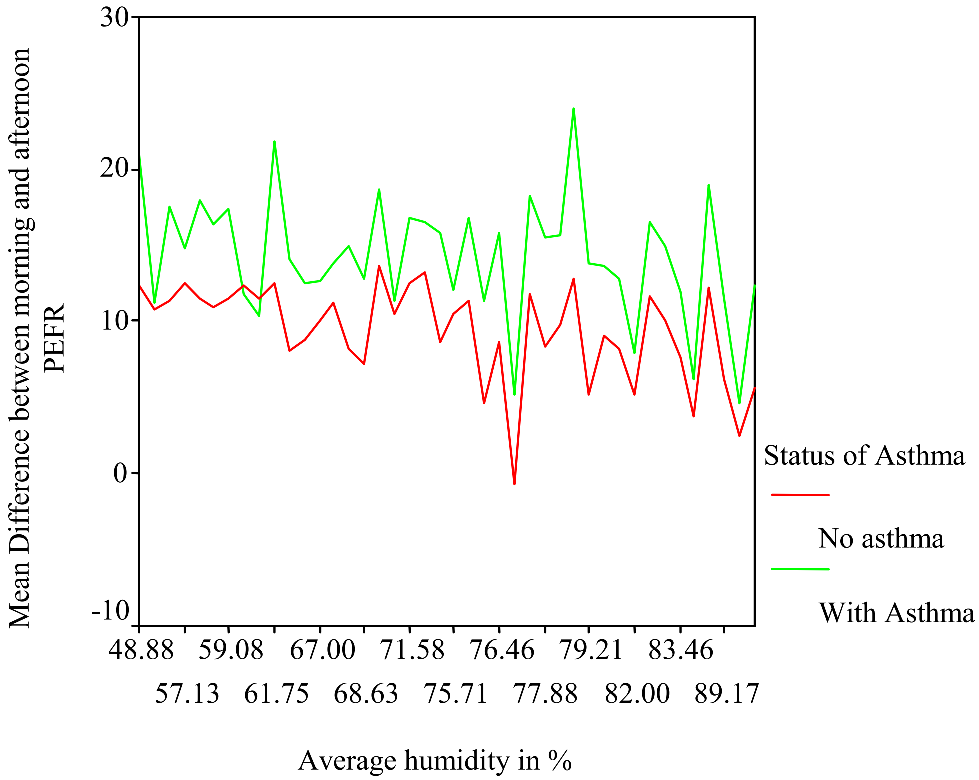


4.2.7.11 Difference between morning and afternoon PEFR with the daily average humidity:

There was highly significant effect of daily average humidity on the difference between morning and afternoon PEFR but accounted for only 1.50% variance of the morning PEFR (with an F change value of 102.91; p= <0.001). When the asthma status was included in the model, there was a significant increase in adjusted R^2 value to 5.30% (with and F Change value of 307.61; p=<0.001 for asthma status).

Standardized coefficient beta indicated that the increase in one standard deviation of daily average humidity while holding the asthma status constant would reduce the difference between morning and afternoon PEFR by 0.12 standard deviations.

Fig: 27- Relationship of difference between morning and afternoon PEFR with the daily average humidity by asthma status

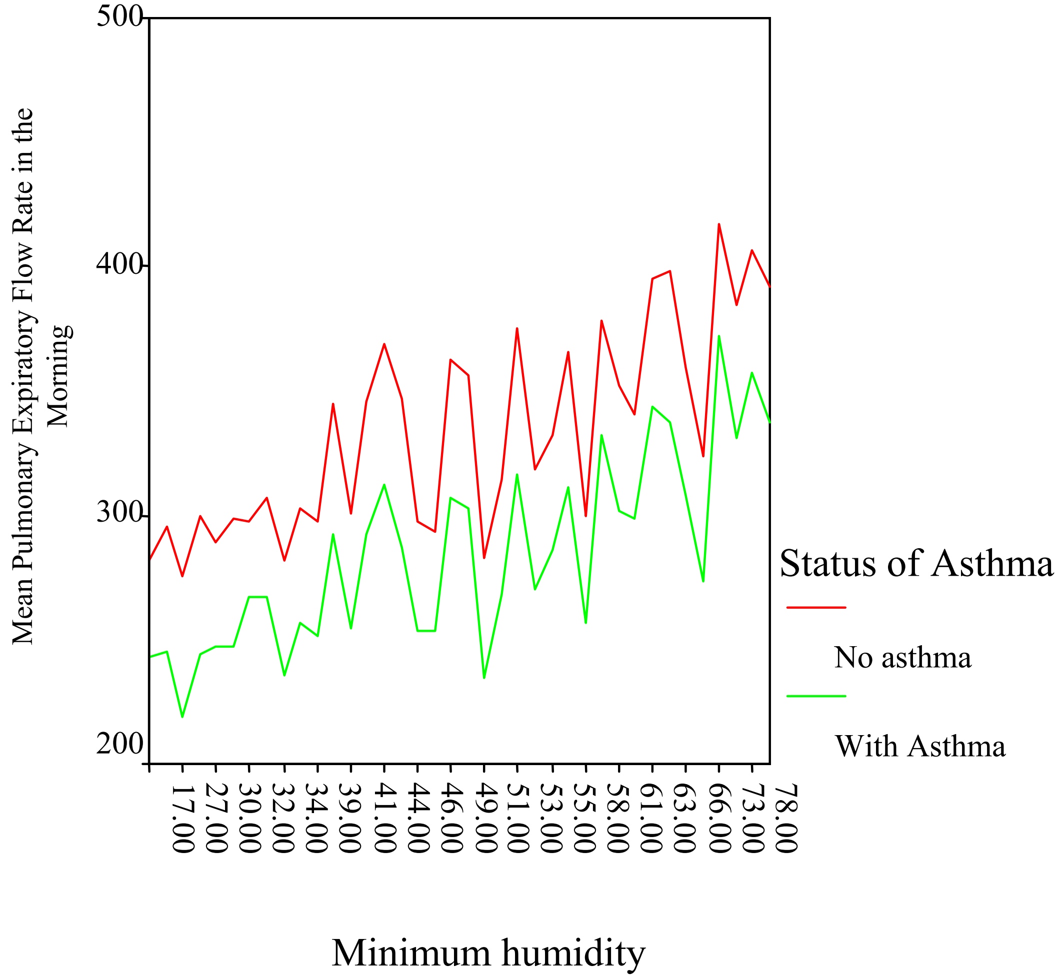


4.2.7.12 Morning PEFR with the daily minimum humidity

There was highly significant effect of daily minimum humidity on morning PEFR and was alone accounted for 26.00% variance of the morning PEFR (with an F change value of 2634.02; p= <0.001). When the asthma status was included in the model, there was a significant raise of adjusted R^2 value to 42.90% (with and F Change value of 2225.56; p=<0.001 for asthma status).

Standardized coefficient beta indicated that the increase in one standard deviation of daily minimum humidity while holding the asthma status constant would increase the morning PEFR by 0.51 standard deviations.

Fig: 28- Relationship of morning PEFR with the daily minimum humidity by asthma status

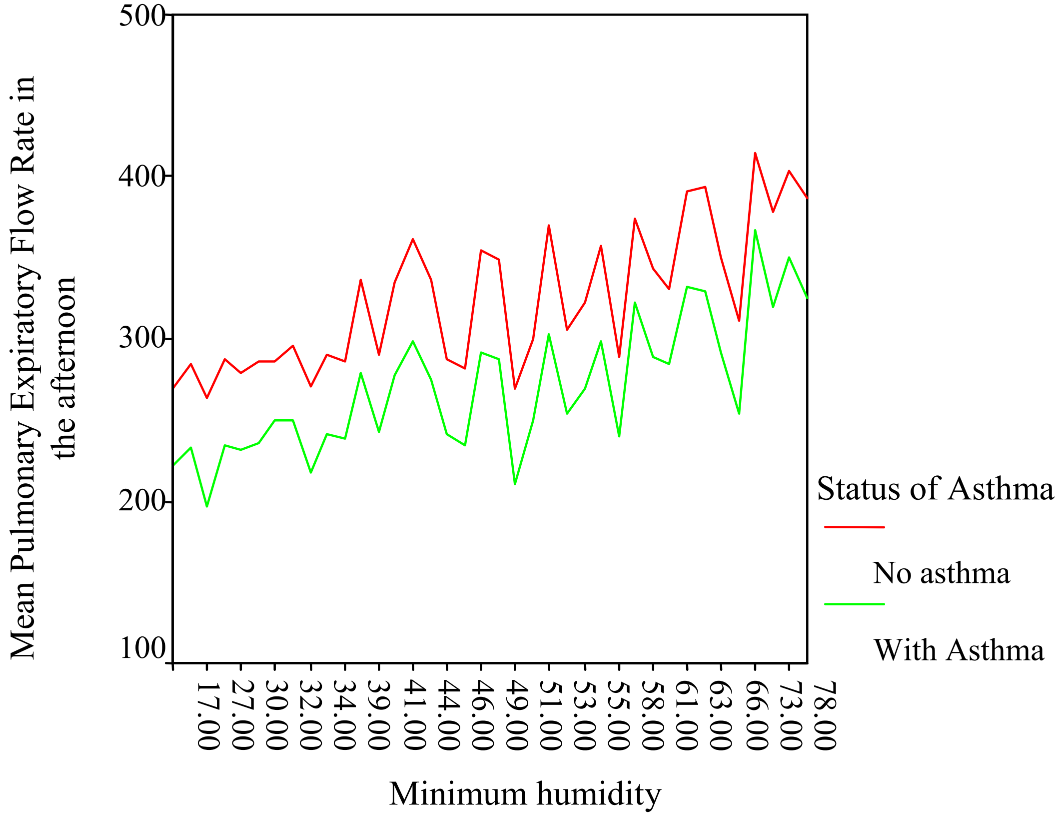


4.2.7.13 Afternoon PEFR with the daily minimum humidity

There was highly significant effect of daily minimum humidity on afternoon PEFR and was alone accounted for 25.80% variance of the morning PEFR (with an F change value of 2611.35; p= <0.001). When the asthma status was included in the model, there was a significant increase in adjusted R^2 value to 44.10% (with and F Change value of 2451.10; p=<0.001 for asthma status).

Standardized coefficient beta indicated that the increase in one standard deviation of daily minimum humidity while holding the asthma status constant would increase the afternoon PEFR by 0.51 standard deviations.

Fig: 29- Relationship of afternoon PEFR with the daily minimum humidity by asthma status

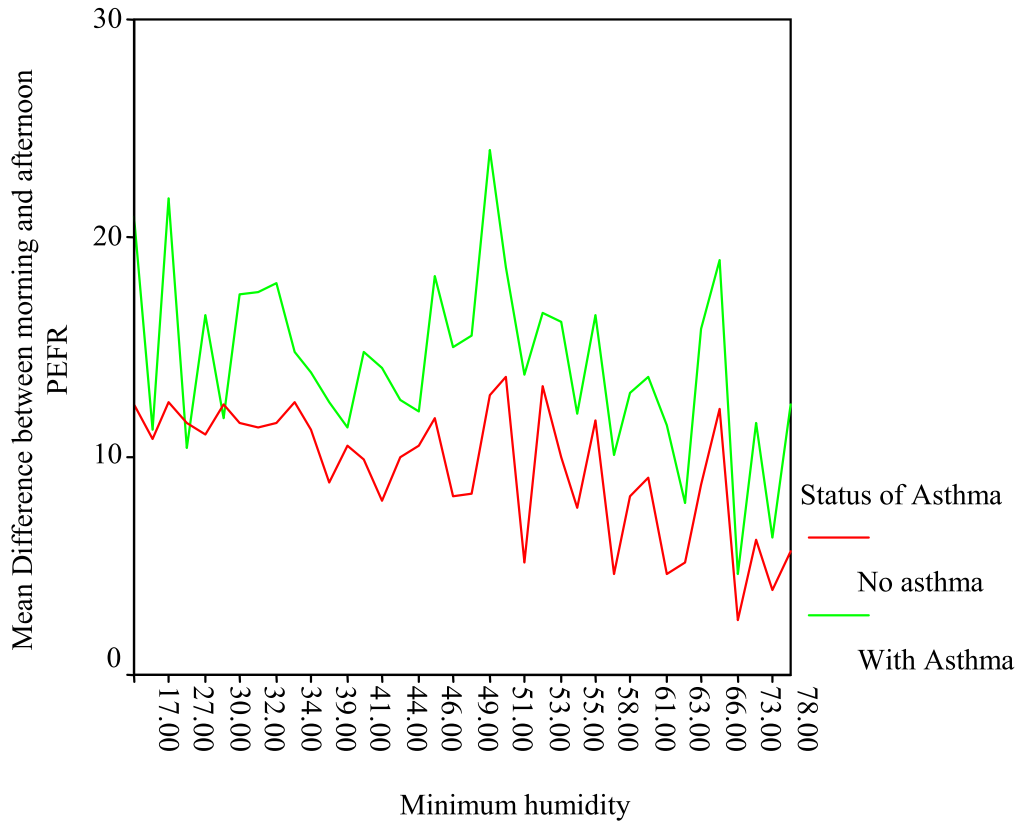


4.2.7.14 Difference between morning and afternoon PEFR with the daily minimum humidity:

There was highly significant effect of daily minimum humidity on the difference between morning and afternoon PEFR but accounted for only 1.90% variance of the morning PEFR (with an F change value of 142.01; p= <0.001). When the asthma status was included in the model, there was a significant increase in adjusted R^2 value to 5.70% (with and F Change value of 308.97; p=<0.001 for asthma status).

Standardized coefficient beta indicated that the increase in one standard deviation of daily minimum humidity while holding the asthma status constant would reduce the difference between morning and afternoon PEFR by 0.14 standard deviations.

Fig: 30- Relationship of difference between morning and afternoon PEFR with the daily minimum humidity by asthma status

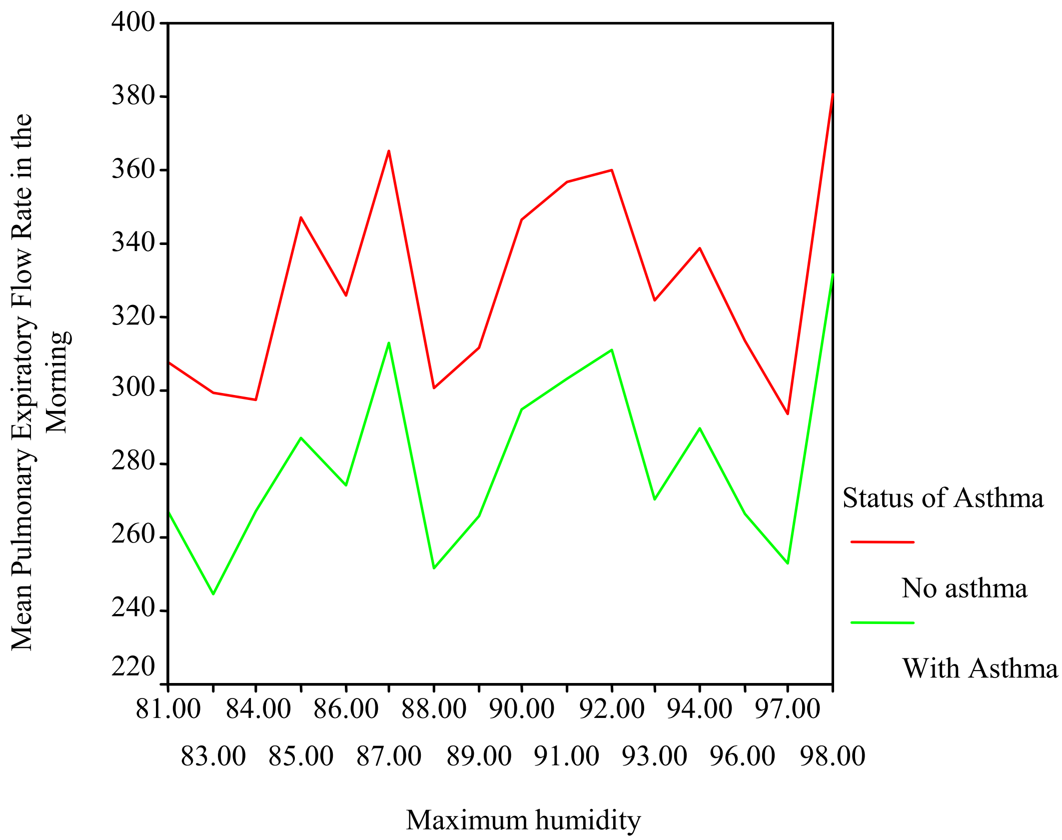


4.2.7.15 Morning PEFR with the daily maximum humidity

There was highly significant effect of daily maximum humidity on morning PEFR and was accounted for 2.80% variance of the morning PEFR (with an F change value of 212.83; p= <0.001). When the asthma status was included in the model, there was a significant substantial raise of adjusted R^2 value to 19.70% (with and F Change value of 1579.95; p=<0.001 for asthma status).

Standardized coefficient beta indicated that the increase in one standard deviation of daily maximum humidity while holding the asthma status constant would increase the morning PEFR by 0.17 standard deviations.

Fig: 31- Relationship of morning PEFR with the daily maximum humidity by asthma status

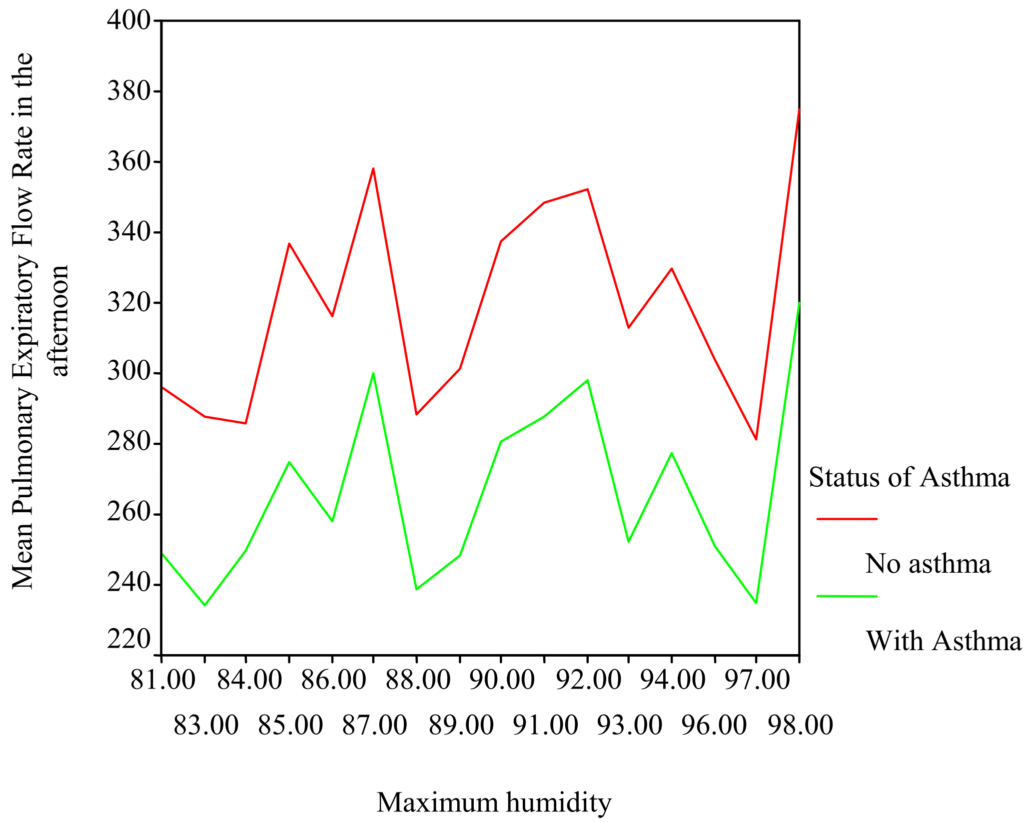


4.2.7.16 Afternoon PEFR with the daily maximum humidity

There was highly significant effect of daily maximum humidity on afternoon PEFR and was alone accounted for 2.80% variance of the morning PEFR (with an F change value of 214.47; p= <0.001). When the asthma status was included in the model, there was a significant increase in adjusted R^2 value to 21.00% (with and F Change value of 1733.72; p=<0.001 for asthma status).

Standardized coefficient beta indicated that the increase in one standard deviation of daily maximum humidity while holding the asthma status constant would increase the afternoon PEFR by 0.17 standard deviations.

Fig: 32- Relationship of afternoon PEFR with the daily maximum humidity by asthma status

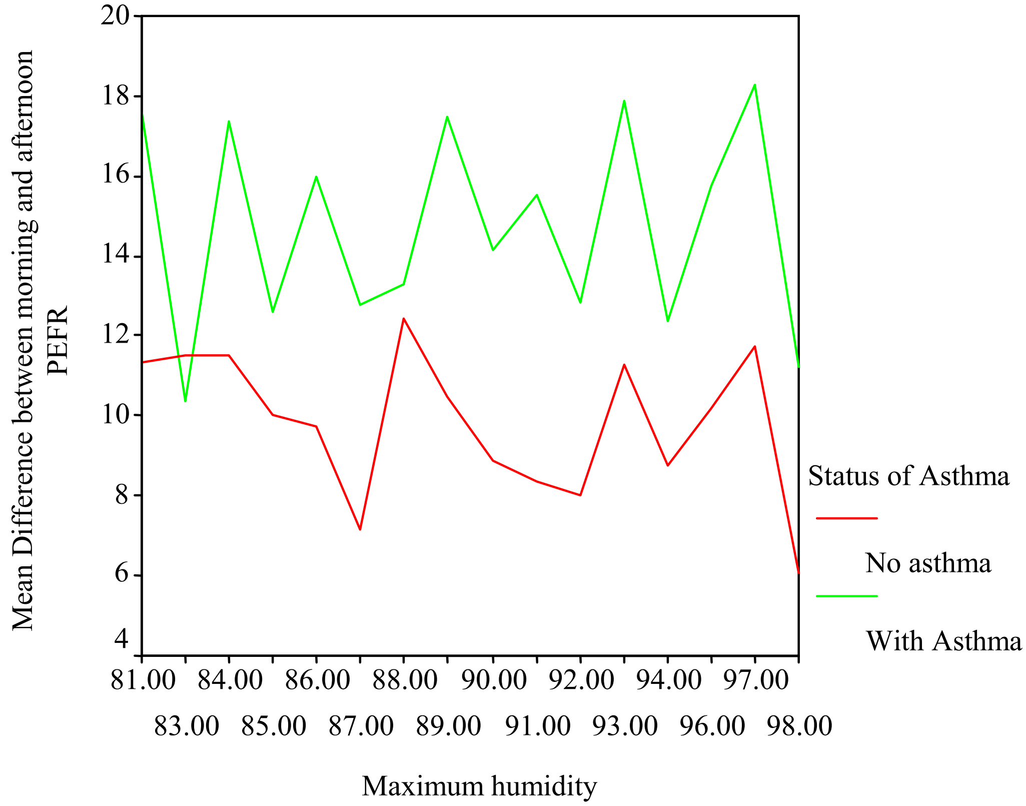


4.2.7.17 Difference between morning and afternoon PEFR with the daily maximum humidity:

There was highly significant effect of daily maximum humidity on the difference between morning and afternoon PEFR but accounted for only 0.30% variance of the morning PEFR (with an F change value of 18.98; p= <0.001). When the asthma status was included in the model, there was a significant increase in adjusted R^2 value to 4.10% (with and F Change value of 303.68; p=<0.001 for asthma status).

Standardized coefficient beta indicated that the increase in one standard deviation of daily maximum humidity while holding the asthma status constant would reduce the difference between morning and afternoon PEFR by 0.05 standard deviations.

Fig: 33- Relationship of difference between morning and afternoon PEFR with the daily maximum humidity by asthma status



4.3. Respiratory problems experienced during past year and cost involvement.

Among the 180 participants who participated in the main study 88.3% (159) responded to the queries regarding frequency of respiratory problems suffered by the child during the past year, number of days of absence from school and cost involved for the problem.

Response rate for non asthmatic children was 91.7% while that for asthmatic children was 86.7% (Table 15).

Table 15: Response to queries on episodes of respiratory problems of the child in last year

Study group	Response to queries on episodes of respiratory problems of the child within last year		Total
	No	Yes	
Non-asthmatic	5 (8.3%)	55 (91.7%)	60
Asthmatic	16 (13.3%)	104 (86.7%)	120
Total	21 (11.7%)	159 (88.3%)	180

Table 16: Respiratory Problems with Duration and Expenditure

Respiratory Problems with Duration and Expenditure	Status of Asthma	Mean (±SD)	Min	Max	Significance
No of episodes of respiratory problems in last year	No asthma (55)	1.18 (±1.20)	0	5	t=-4.953, df157; p<0.001
	With Asthma (104)	2.51 (±2.18)	0	10	
Days of absence in school for these problems	No asthma (55)	3.35 (±3.85)	0	10	t=-7.597, df157; p<0.001
	With Asthma (104)	11.53 (±9.63)	0	36	
Total taka spend for doctor's fee for these problem	No asthma (55)	585.45 (±1029.41)	0.00	5000.00	t=-1.338, df157; p= 0.183
	With Asthma (104)	830.29 (±1131.08)	0.00	5000.00	
Total taka spend for medicine for these problem	No asthma (55)	1086.54 (±1694.47)	0.00	10000.00	t=-6.480, df157; p<0.001
	With Asthma (104)	3276.36 (±2539.29)	0.00	9763.00	
Total taka spend for transportation for these problem	No asthma (55)	208.54 (±434.69)	0.00	2000.00	t=-0.734, df157; p= 0.464
	With Asthma (104)	260.97 (±424.65)	0.00	2000.00	

The number of episodes of respiratory problem amongst the asthmatic children 2.51 (±2.18) was significantly higher (t=-4.953, df157; p<0.001) than among the non asthmatic children 1.18 (±1.20).

Similarly school absenteeism was significantly higher (p<0.001) among asthmatic children (11.53±9.63 days) than among the non asthmatic children (3.35±3.85 days). No statistically significant difference between the groups was detected in terms of expenditure as doctor's fee (p=0.183) and expenditure for transportation (p=0.464). But the expenditure for medicines was significantly higher (p<0.001) for asthmatic children Tk3276.36 (±2539.29) than for non asthmatic children Tk1086.54 (±1694.47) (Table 16).

Table 17: Lab Expenditure for Asthma Status

Investigation Cost	Status of Asthma	Mean (±SD)	Min	Max	Significance
Total taka spend for lab investigation for respiratory problems	No asthma (8)	1266.25 (±916.42)	450.00	2500.00	t=-0.309, df34; p<0.759
	With Asthma (28)	1364.29 (±755.70)	450.00	2500.00	

Among the 159 study participants responded to the queries regarding frequency of respiratory problems suffered by the child during the past year, number of days of absence from school and cost involved for the problem, 36 (22.6%) children had to take laboratory investigation(s). And laboratory investigation was taken by 14.5% non asthmatic and 26.9% asthmatic children. The cost involved for laboratory investigation was significantly higher (p<0.001) among asthmatic children (1364.29 ±755.70) than among non asthmatic children (1266.25 ±916.42) (Table 17)

Table 18: Extra Expenditure for the Respiratory Problems in regards to Asthma Status

Status of Asthma	Spending any other money for extra expenditure in regards to Asthma		Total
	No	Yes	
No asthma	46 (83.6%)	9 (16.4%)	55 (100.0%)
With Asthma	89 (85.6%)	15 (14.4%)	104 (100.0%)
Total	135 (84.9%)	24 (15.1%)	159 (100.0%)

Only 15.1% of the 159 participants had spent money for purpose other than doctor's fee, medicine cost and transportation. Higher proportions of non asthmatics (16.4%) than asthmatics (14.4%) had such expenditures (Table 18.).

Table 19: Total Expenditure for Asthma Status

Total expenditure	Status of Asthma	Mean (±SD)	Min	Max	Significance
Expenditure	No asthma (55)	2213.81 (±3715.92)	0.00	19000.00	t=-4.067, df157; p<0.001
	With Asthma (104)	4856.38 (±4218.44)	0.00	17200.00	

Total expenditure for respiratory problems experienced by study participants during the past year was found to be significantly higher ($p<0.001$) for asthmatic children (Tk4856.38 ±4218.44) than for non asthmatic children (Tk2213.81 ±3715.92) (Table 19).

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