Research Report

Assessment of Impacts of Particulate Air Pollutants on Respiratory Health of School Children in Kathmandu Valley

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Prof. Dr. Chop Lal Bhusal

Executive Chairman

List of Abbreviations

AQMS	Air Quality Monitoring Station
BS	Black Smoke
CI	Confidence Interval
COPD	Chronic Obstructive Pulmonary Disease
ICIMOD	International Center for Integrated Mountain Development
ISAAC	International Study of Asthma and Allergies in Childhood
MD	Mean Difference
MOEST	Ministry of Environment Science and Technology
NAAQS	National Ambient Air Quality Standard
NHRC	Nepal Health Research Council
PEF	Peak Expiratory Flow
PEFR	Peak Expiratory Flow Rate
PM	Particulate Matter
SD	Standard Deviation
SPSS	Statistical Package for Social Sciences
UNEP RRC.AP	United Nations Environment Program Regional Resource Center for Asia Pacific

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Executive Summary

Vehicular emissions as well as other pollutants degrading air quality is a global concern today. This is one of the greatest challenges and key environmental issue in Asia-Pacific region, with the growth of the megacities. The adverse health impacts resulting from small increases in concentrations of the worst pollutant, particulate matter (PM), are quite significant. These effects are especially severe in infants and children. The effect of particulate matter in the health of the people is one of the most important impact of air pollution that have been identified as the key problem as shown from various studies in developed countries. The impact of air pollutants and its adverse effect on children's health could be harmful till their adulthood. Developed countries are concerned about outdoor air pollution more than they do for indoor air pollution. Developing countries like Nepal are at double jeopardy; as the problem of outdoor as well as indoor air pollution is growing fast. As most lung alveoli are formed postnatal, changes in the lungs continue through adolescence and the developing lungs of children are more vulnerable to the adverse effects of air pollution than adult lungs. As child health is an essential indicator for the overall assessment of country health status, this study is expected to provide a basis to understand the effect of air pollutants on human health. This study can address the need for the information on the effects of air pollution on health in this region of the world and provide locally-gathered evidence to support actions by government to control particulate emissions.

The objectives of the study were to assess the impact of air pollution (Particulate Matter) in respiratory health of school children of selected schools in Kathmandu Valley and measure the association between PM concentration and lung function.

The study had two components: i) baseline survey and ii) health impact assessment both following quantitative methods and carried out in one year from July 2011 to June 2012. A baseline survey was conducted in 7 schools of different locations in Kathmandu valley among 1184 children using a structured questionnaire, modified ISAAC (The International Study of Asthma and Allergies in Childhood) questionnaire. For the second component correlational study was done to assess the health impact in two schools among 137 students out of 507. After the baseline survey St. Xavier's school (urban roadside) and Santaneshwor Vidya Mandir (Semi urban residential) were taken for the second component where children of age between 10 to 15 years were assessed daily for their lung function by measuring morning peak expiratory flow rate. Meanwhile, data for particulate matter (PM 2.5) was also recorded daily for both schools by

using a personal monitor (dusttrak). Weather data was achieved from the Department of Hydrology and Meteorology.

Data obtained from these procedures were entered in MS Excel and analyzed using SPSS 16.0 version. Descriptive analysis was done to describe the findings of baseline survey about respiratory manifestations. Similarly, descriptive analysis using frequency tables was done for the general characteristics of the students enrolled for health impact assessment. Mean PM 2.5 of two schools was compared and tested for the difference using Mann Whitney U test. Similarly, mean PEFR for the two schools was tested for the difference using independent samples t test. This test was also done for two different groups of St Xavier's School segregated on the basis of gender as well as age groups. To identify the correlation of PM with lung function of children the average daily PEFR was plotted with average daily PM 2.5 for different groups.

Nearly 70 percent of the children from St. Xavier's school (school 1) and 85 percent of the children from Santaneshwor Vidya Mandir (school 2) were in the age group 13 to 15 years. Rest of them in both the schools was from the age group of 10 to 12 years. Male children were nearly 60 % in both the schools. The mean age of the children was almost similar just above 13 without any significant difference. Mean height and weight of the children were significantly different in the two schools.

The mean concentration of PM 2.5 was 203.14(±75.01) and 137.69 (±44.52) in school 1 and 2 respectively and the difference is statistically significant ($p = 0.04$). The mean PEFR was higher for school 1 with statistically significant difference ($p < 0.05$, 95% CI 39.61 – 126.17). The mean PEFR level between the two sexes of school 1 was significantly different ($p=0.01$, 95% CI 10.52- 80.36), the value being higher for the male children.

The PEFR level of the total students of school 1 is found to be varying on certain days with the changing levels of PM concentration which was seen to be varying between the values of 100 $\mu g/m^3$ and nearly 340 $\mu g/m^3$. The PEFR levels of younger (10-12 years) children seem to be correlating with the changes in PM 2.5 concentrations in the initial days and later days of the assessment. Similarly, the PEFR levels of female children also seem to be correlating with the variation in daily PM concentrations on few days. The daily PEFR levels of 20 students taken from the semi urban school is in the inverse relationship with the changes in PM concentrations for most of the days in later half except for few days. It can be concluded that there is an

association of lung function with the particulate matter in the atmosphere. However, the relation could not be quantified statistically due to less number of observations.

In an overall impression, it shows that the impact is more pronounced in the younger age groups and female children. Hence, the intervention needs to be focused to protect the most vulnerable groups from the increasing pollutants. The cross sectional component of this study conducted in the larger group as a baseline study before the impact assessment study hints that the burden of fine particles on the respiratory health could be huge and thus requires further investigation.

Chapter I: Introduction

1.1 Background

Particulate matter (PM) is the term used to define a complex mixture of naturally occurring airborne particles and those resulting from human activity. In urban environments, fine particles derive primarily from fossil fuel combustion, including mobile sources such as motor vehicles and stationary sources such as power plants (1). Fine and ultrafine particles (PM2.5) and coarse particles (PM10) are predominantly emitted from combustion processes, such as power plants and motor vehicles, while coarse particles are mostly generated by mechanical processes from a variety of non combustion sources (2). Emission of those air pollutants degrades the air quality and has now become global concern. The adverse health impacts resulting from small increases in concentrations of the worst pollutant, particulate matter (PM), are quite significant. These effects are especially severe in infants and children. And it is one of the greater challenge and key environmental issues in Asia-Pacific region, with the growth of the megacities (3). The effect of particulate matter in the health of the people as the most important impact of air pollution have been identified as the key problem as shown from various studies in developed countries (4). The impact of air pollutant and its adverse effect on children may be harmful till their adulthood. As child health is an essential indicator for the overall assessment of country health status, impact assessment of particulate matter on children provides a basis to understand the effect of air pollutants on the health of the children (5). Some studies from developing countries of urban area have shown children health status with respect to ambient air pollution and respiratory infection is not too good. Basically, developed countries are concerned about outdoor air pollution more than they do for indoor air pollution. However, developing countries like Nepal are at double jeopardy; as the problem of outdoor as well as indoor air pollution is growing fast.

Vehicular emission is also a major problem for developing countries. A report from the transport authority has shown significant rise in the number of vehicles in the country. The total number of vehicles in 1989/1990 was 76378 that increased to 1348995 in 2011/2012. There has been a huge increase in the number of vehicles. (6)

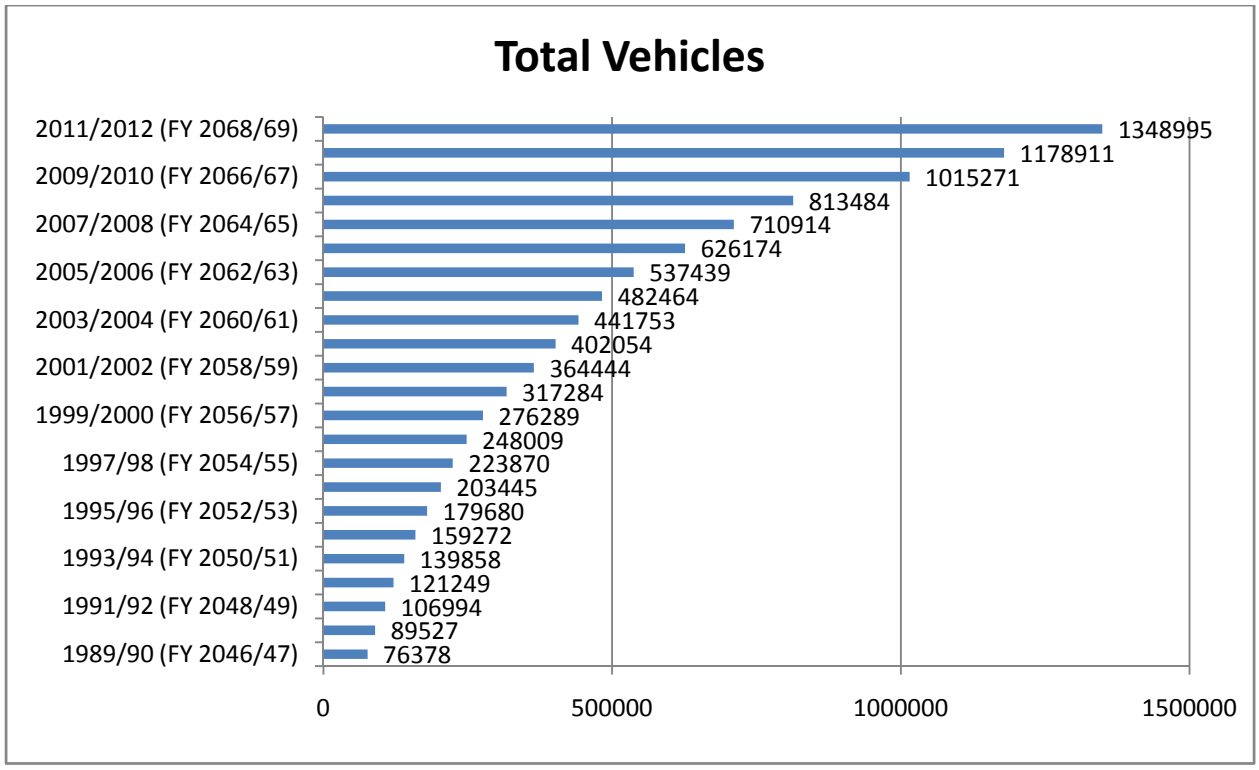

Figure 1 Vehicles Growth in Nepal (1989-2012)

Source: Department of Transport Management, 2012

The monitoring systems, initiated by the Government of Nepal in 2001, are located at six different stations. The station is not in operation since 2009. The previous results of the air quality monitoring stations have shown that the main problem of concern regarding the outdoor air quality is the very high level of suspended particulate matter.

The annual average concentration of PM_{10} from 2003 to 2007 in six different stations of Kathmandu Valley shows that the two roadside stations Putalisadak and Patan throughout had the PM 10 concentrations more than the national standard of 120 µgm/m^3 (7).

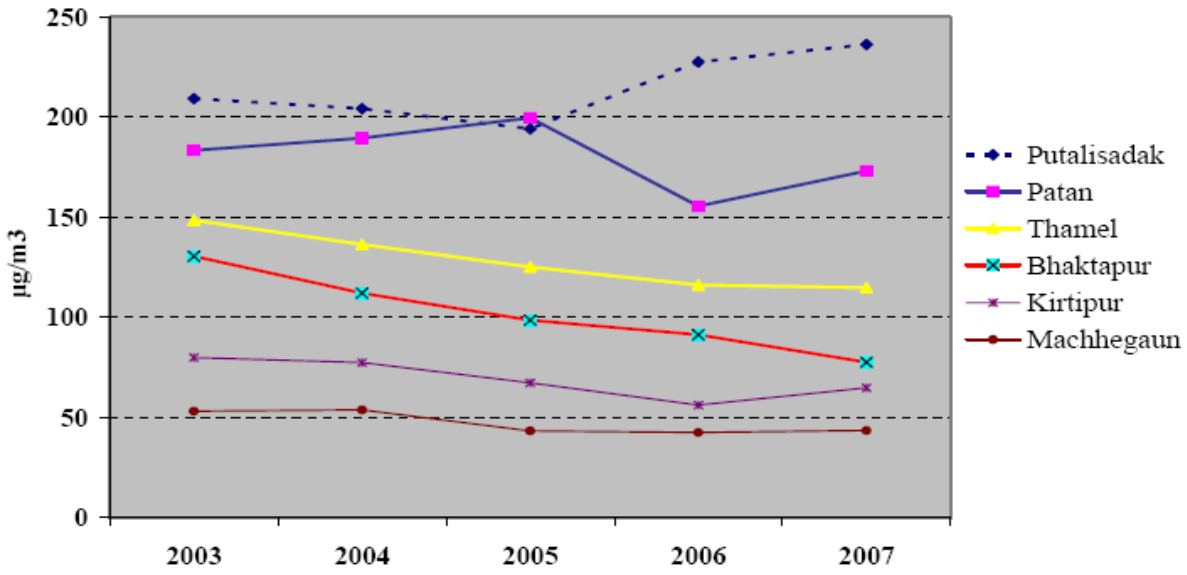

Figure 2 Annual Average PM10 concentration: Results from 2003- 2007, station by station

Source: Status on ambient air quality of Kathmandu Valley, 2007, MoEST

There has been positive association between various health effects and ambient air pollution. The coefficients of PM10 are found to be statistically significant for respiratory morbidity and COPD morbidity and insignificant for others at 95% confidence level (8). Current situation of air pollutants level even though the exact data is not available is certainly detrimental and the adverse impacts on public health due to ambient air particulate matters at Kathmandu valley and other major cities of Nepal are on rise.

The quantified value of air pollution concentration of particulate matter (PM10 and PM2.5) is significantly higher than developed national standard value in most of the developing countries. Studies likewise have shown very significant correlations between high PM2.5 and PM10 levels and increased cardiopulmonary disease (9). Apart from cardiovascular disease and the increased risk of premature death, PM exposure levels have been correlated in the short term with a number of other effects. All particulates are irritants, and persistent cough with phlegm has been linked to high PM levels, along with wheezing and physical discomfort in breathing (10). As most lung alveoli are formed postnatal, changes in the lungs continue through adolescence and the developing lungs of children are more vulnerable to the adverse effects of air pollution than adult lungs. Children are more susceptible to the exposure to the harmful particles than adults

because of higher ventilation rates, higher relative concentrations of particles into smaller lung volumes and higher levels of physical activity (11).

Developing countries in South Asia including Nepal lack adequate information reflecting national policies on health impact due to particulate air pollutant (PM 10 and PM 2.5 and less than PM2.5). Relatively fewer studies have been made in the developing countries than in developed countries. With the increasing pollution, the concentration of air pollutants in major cities are higher and the source and chemical composition of particles in cities in developed and developing countries may differ. Consequently information is needed to assess the impacts of the much higher concentrations of PM10 (with a mean aerodynamic diameter of or smaller than 10 microns) and PM2.5 found in the large cities of developing countries.

As child health is an essential indicator for the overall assessment of country health status, this study will certainly provide a basis to understand the effect of air pollutants on human health. Current study attempts to asses PM 2.5 concentration and respiratory manifestations and respiratory functions and assess the association between PM concentration and lung function. This study can address the need for the information on the effects of air pollution on health in this region of the world and provide locally-gathered evidence to support actions by government to control particulate emissions.

1.2 Objectives

General Objective:

To assess the impact of air pollution (Particulate Matter) in respiratory health of school children of selected schools in Kathmandu Valley

Specific Objectives:

- To describe the respiratory manifestations of children of selected schools
- To identify the correlation of PM 2.5 with the lung function (PEFR)
- To measure the association between daily PM 2.5 concentration and lung function (PEFR) in children

Chapter II: Methodology

The study consisted of a baseline survey followed by health impact assessment component among the school children. Study was conducted in selected schools of Kathmandu valley by using quantitative methods and the design of study was correlational. Ethical approval was taken from the Ethical Review Board of Nepal Health Research Council prior to implementation of the study.

2.1 Phase I: Baseline Survey

2.1.1. Sampling

The baseline survey was proposed to be carried out in 6 schools initially with the rationale of taking one school each located near by the six Air Quality Monitoring Stations situated in different locations through purposive sampling. Six schools thus chosen for the study were Green Village School, Kirtipur, Jaycees Secondary School, Bhaktapur, Magus English School, Matsyagaon, Neptune English School, Putalisadak, Next Generation School, Basantapur, St Xavier's School, Jawalakhel. Apart from these schools, Santaneshwor Vidya Mandir, Chapagaon was chosen with the purpose of including that school in the health impact assessment component as a school located in less polluted area. Within those schools, census method for the children of class 6 to 9 was followed to include the participants in the study. Hence a total of 1184 students were targeted for the baseline survey.

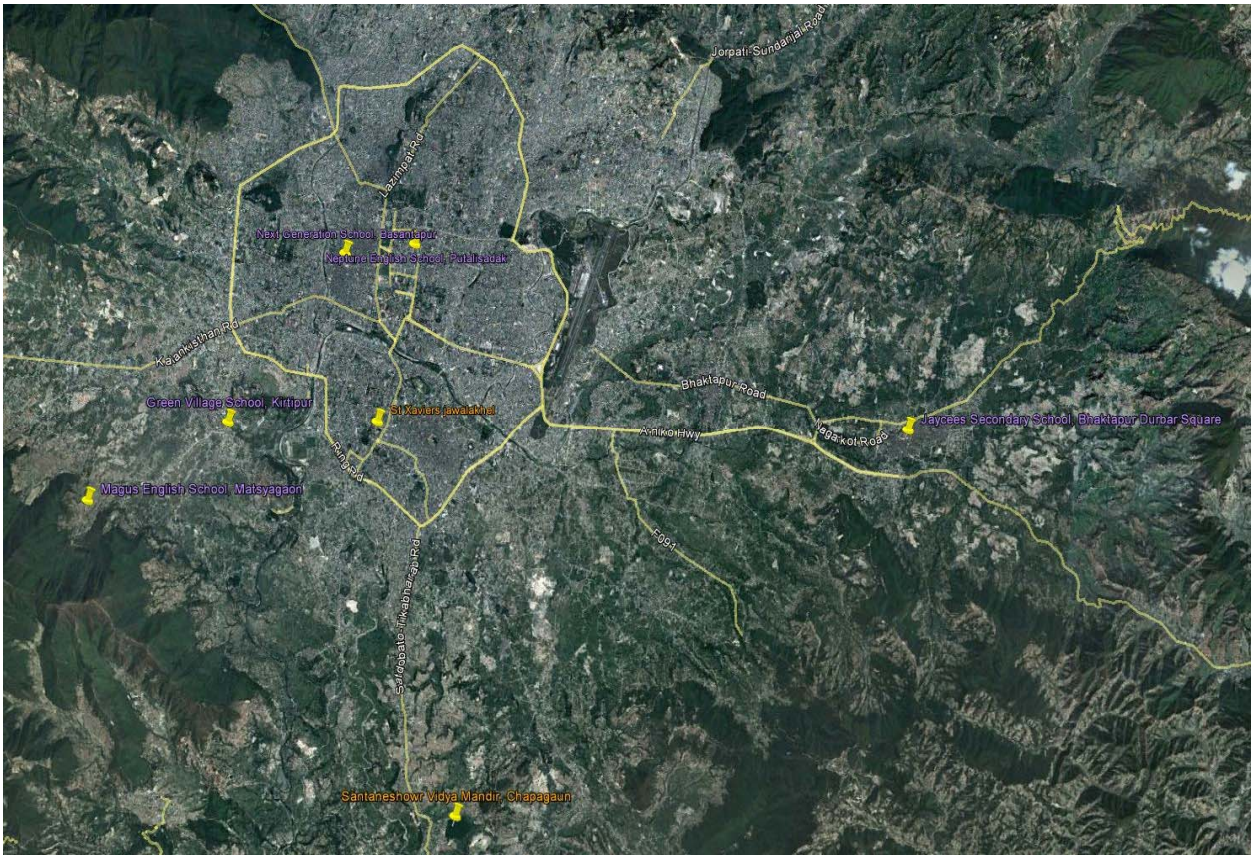

Figure 3 Locations of Schools taken for the Study

Out of the 7 schools in total, at the second stage two schools (Spotted with red color in the map) St Xavier's School, Jawalakhel and Santaneshwor Vidya Mandir, Chapagaun were taken for the health impact assessment component. The locations of other five schools have been spotted in the map with blue color.

2.1.2 Data Collection

The International Study of Asthma and Allergies in childhood (ISAAC) questionnaire was used for the data collection in baseline survey. The questionnaire was modified to suit the local situation and then translated to Nepali and re-translated back to English to ensure that the meaning of the original questionnaire was not misinterpreted. The Nepali questionnaire was checked for the simplicity and clarity of each question. This questionnaire was then pre tested in one of the non participating road side school, which was then modified as required.

The questionnaire had two major sections in it. First part had informed consent sheet including introductory information as well as socio demographic details of the child. The second section had three sub sections in it. Section I had questions related to the respiratory health of the

children. Section II had questions related to respiratory manifestations in children when the child was not suffering from cold or flu like conditions. The questionnaire was then distributed to the children through their class teachers and asked to fill up on their own with parental assistance or get the questionnaire filled up by the parents. This was accomplished in the month of November 2011. The distributed questionnaires were collected back in one week time. The response rate was 67.65 % and thus a total of 801 questionnaires were received back. (Sample questionnaire enclosed is the Annex)

2.1.3 Data Analysis

All the data collected from the questionnaire survey was coded and then entered in Microsoft excel which was then later transferred to SPSS version 16.0 for further analysis. Once transferred into SPSS the data was thoroughly cleaned for any discrepancies and any missing entry or faulty entries. The discrepancies found were corrected by again going back to the filled questionnaire. After this the data was decoded and analyzed for frequencies and distribution in different groups. The information thus generated was tabulated grouping together the related variables.

2.2 Phase II: Health Impact Assessment

2.2.1 Sampling

A roadside school in the urban settings (St. Xavier's School, Jawalakhel – school I) and a school in semi urban residential settings (Santaneshwor Vidya Mandir, Chapagaon – school II)) were chosen purposively for the health impact assessment component. Within these schools the total responses in the baseline survey were 449 and 58 from school I and school II respectively. Out of the 449 children in school 1 there were 330 eligible students who met the inclusion criteria and from these a total of 150 children were selected following simple random sampling (lottery method). These 150 children were taken for the physical and clinical examination and finally 117 children were taken for the lung function assessment after excluding the children meeting exclusion criteria in examination.

Similarly, out of the 58 responses in school II, there were only 23 students who met the inclusion criteria. Hence, all 23 students were chosen for the physical and clinical examination and finally 20 students were taken for the lung function assessment after excluding the children meeting exclusion criteria in examination.

The inclusion criteria for selecting the students for lung function assessment were age between 9 to 15 years and studying in the school at least since 1 year. The exclusion criteria were any smoking habit, use of solid fuel at home, child having asthma or other chronic respiratory illness and child with smoker at home.

2.2.2 Data Collection

Physical examination

Physical examination was done by a Pediatrician and cases found to be having respiratory as well as cardiac illness were excluded from the study. 117 students from school I and 20 students from school II were then taken for the lung function assessment (PEFR measurements). During the physical examination, height in cm weight in kg was measured of the students using a standard measuring tape and weighing scale.

Lung Function Assessment

Teachers were trained on the whole process of assessment (2 teachers in school I and 1 teacher in school II). Two data collectors and one field supervisor each in school I along with the 2 teachers then completed the whole process of data collection on PEFR measurement from 25 January to 06 March 2012. One data collector and field supervisor along with one teacher in school II completed the data collection process in the same period.

Whole process was supervised by one of the investigators on a regular basis. Students were trained to use the peak flow meters in small groups as well as on individual basis. Name of participating student was written in the peak flow meters and given to them. However, it was collected after the reading and stored by the study team to give it again the next day. PEFR reading was taken in the first hour of school that is after school assembly in the morning. The students were instructed on the procedure of PEFR measurement and given the sheet to record the PEFR. The students recorded the maximum reading of PEFR out of 3 readings in the presence of either one of the teachers or data collectors.

This process of PEFR measurement was originally planned for 6 weeks and total measurement for 42 days was planned. By the end of the study we could measure the lung function of students for 31 days within the span of 42 days where 9 days were missed due to public holidays and other disturbances such as strike.

Particulate Matter and Weather Data

Initially, the Air Quality Monitoring Stations (AQMS) were about to be revived to function as per the government source however that did not happen. Finally the study team with the consent and technical support from ICIMOD decided to measure the PM 2.5 concentration by using the personal dusttrak TSI model 8250 on a regular basis. 24 hour average was taken for the analysis purpose. Relevant meteorological data such as average daily temperature, daily relative humidity and daily total rainfall for the period of lung function assessment were taken from the Department of Hydrology and Meteorology.

2.2.3 Data Analysis

The general characteristics such as age, sex, height and weight of the students who were taken through the lung function assessment were analyzed and described in tabular forms. This information was grouped as per school I and school II. Similarly the PM 2.5 concentrations and PEFR readings of the students of both the schools were interpreted separately and the mean values were compared. For school I, as there was enough number of students for statistical power the analysis was further categorized as per the sex and age group (higher – 13 to 15 years and lower – 10 to 12 years) of the students. For comparing the mean PM 2.5 concentrations Mann Whitney U test was done as the data was found not to follow the normal distribution. The mean PEFR readings of two schools as well as two different groups within school I were compared using independent samples t test.

The correlation of PM 2.5 and PEFR readings was done separately for school I and school II as well as two different groups within school I by using graphical plots. As planned initially for measuring the association and quantifying the relation of PM 2.5 with PEFR, the daily average data for PM and PEFR were tested for the linearity to perform multiple linear regressions by taking PEFR as dependent variable and weather data as independent variables along with PM 2.5. However, the data was not found to be linear and the log conversion, quadratic conversion, cubic conversion and exponential conversion also did not give the significant results. Hence, the regression analysis was omitted from the analysis.

Chapter III: Results of the Study

3.1 Phase I: Baseline Survey

3.1.1 Socio demographic characteristics of school children

The baseline survey for the initial assessment in the first phase targeted 1184 students from 7 different schools. Out of that, 801 students responded with the completed questionnaire which was 67.65 %. Six schools were taken one each from the vicinity of six air quality monitoring stations in Kathmandu valley. The seventh school was purposively chosen from a possibly less polluted urban background site.

Table 1 Socio demographic characteristics of school children, Baseline Survey

Age of the Students in Group	**Frequency**	**Percent**
10 to 12 Years	313	39.1
13 to 15 years	488	60.9
Sex of the Students		
Male	466	58.2
Female	335	41.8
Religion of the Students		
Hindu	714	89.1
Buddhist	55	6.9
Others	32	4.0
Total	**801**	**100.0**

Among the total students of 801 from all the selected schools, 60.9% of them were from the age group of 13-15 years while remaining was from the age group of 10-12 years. Similarly, 58.2 % were male and 41.8 % female. Majority (nearly 90%) of the students was Hindu and few were Buddhist and a negligible proportion was from Christian and Muslim.

3.1.2. Respiratory and Allergic Manifestation Analysis

Of the 801 students who responded with the questionnaire the responses were analyzed in terms of various respiratory as well as non respiratory manifestations.

Table 2 Respiratory Symptoms Manifestations

Manifestations	Response	Frequency	Percent
Asthma, wheeze or Whistling Sound Ever	No	735	91.8
	Yes	66	8.2
	Total	801	100.0
Asthma, wheeze or Whistling Sound in last 12 months	No	36	54.55
	Yes	30	45.45
	Total	66	100.00
Frequency of such symptoms in last 12 months	Don't know	2	6.67
	1-3 times	24	80.00
	4-12 times	2	6.67
	More than 12 times	2	6.67
	Total	30	100.00
Sleep disturbance by such respiratory problems in last 12 months	No	19	63.33
	Yes	11	36.67
	Total	30	100.00
Number of days of Disturbed Sleep	1 week	2	18.18
	More than a week	1	9.09
	1-2 days	8	72.73
	Total	11	100
Speech hampered by such respiratory problems in last 12 months	No	19	63.33
	Yes	11	36.67
	Total	30	100.00
Asthma or Wheeze experienced by child during or after exercise or play in last 12 months	No	732	91.4
	Yes	69	8.6
Cold or dry Cough at night in last 12 months	No	542	67.7
	Yes	259	32.3
	Total	801	100.0

Among 801 participants in the study, 66 (8.2%) of them were found to be suffered from asthma, wheeze or whistling sounds ever while among them 30 of them had those problems in the last 12 months.

Among those who had such problems in the last one year, 24 of them suffered 1-3 times, 2 of them 4-12 times while 2 students suffered more than 12 times. However, 2 of them who suffered from those conditions were found not to remember the frequency of such suffering.

Among those suffered in last 1 year, 11 of them had sleep disturbance due to the suffering out of 30 children. Majority (73%) of them suffered for 1 to 2 days followed by about 18 % for about a week. The same proportion 11 out of 30 (37%) also had their speech hampered due to the respiratory problems in the last year.

Out of the total children 8.6% experienced asthma or wheeze like manifestations during or after play or exercise. Similarly, almost one third (32.3%) of the total children were found to suffer from cold or dry cough in the night in last 12 months.

Table 3 Respiratory Symptoms when not suffered from Cold or Flu

Manifestations	**Response**	**Frequency**	**Percent**
Sneezing, running nose or nasal blockade ever	No	566	70.7
	Yes	235	29.3
	Total	801	100.0
Sneezing, running nose or nasal blockade in last 12 months	No	73	31.1
	Yes	162	68.9
Hampering or difficulty of study and play due to such problems in last 12 months	No	181	77.0
	Yes	54	23.0
	Total	235	100.0

Of the total children, nearly 30% were reported to have respiratory symptoms such as sneezing, running nose or nasal blockade even when they did not have common cold or flu. Among those 30 % (235) children just above 69 % had such symptoms in last 12 months and 23 % of them had difficulty or hamper in studies and activities like playing.

Month of suffering from respiratory symptoms when not suffered from cold or flu

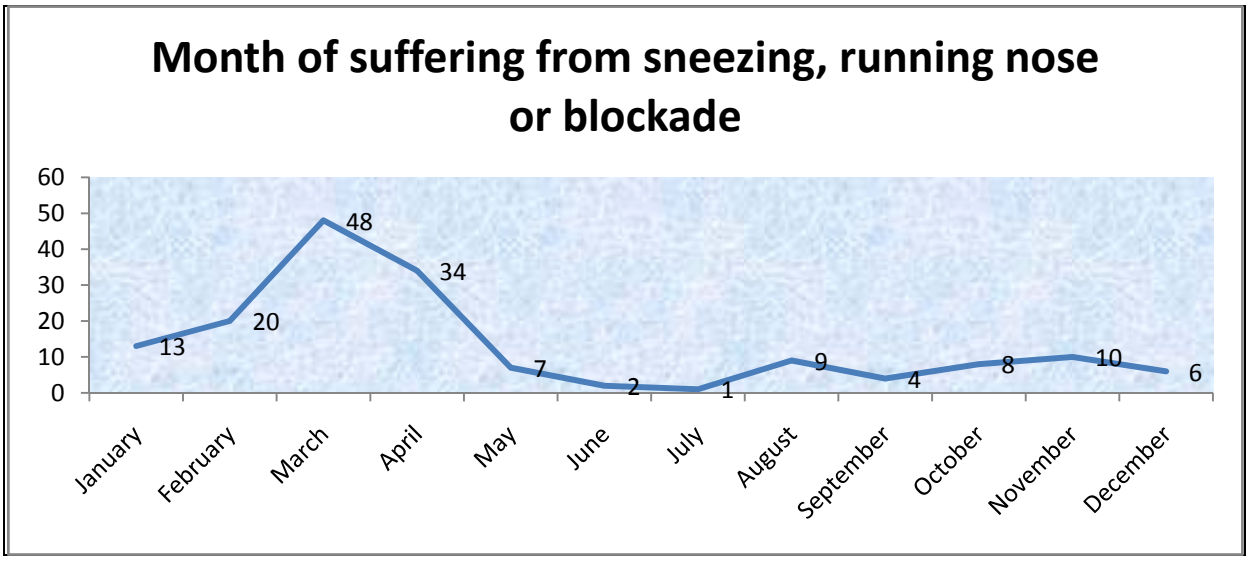

Figure 4 Month of suffering from respiratory symptoms when not suffered from cold or flu

The distribution of the respiratory problems during 12 months period has the peak in the months of March April. Out of the 162 children who had such respiratory problems in the last year nearly 30% had the problem in March followed by 21 % in the month of April.

Table 4 Month of suffering from sneezing, running nose or blockade

Months	Frequency	Percent
January	13	8.0
February	20	12.3
March	48	29.6
April	34	21.0
May	7	4.3
June	2	1.2
July	1	0.6
August	9	5.6
September	4	2.5
October	8	4.9
November	10	6.2
December	6	3.7
Total	162	100.0

Table 5 Non Respiratory (Allergic) Manifestations

Manifestations	Frequency	Percent
Allergic fever		
Yes	105	13.1
No	696	86.9
Eczema ever in Child		
Yes	167	20.8
No	634	79.2
Total	801	100.0

Regarding other manifestations besides respiratory symptoms such as allergic conditions 13 % of the children were found to suffer from allergic fever while 21% suffered with eczema.

Smoking and Solid Fuel Use

Information on smokers within the household as well as use of solid fuels for heating or cooking was collected and has been tabulated as below.

Table 6 Smoking and Solid Fuel Use

Characteristics	Frequency	Percent
Smokers among household members		
Yes	184	23.0
No	617	77.0
Total	801	100.0
Smokers smoking inside house		
Yes	106	57.6
No	78	42.4
Total	184	100.0
Use of solid fuel for heating or cooking		
Yes	55	6.9
No	746	93.1
Total	801	100.0

Among total respondents of 801, 23% mentioned that they had at least one smoker in their family and out of those 106 smokers among 57.6% of them were reported to smoke inside house. Regarding use of solid fuel 6.9% were found to use it for heating or cooking purpose.

3.1.3 Economic cost analysis

The economic burden as well as other impacts of respiratory problems was attempted to be calculated by analyzing the number of school days missed, office days missed as well as the cost incurred by the respondents in the treatment of their children for respiratory problems.

Table 7 Respiratory problems and loss to the children and parents

Any kind of respiratory problems faced in last year	**Frequency**	**Percent**
No	564	70.4
Yes	237	29.6
Total	801	100.0
Number of school days missed by child		
Not missed school	35	14.8
1 to 2	102	43.0
2 to 4	63	26.6
more than 4	37	15.6
Office missed by Guardian		
Yes	99	41.8
No	138	58.2
Total	237	100.0

Out of the total children, nearly 30% (237) were found to be suffered with one or the other kind of respiratory problems and had to visit the doctor/health facility. Due to the problems faced 43 % of the children missed school for 1 to 2 days followed by 27% children for 2 to 4 days and nearly 16% missed for more than 4 days. Similarly, 42 % of the children's guardian missed their office due to those problems in children and number of days missed were mostly 1 to 2 days.

Table 8 Expenditure in Nepali Rupees (NRs) for the respiratory problems of Children

Expenditure (NRs)	Frequency	Mean	Median	Std. Deviation	Minimum	Maximum
Money Spent for Medicines and Doctor	237	1966.456	1000	2669.806	100	20000
Money Spent on Traveling during the Visit	237	408.9451	200	525.2208	50	3000
Total money spent for respiratory problems	237	2375.401	1400	3063.814	150	23000

Out of the 237 children who had to visit the health facility/doctors for their respiratory problems it was found that they spent minimum NRs 100 to maximum NRs 20000 with mean expenditure of 1966 and median of 1000. Similarly, the median expenditure for traveling was 200 with mean value of 408 and minimum NRs 50 to maximum NRs 3000. Accordingly, total expenditure ranged from NRs 150 to 23000 with median of 1400 and mean of 2375.

3.2 Phase II: Health Impact Assessment

For the second phase of the study 117 children from St. Xaviers (urban roadside) and 20 children from Santaneshwor Vidya Mandir (rural) were taken. They were assessed for lung function with peak expiratory flow rate measurement and the findings of this component of study has been presented under various sections below. Statistical analysis was done using t test and Mann Whitney U test wherever applicable. To determine the statistical association, the confidence level was taken to be 95 % which is presented as 95% CI in the analysis. This indicates that 95 % of the data fall within the range that will appear while using the statistical test for each variable. Similarly, the level of significance would be 0.05. By this the interpretation would be in such a way that if the test value of particular variable is less than 0.05 then the relation or difference what we are looking for is statistically significant.

3.2.1 General characteristics of the Students

Demographic characteristics, anthropometry and other related information of the children from both the schools has been presented in this section. Mean values of age and the anthropometric measurements are compared between the schools. Interschool comparison of anthropometry has

been done only for St Xavier's as the number of students enrolled for the study in Santaneshwor Vidya Mandir is quite less and insufficient for the analysis.

Table 9 Age, sex and grade of the children, Impact Assessment

		St. Xaviers		Santaneshwor Vidya Mandir	
Variables	**Characteristics**	**Frequency**	**Percent**	**Frequency**	**Percent**
Age of the respondents in category	10 to 12 years	36	30.77	3	15
	13 to 15 years	81	69.23	17	85
Sex of the Students	Male	69	58.97	9	45
	Female	48	41.03	11	55
Class	VI	32	27.35	-	-
	VII	30	25.64	7	35
	VIII	30	25.64	5	25
	IX	25	21.37	8	40
Total		117	100.00	20	100

Out of the 117 children from St Xavier's 70 % of them fell into the age group 13 to 15 years and the rest in the age group 10 to 12 years. The male children were nearly 60 % and the class distribution was almost similar in the four classes that is class 6 to 9. In the other school, Santaneshwor Vidya Mandir, 85 % of the children were from age group 13 to 15 years and 55% were female. There was none from class 6 and 40% from class 9 followed by 35 and 25 % respectively from class 7 and class 8.

Table 10 Comparison of age and anthropometry of two schools

Variables of Interest	School	Mean	SD	t - value	P Value	MD	95% CI	
							Lower	Upper
Age of the Students	St. Xaviers	13.15	1.15	-1.12	0.26	-0.30	-0.84	0.23
	Santaneshwor	13.45	0.89					
Height of the respondents in cm	St. Xaviers	155.56	9.22	2.56	0.01	5.61	1.27	9.96
	Santaneshwor	149.95	8.11					
Weight of the respondents in kg	St. Xaviers	50.31	11.02	3.73	0.00	9.56	4.49	14.63
	Santaneshwor	40.75	7.50					

Mean age of the children of St Xavier's (Urban roadside – school I) is found to be 13.15 years and that of Santaneshwor Vidya Mandir (Semi urban residential– school II) is 13.45 years with a mean difference of 0.3. This difference is not significant statistically when the mean difference was tested by using independent samples t test and it gave the result with p value more than 0.05. Mean height of the children of school I is higher (155.56 cm) than that of the school II (149.95 cm) with mean difference of 5.61 which is statistically significant (95% CI 1.27 -9.96, p = 0.01). Similarly, the mean difference (9.56) of the weight of the children is also statistically significant with p value less than 0.05 and 95 % CI 4.49 – 14.63. The mean weight of the children of school I is 50.31 kg and that of school II is 40.75 kg.

Table 11 Comparison of anthropometry of St Xavier's among Male and Female children

Variables of Interest	Sex of the children	Mean	SD	t - value	P Value	MD	95% CI	
							Lower	Upper
Height of the respondents in cm	Male	157.51	10.25	2.81	0.01	4.74	1.40	8.07
	Female	152.77	6.66					
Weight of the respondents in kg	Male	51.55	11.38	1.47	0.14	3.03	-1.05	7.11
	Female	48.52	10.34					

The mean height and weight among the male and female children were analyzed separately for school I which shows that there is significant difference in the mean height of the children between male (157.51 cm) and female (152.77 cm) with mean difference 4.74. This difference is statistically significant with 95 % CI (1.4 – 8.07), p = 0.01. However, the difference in the mean weight was not statistically significant among male (51.55 kg) and female (48.52 kg) children, though it appeared to be higher among the male children.

3.2.2 Particulate matter and PEFR

Measurement of PEFR was planned for 42 days initially during the project conceptualization phase and data of particulate matter was planned to be collected from the air quality monitoring stations (AQMS). However, due to the nonfunctioning of all the AQMS that are located at 6 points in Kathmandu valley PM data was collected using Dusttrak. The period of collection of PM and PEFR data was from 25 January 2012 to 06 March 2012 with a total span of 6 weeks. However, the actual number of days of observation of PEFR was 31 days. These data from both the schools are thus taken into consideration for showing the correlation with the changes in the PEFR of children of the same date.

Mean PM 2.5 (µg/m^3) of two schools

School	Number of Observations	Minimum	Maximum	Mean	Std. Deviation
St Xavier's	31	101.83	337.25	200.01	54.39
Santaneshwor Vidya Mandir	31	76.34	230.63	123.35	32.75

The concentration of PM 2.5 in St. Xavier's (Urban roadside school) varied between 101.83 to 337.25 µg/m^3 with a mean value of 200.01 and SD 54.39. On the other hand for the semi urban school Santaneshwor Vidya Mandir it was slightly on the lower side. The mean concentration was found to be 123.35 with SD 32.75 and values ranging between 76.34 to 230.63 µg/m^3.

Comparing the mean PM 2.5

School	Mean Rank	Mann-Whitney U	P Value
St Xaviers	43.65	104	0.0000
Santaneshwor Vidya Mandir	19.35		

To test the mean difference of PM 2.5 between these two schools Mann-Whitney U test was used as the daily data was not found to follow the normal distribution which shows that the difference is statistically significant with the value of 104 and p value less than 0.05.

Comparing mean PEFR (L/min) of two schools

Name of the school	N	Mini mum	Maxi Mum	Mean	SD	t-value	P value	MD	95% CI	
									Lower	Upper
St. Xaviers	31	357.26	451.54	409.24	28.90	7.88	0.000	50.23	37.47	62.99
Santaneshwor Vidya Mandir	31	314.00	388.00	359.02	20.62					

The above table compares the mean difference of the PEFR among children of two schools. It shows that the mean PEFR is higher for St. Xavier's school and the difference is statistically significant with 95% CI (37.47– 62.99) & p value less than 0.05. The average PEFR of the children ranged from 357.26 to 451.54 L/min for St. Xavier's whereas it ranged from 314 to 388 L/min for Santaneswhor Vidya Mandir.

Comparing mean PEFR of St Xavier's school as per sex and age group

Variables		N	Mean	SD	t- value	P value	Mean Difference	95% CI	
								Lower	Upper
Sex	Male	31	407.69	33.67	.899	.372	7.032	-8.61	22.67
	Female	31	400.66	27.59					
Age group	10 to 12 years	31	379.67	48.85	-3.769	0.0000	-36.31	-55.58	-17.04
	13 to 15 years	31	415.98	22.15					

The PEFR was again analyzed separately for male and female children as well as higher and lower age groups for St. Xavier's school. It was found that there is significant difference in the mean PEFR level between the two age groups (95% CI 10.52- 80.36, p=0.01). The average value is 415.98 for older age groups (13 to 15 years) and 379.67 for younger age groups (10-12 years). On the other hand, the difference of mean PEFR levels between the two sexes is visible with the PEFR level being 407.69 and 400.66 respectively for male and female children. However, the difference is not significant statistically (p = 0.372).

3.2.3 Correlation of PM 2.5 and PEFR

The relation between PM 2.5 and PEFR were analyzed using graphical plots for the two schools separately. Apart from this for St. Xavier's the relation between PM 2.5 and PEFR was attempted to be shown separately for older and younger age groups as well as for male and female children. However, to calculate the regression of these two variables the data was not found to be linear. The attempt to convert the data into linear by log conversion, quadratic conversion, exponential conversion, cubic conversion etc was not successful.

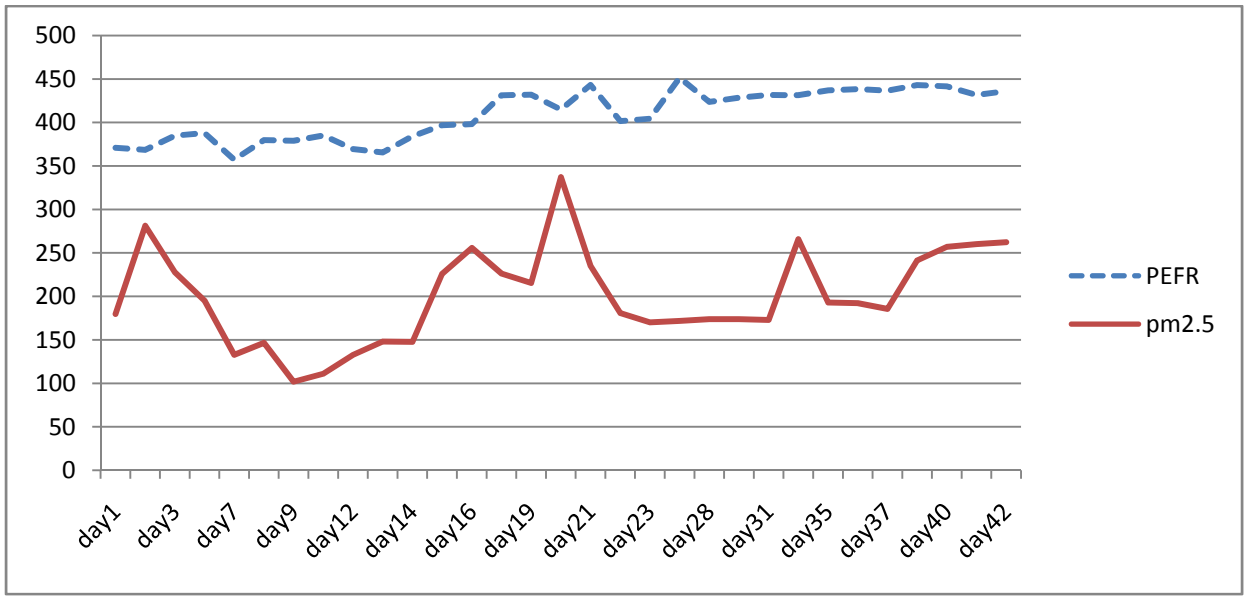

Figure 5 Correlation of PEFR and PM 2.5 for St. Xavier's (Urban roadside school)

The PM concentration is seen to be varying daily between the values of 100 µg/m^3 and nearly 340 µg/m^3. However, with the changes in PM there does not seem to be much fluctuation in the average PEFR of the students. There are days in between where the daily PEFR is falling with the rise in the PM 2.5 concentration for instance in day 20 and there is rise in PEFR concentration with the fall in PM concentration around day 28. In other days it seem to be not changing with the daily change in PM. This shows that there could be other factors besides PM as an important factor to have affected the lung function.

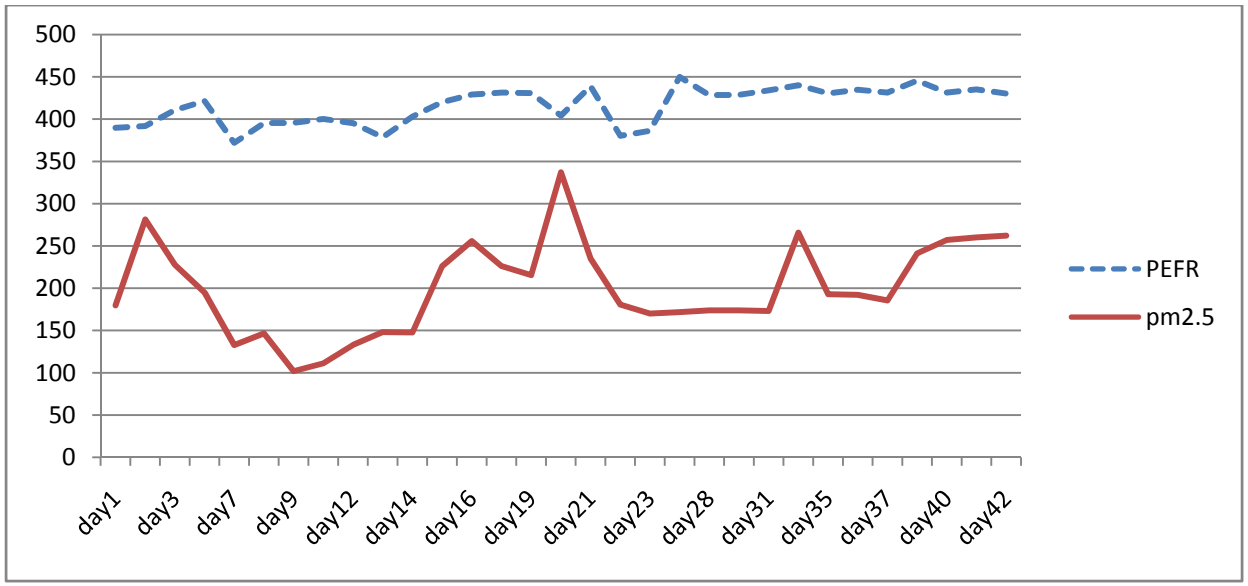

Figure 6 Correlation of PEFR of 13 to 15 years old children and PM 2.5 for St. Xavier's

The above graph depicts the relation of PEFR with daily averages of PM 2.5. The PEFR of older age group (13 to 15 years) children appears to be varying slightly with the changes in PM 2.5 concentrations. In the period of day 19 to day 21 the increasing trend of PM 2.5 is matching with decreasing trend in PEFR concentrations. In the days 28 and 29 the daily PEFR is seen to be increasing when the PM level is maintained in low levels. Otherwise, the older children's PEFR seems to be not affected by daily changes in PM 2.5 concentrations.

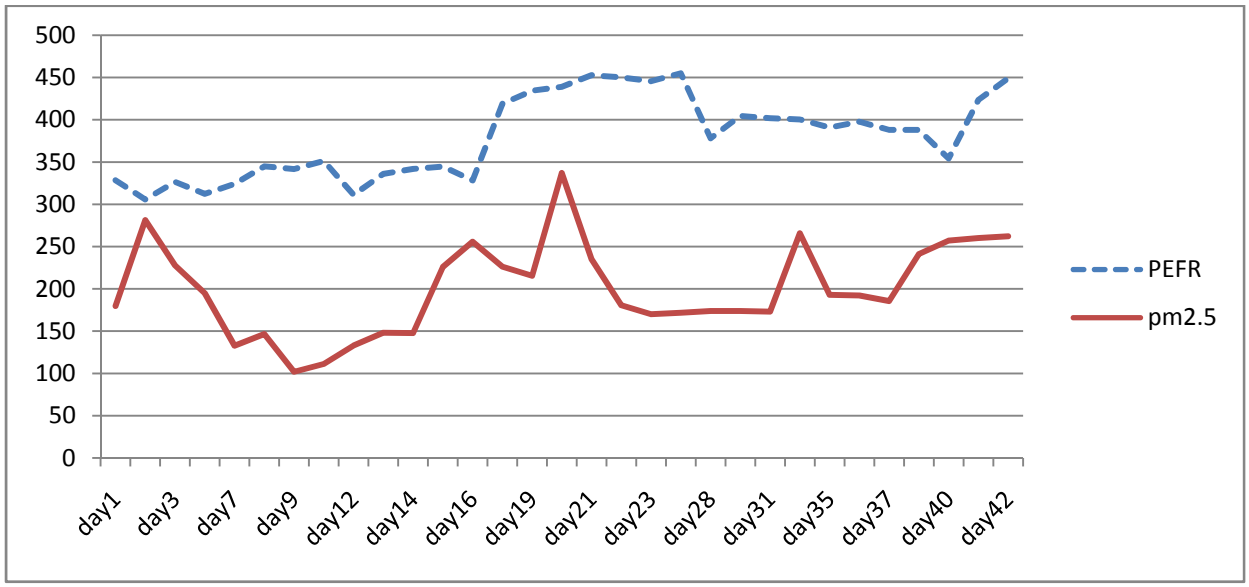

Figure 7 Correlation of PEFR of 10 to 12 years old children and PM 2.5 for St. Xavier's

When the PEFR of younger children is plotted separately in the above figure it shows that in the initial days and later days of the assessment there has been a correlation. The PEFR level seems to be decreasing when the PM level is increasing in the initial days and again around 16. The daily PEFR level is decreasing around day 40 when the PM concentration is in the increasing trend.

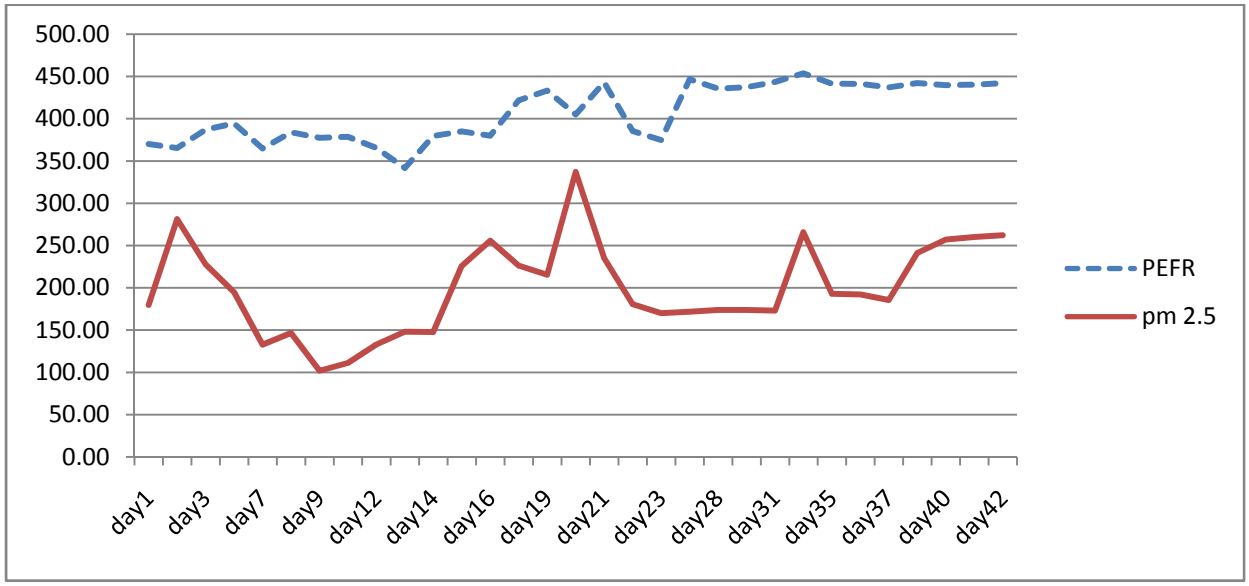

Figure 8 Correlation of PEFR of male children and PM 2.5 for St. Xavier's

The above graph shows the correlation of daily PM 2.5 and PEFR of male children of St. Xavier's school. The PEFR levels seem to be slightly decreasing when the PM concentration is on the rise around day 20. Otherwise there seem to be not much of correlation between the daily variation in PM and PEFR levels.

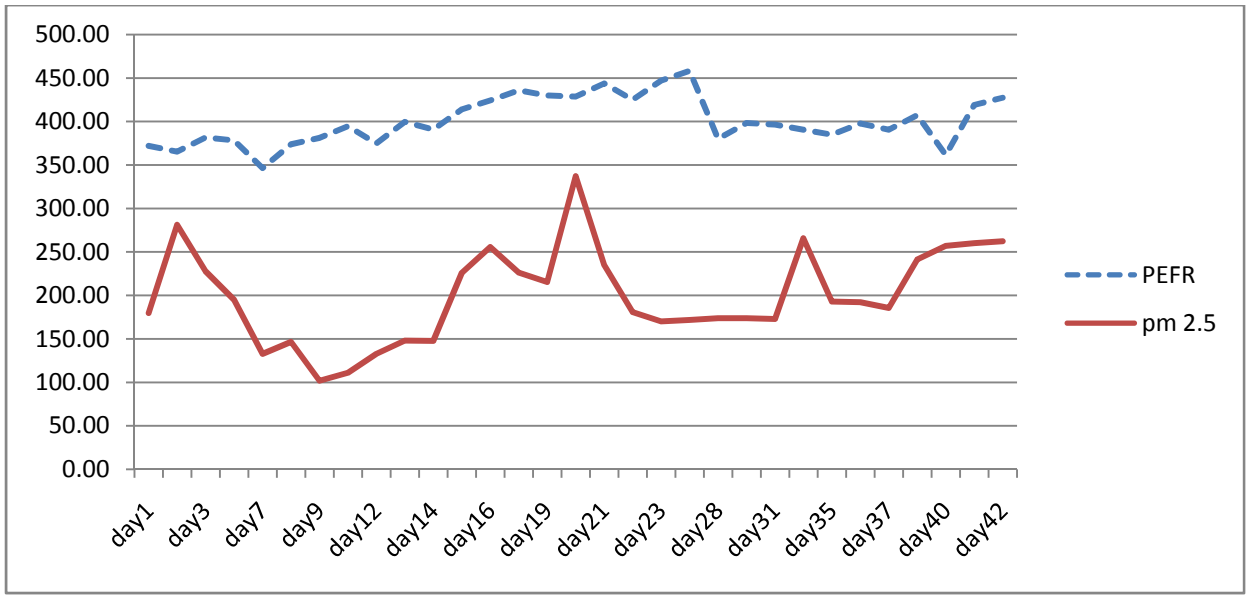

Figure 9 Correlation of PEFR of female children and PM 2.5 for St. Xavier's

The daily PEFR levels and PM 2.5 concentrations were separately plotted for female children. This shows that there is little variation in the PEFR levels in line with the variation in daily PM concentrations. The change in PEFR level is related with the change in PM 2.5 levels in most of the days. Around day 23 to 28 there is rise in the daily PEFR levels when the PM level is maintained in the lower side. In comparison to the plots of male children, the plots of female children show certain level of inverse relationship between PM concentrations and PEFR levels that is the PEFR is increasing on the days PM is maintained in the low levels. This association between PEFR and PM could be associated with relatively poorer physical built of the female children. However, this needs to be investigated further as this study has not looked into the details.

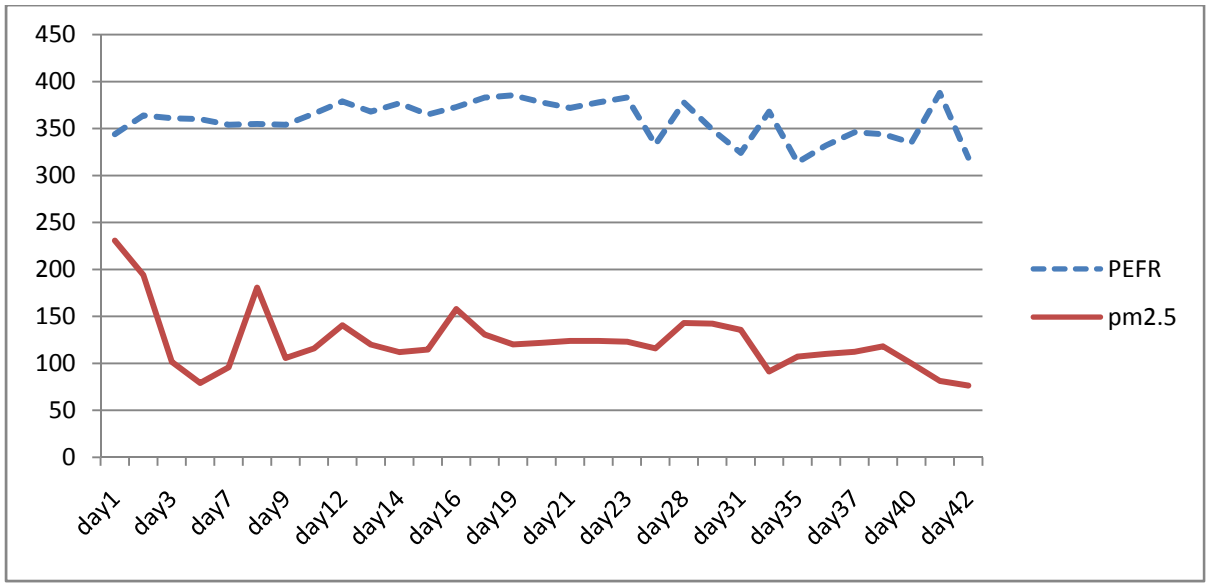

Figure 10 Correlation of PEFR and PM 2.5 for Santaneshwor Vidya Mandir (Semi urban – residential)

The daily PEFR levels of 20 students taken from the semi urban school was plotted with the daily PM 2.5 concentrations. The figure above shows that the PM concentration is overall in the lower side as seen in the urban school earlier. The change in PEFR levels is matching the change in PM concentration in the later days. Around day 27 and day 32 the PEFR level is decreasing when the PM concentration is increasing. In the earlier days the PEFR levels do not seem to be varying much with the varying levels of PM concentrations.

Chapter IV: Discussion

The health effects of air pollution have been a subject of intense study in the recent years. Exposure to urban environment, especially pollutants such as airborne particulate matters have been associated with the increase in respiratory diseases. The major sources of pollutants identified worldwide have been vehicular emission and it is known to create large quantities of particulate matters.

Vehicular emission has been a major problem for urbanized cities of Nepal (12). A report from the transport authority has shown significant rise in the number of vehicles and hence air quality in major cities of Nepal has been deteriorating over the years (6). The goal of the current study was to explore the health impact of air pollution and understand the relationship between changes in lungs functions (PEFR) in children with varying concentration of particulate matter in air ($PM_{2.5}$). This study was carried out in two stages, a base line study carried out in seven schools and health impact assessment carried out in two schools. For the health impact assessment the lung function (PEFR) of students was measured for 31 days within the span of 42 days where 9 days were missed due to public holidays and other disturbances such as strike. Along with that 24 hour average of air quality ($PM_{2.5}$) data has been taken for the analysis purpose with respect to health impact of air pollution. The daily average PEFR, mean age, mean height and weight of the children was calculated separately for each school and compared. Similarly, these variables were also calculated again separately for male and female children as well as younger (10-12 years) and older (13-15 years) children of St. Xavier's school. The correlation of particulate matter (daily average of $PM_{2.5}$) and lung function (daily average of PEFR) has been depicted by plotting them graphically. Some limitations mentioned earlier and confounding variables might have played certain role in the findings of this study.

Mean age of the children in the two schools taken for the health impact assessment appears to be almost similar with just a difference of 0.3. This difference is not significant statistically when the mean difference was tested by using independent samples t test and it gave the result with p value more than 0.05. The group of students hence is comparable in terms of age groups. In the school selected from urban roadside (School I), the mean height and weight among the male and female children have been analyzed and it shows that there is significant difference in the mean weight of the children with mean difference 4.74, which is statistically significant ($p = 0.01$).

However, the difference in the mean weight is not statistically significant among male and female children, though it is appeared to be higher among the male children. A similar study carried out in Bangladesh shows that there was no significant differences between the two groups of children (asthmatic and non-asthmatic) taken for the study in terms of socio demographic characteristics and anthropometric measurements (13). In this study the students were not categorized as per the disease status, however, the children from two different schools were homogenous in terms of socio demographic variables.

The concentration of $PM_{2.5}$ in school I (urban roadside school) varied between 101.83 to 337.25 $\mu g/m^3$ with a mean value of 200.01 (±54.39). On the other hand for the school II (semi urban school) it has been recorded slightly lower. The mean concentration has been found to be 123.35 (± 32.75) and values ranging between 76.34 to 230.63 $\mu g/m^3$. And the mean difference of $PM_{2.5}$ between these two schools is statistically significant ($p< 0.05$). This may be the effect of urbanization around school I in comparison to School II where the vehicular movement as well as population residing in the area is quite low. PM 2.5 data is only measured on ad hoc basis hence there is no any national data available for this parameter. Measurement of PM_{10} data is available from 2003 to 2007. Due to technical problem this was halted which will be revived soon in the coming days according to the MOEST officials. The revised National Ambient Air Quality Standard (NAAQS), 2012 has included $PM_{2.5}$ as an additional parameter and the standard for it has been set as 40 $\mu g/m^3$. It has been proposed that $PM_{2.5}$ also will be measured through these stations once they are revived. An ambient air quality measurement study conducted by NHRC considering annual average concentration of PM_{10} from 2003 to 2007 in those six different stations of Kathmandu Valley had shown that the PM_{10} concentration is higher than the national standard of 120 $\mu g/m^3$(7). The $PM_{2.5}$ concentration in this study of the urban roadside school is seen to be varying daily between 100 $\mu g/m^3$ and nearly 340 $\mu g/m^3$ which exceed the national standard of $PM_{2.5}$ concentration (40 $\mu g/m^3$) according to NAAQS 2012 (Nepal Gazette 2012) in all the days out of the 31 days measured. When compared with the national standard of $PM_{2.5}$ of Bangladesh (65 $\mu g/m^3$) [13] and that of India (60 $\mu g/m^3$) [14] the $PM_{2.5}$ concentration is found to be quite high throughout the measurement period. In another study conducted in Bangladesh, the 24 hour mean PM10 concentration level on the days of data collection ranged from 38 to 385 $\mu g/m^3$ with a mean value of 119.12(+_70.26) $\mu g/m^3$. The 24 hour mean $PM_{2.5}$ on the other hand ranged from 18 to 233 $\mu g/m^3$ with a mean value of 67.57 (±47.82) $\mu g/m^3$(13).

The mean PEFR is higher for St. Xavier's school (School I- Urban roadside) compared to Santaneswhor Vidya Mandir (School II – Semi urban) and the difference of 50.23 is statistically significant with 95% CI (37.47– 62.99) & p value less than 0.05. The average PEFR of the children ranged from 357.26 to 451.54 L/min for St. Xavier's whereas it ranged from 314 to 388 L/min for Santaneswhor Vidya Mandir. This difference in the average PEFR between two schools may be due to varying anthropometric measurements rather than the varying $PM_{2.5}$ levels in the surrounding. The average height and weight of the students of school 2 is significantly lower than the school 1 with mean difference of 5.61 and 9.56 respectively for height and weight.

However when we look into the PEFR of urban roadside school between two age groups the average PEFR of older students (13-15 years) is quite higher when compared to younger age groups (10 -12 years). The mean difference of 36.31 is statistically significant as well with p value less than 0.05. On the other hand, the average PEFR of male and female students is only slightly different. The mean difference is 7.032 with the average value being higher for males, however without any statistical significance. This difference in the average PEFR of male and female as well as younger and older children shows that the lung function of the children varies specially with the age category.

Average PEFR levels of all the students of urban roadside school were plotted along with the daily average $PM_{2.5}$ concentrations. The $PM_{2.5}$ concentration is found to be varying between the values of 100 $\mu g/m^3$ and nearly 340 $\mu g/m^3$. However, with the changes in PM there does not seem to be much fluctuation in the average PEFR of the students. There are few days in between where the daily PEFR is falling with the rise in the $PM_{2.5}$ concentration there is rise in PEFR concentration with the fall in $PM_{2.5}$ concentration in few other days. This shows that there is an inverse relationship between the daily $PM_{2.5}$ concentrations and PEFR of school children. However in some other days it seem to be not changing with the daily change in PM. Hence in the other side this shows that there could be other factors besides PM as an important factor to have affected the lung function. A study has shown the effects of daily variations in particles of size PM 10 and black smoke (BS) on peak expiratory flow (PEF) during a 57 day follow-up of 39 asthmatic children. The study shows a statistically significant association of PM 10 and BS with the declines in PEF. However, the case is not similar with the ultrafine particles except PM 10 and BS which does not show a strong association with variation in PEF (15). The findings of

study usually depend on various cofounding variables and study limitation such as study duration, measurement procedures. In this particular study there are factors which were not measured such as household environment except use of solid fuel and indoor smokers. Exposure level to the pollutants around the school only was the variable considered. There may be the possibility of children being fully protected from the pollutants when not in the school. A study conducted to assess the association between daily changes in respiratory health and respirable particulate pollution (PM10) in Utah among fifth and sixth grade students showed relatively small but statistically significant ($p<0.01$) negative associations between PEFR and PM10 among both symptomatic and asymptomatic children. This association was however, stronger among the symptomatic children. The study concluded that both symptomatic and asymptomatic children may suffer acute health effects of respirable particulate pollution, with symptomatic children suffering the most (16).

The PEFR of older age group (13 to 15 years) children appears to be varying slightly with the changes in $PM_{2.5}$ concentrations. In the period of day 19 to day 21 the increasing trend of $PM_{2.5}$ is matching with decreasing trend in PEFR concentrations. In the days 28 and 29 the daily PEFR is seen to be increasing when the $PM_{2.5}$ level is maintained in low levels. Otherwise, the older children's PEFR seems to be not affected by daily changes in $PM_{2.5}$ concentrations. This could be because of other factors such as nutritional status of the children including anthropometry that the lung function has not been affected by changes in the PM levels. The findings of the current study have not shown a strong correlation between dependent and independent variables among this age group of children that may be due to other environmental factors as well as physiological features. The PEFR level of younger children seems to be decreasing when the PM level is increasing in the initial days and again later during the middle period as well as later days of the measurement. A study to measure the short term effects of air pollution on respiratory morbidity among asthmatic children from Sokolov, Czech Republic, shows the following findings. The elevated levels of air pollution was found to be associated with decreased peak expiratory flow rates, increased respiratory symptoms, increased prevalence of school absence and fever, and increased medication use (17).

There is little variation in the PEFR levels in line with the variation in daily PM concentrations among female and male children. The change in PEFR level is related with the change in $PM_{2.5}$ levels in most of the days. With comparison to the plots of male children, the plots of female

children show certain level of inverse relationship between PM concentrations and PEFR levels that is the PEFR is increasing on the days PM is maintained in the low levels. This association between PEFR and PM could be related with relatively poorer physical built of the female children. However, this needs to be investigated further as this study has not looked into the details. A study conducted to monitor changes in personal PM exposures and PEFR simultaneously for the subjects between December 2003 and February 2005 in Taipei county, Taiwan has shown the association between PM and lung function. The finding of the study reveals that exposure to particulate matter is more strongly associated with the changes in lung function (PEFR). The particulate matters PM10 and PM 2.5 have been the primary indicators of pollution and known causative factors for adverse respiratory function (18). With respect to the interpretation of our results, several limitations could be considered. Even not depicted here, analysis was done whether the effects of particulate pollutants (PM) on the lung function (PEFR) was modified by temperature, rainfall and relative humidity. The analysis could not show statistically significant regression analysis due to the non linearity of the data in the study. Apart from this there could be several other factors in the study which requires a longitudinal study. Also a regular quality data of the pollutants from the monitoring stations would be important. Besides the continuous data of PM the concentrations of various other pollutants also could be achieved and tried to be controlled during the analysis to identify the impact of particulate air pollutants.

Chapter V: Conclusion and Recommendations

4.1 Conclusion

This study had two components in total. The first one being a baseline survey conducted in 7 different schools of Kathmandu valley taking 1184 students. The second one was conducted in two of those schools among selected students.

Among 801 participants in the study, nearly 30% (235) were reported to have respiratory symptoms such as sneezing, running nose or nasal blockade even when they did not have common cold or flu. Out of which just above 69 % of them had such symptoms in last 12 months and 23 % of them had difficulty or hamper in studies and activities like playing. The distribution of the respiratory problems during 12 months period shows the peak in the months of March April with 30% and 21% of the children suffering in the months of March and April respectively. Among the total respondents, 23% of them had at least one smoker in their family and out of those 57.6% of them smoked inside house. Out of the total children, nearly 30% (237) were found to be suffered with one or the other kind of respiratory problems and had to visit the doctor/health facility. Due to the problems faced 43 % of the children missed school for 1 to 2 days and 42 % of the children's guardian missed their office due to those problems in children and number of days missed were mostly 1 to 2 days. For this problem the median expenditure for health facility/doctor was NRs 1000 and for traveling was NRs 200 with the total median expenditure of NRs 1400.

Two schools were taken for the health impact assessment, school I from the urban roadside (St Xavier's) and school II from the semi-urban residential (Santansehwor Vidya Mandir).

Mean PM 2.5 concentration was 200.01 and 123.35 $\mu g/m^3$ for school I and school II respectively. And the difference was statistically significant with p value less than 0.05 (Mann-Whitney U test). The mean PEFR is higher for school I (409.24) than school II (359.02) and the difference is statistically significant with 95% CI (37.47– 62.99) & p value less than 0.05. There is significant difference in the mean PEFR level between the two age groups (95% CI 10.52- 80.36, p=0.01) of school I with the mean of 415.98 for older age groups and 379.67 for younger age groups.

The changes in PM of school I do not seem to have been associated with the fluctuation in the average PEFR of the total students except for some days in between where we could see an

inverse relationship between PM concentration and PEFR levels. However, when the relation was plotted separately for older age (13 to 15 years) children the PEFR appears to be varying slightly with the changes in PM 2.5 concentrations. There are days when the increasing trend of PM 2.5 is matching with decreasing trend in PEFR concentrations as well as days when the daily PEFR is seen to be increasing when the PM level is at low levels. Similarly in the case of younger children in the initial days and later days of the assessment there has been an inverse relationship between PM Concentrations and PEFR levels. The PEFR level seems to be decreasing when the PM level is increasing in the initial days and again around day 16. The daily PEFR level is decreasing around day 40 when the PM concentration is in the increasing trend. Compared to the plots of older children, the plot of younger children shows inverse relationship between PM concentration and PEFR levels in higher number of occasions. On the other side, there is little variation in the PEFR levels in line with the variation in daily PM concentrations for female children of school I. In comparison to the plots of male children, the plots of female children show certain level of inverse relationship that is the PEFR is increasing on the days PM concentration is maintained at the low levels.

In case of school II, the change in PEFR levels is matching with the change in PM concentration in the later days. Around day 27 and day 32 the PEFR level is decreasing when the PM concentration is increasing.

The greater proportion of children (30%) having been suffered from respiratory symptoms such as sneezing and running nose when not having common cold or flu shows that the atmospheric pollutants particularly the fine particles such as $PM_{2.5}$ has a huge role in the respiratory manifestations. The mean $PM_{2.5}$ concentration is quite high in both the schools; urban road side - school I (200.01 $\mu g/m^3$) and semi urban residential - school II (123.35 $\mu g/m^3$). This value is quite higher than that of national standard of Nepal (40 $\mu g/m^3$) as well as that of Bangladesh (65 $\mu g/m^3$) and India (60 $\mu g/m^3$). In Nepal $PM_{2.5}$ is however only measured on ad hoc basis and has been included as one of the parameters recently in 2012 by the Ministry of Environment, Science and Technology. Even though a strong correlation has not been seen in this study, the high level of $PM_{2.5}$ definitely could have greater impact on health status of people especially children. The impact of $PM_{2.5}$ in this study was measured in terms of daily variation in PEFR levels and it shows an inverse relationship between PM concentrations and PEFR levels in some of the days. The younger children and female children have been found to be affected more than the older

children and male children respectively as seen by the differences in the plots of these four groups. This indicates that age and sex could be the factor that plays an important role in the manifestation of impacts of pollutants in the atmosphere. The effects of PM on the lung function (PEFR) could have been modified by temperature, rainfall & relative humidity. However, this could not be statistically justified in this study.

In an overall impression, it shows that the impact is more pronounced in the younger age groups and female children. Hence, the intervention needs to be focused to protect the most vulnerable groups from the increasing pollutants. The cross sectional component of this study conducted in the larger group as a baseline study before the impact assessment study hints that the burden of fine particles on the respiratory health could be huge and thus requires further investigation.

4.2 Recommendations

- Air pollution control measures should be considered with prime importance.
- Development of green belt around the school should be promoted.
- School environment maintenance in terms of reducing respirable particulate matter should be focused.
- Awareness raising among the parents/guardians should be promoted to reduce the indoor pollutants (such as indoor smoking) at home.
- Air quality monitoring stations should be revived as soon as possible and regular monitoring of air pollutants should be ensured.
- Establishing the causal relationship of respiratory problems among children should be one of the key research areas in environmental health research.
- Large scale longitudinal studies need to be carried out to determine the health impact of pollutants in children as well as other population.
- The effects of other pollutants in the air need consideration for research.
- The formulation and implementation of Clean Air Act as a comprehensive approach to combat the threat of air pollution is necessary.
- Investment on long-term research on health impacts of air pollution is must.
- There is a need of inter-sectoral coordination among the Ministries and Departments to mitigate health impacts of air pollution in Nepal.

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Annexes

Annex 1: Baseline Study Questionnaire (English)

Title: **Assessment of Impacts of Particulate Air Pollutants on Respiratory Health of School Children in Kathmandu Valley**

Nepal Health Research Council and ICIMOD are jointly conducting a study of impacts of air pollution on school children in selected schools. This will help to design measures to protect the health of both adults and children. The following information is necessary about the health of your child. Your cooperation in providing this information will help us to protect school children in our city. All the information will be used for research purpose only and will be kept confidential. After receiving this information we will conduct a medical examination by a pediatrician in selected children and test their lung function by using an individual equipment to measure Peak Expiratory Flow Rate. We request you to kindly co-operate us in seeking the following information and also allow us to examine your child for his/her physical/respiratory health and assess their lung function if selected after the baseline survey. We thank you for your kind assistance and cooperation.

ID No. Date:

General information

1. Date:
2. Name of school:
3. Name of child:
4. Grade:
5. Parent/Guardian's name:
6. Parent's educational level:
7. Age of the child (in complete years):
8. Date of birth:
9. Gender: Male ☐ Female ☐
10. Religion:

Section A

Information related to asthma and respiratory health

1.1 Did your child ever experienced asthma-like or a whistling sound in the chest?

a. Yes b. No If No go to question 6

1.2 In past 12 months did your child ever experience asthma-like or whistling sound in the chest?

a. Yes b. No If No go to question 6

1.3 Frequency of asthma-like or whistling sound in the chest in the last 12 months?

a. None b.1-3 times c.4-12 times d. More than 12 times

1.4 In past 12 months, did asthma-like symptoms or respiratory symptoms cause sleep disturbances?

a. Never b. Once a week c. More than once a week

1.5 In last 12 months did an asthma-like or whistling sound hamper the child's speech while breathing?

a. Yes b. No

1.6 Did your child ever experience asthma or wheeze?

a. Yes b. No

1.7 Did your child ever experienced asthma or wheeze during exercise or playing in the last 12 months?

a. Yes b. No

1.8 Did your child suffer from cold or dry cough at night in the last 12 months?

a.Yes b.No

Section B

Information regarding problems that occur when children did not have a cold or flu

2.1 Did your child ever suffer from sneezing, running nose or nasal blockade when he/she did not have a cold or flu?

a. Yes b. No If No go to question 6

2.2 In past 12 months, did your child suffer from sneezing, running nose or nasal blockage when she/he did not have a cold or flu?

a. Yes b. No If No go to question 6

2.3 In the last one year did the child have eye itching or watering along with nasal ailments?

a. Yes b. No If No go to question 6

2.4 In which month did you experienced the problem?

January	February	March	April	May	June
July	August	September	October	November	December

2.5 Did the nasal problem of your child cause difficulty or hamper on his/her study and play in the last year?

a. Yes b. No

2.6 Did your child ever suffer from hay fever (allergic fever)?

a. Yes b. No

2.7 Did your child ever suffer from Urticaria that lasted three to six months?

a. Yes b. No If No go to question 13

2.8 Was the rash also present in other parts of the body like front of the elbow, back of the knee, back of the ankle, around the neck or beneath the ear or eye?

a. Yes b. No

2.9 Did the rash rapidly disappear?

a. Yes b. No

2.10 Did the rash cause sleep disturbances in last one year?

a. Never b. Less than once a week c. More than once a week

2.11 Did your child ever suffer from eczema?

a. Yes b. No

2.12 Do any members of your household smoke?

a. Yes b. No

2.13 If any member of your household is a smoker, does he/she smoke indoors?

a. Yes b. No

2.14 Do you use solid fuel (e.g. wood, dung, coal etc) for heating or cooking within the home?

a. Yes b. No

Section C

Information related to patient expenses and economy related

3.1 How many times did your child suffer from any kind of respiratory problems in past 12 months?

a. 1-2 times b.2-4 times c. More than 4 times

3.2 How much money did you spend in the hospital/doctors fee (in NRS)

……..

3.3 How much money did you spend in transportation while visiting the hospital/doctor?

……

3.4 How many schools days were missed due to such problems faced by child?

a. Not missed b. 1-2 days c.2-4 days d. More than 4 days

3.5 Did you miss your office days due to such problems of your child related to respiratory diseases?

a. Yes b. No

3.6 If yes how many days were missed?

……

Annex 2: Baseline Study Questionnaire (Nepali)

Title: **"Assessment of Impacts of Particulate Air Pollutants on Respiratory Health of School Children in Kathmandu Valley"**

आदरणीय अभिभावक ज्यू,

नेपाल स्वास्थ्य अनुसन्धान परिषद्ले ICIMOD Nepal सँगको सहकार्यमा वातावरण प्रदूषणले वच्चाको श्वासप्रश्वास प्रणालीमा पार्ने असर सम्बन्धी अनुसन्धान कार्य गर्दैछ । विभिन्न अध्ययनले देखाए अनुसार वायु प्रदूषणले विशेष गरि शहरी क्षेत्रमा रहने व्यक्तिहरुको स्वास्थ्यमा समस्या देखाउने भेटिन्छ र त्यसमा विशेष गरि कम उमेरका बच्चाको श्वासप्रश्वास स्वास्थ्यमा यसको असर देखिने हुन्छ । तल उल्लेखित प्रश्नहरु तपाँईले आफ्नो स्वयच्छाले अप्ठेरो नमानिकन भरी दिनु भएमा हामी आभारी हुनेछौ । हामीलाई तपाँईहरुले दिने सूचना निकै महत्वपूर्ण हुनेछ ।

मिति :

साधारण जानकारी

१. मिति:

२. स्कूलको नाम:

३. कक्षा:

४. वच्चाको नाम:

५. अभिभावकको नाम:

६. अभिभावकको शैक्षिक योग्यता:

७. वच्चाको उमेर:

८. जन्ममिति:

९. लिङ्ग : महिला ☐ पुरुष ☐

१०. धर्म:

खण्ड "क"

दम र श्वासप्रश्वास स्वास्थ्य सम्बन्धी प्रश्नावलीहरु

१ तापाँईले कहिल्यै आफ्नो बच्चामा दम जस्तो भएको अथवा सुसेलेको जस्तो थाहा पाउनु भएको छ ?

(अ) छ (आ) छैन

२ यो गत १२ महिना यता तपाँईले कहिल्यै आफ्नो बच्चामा दम जस्तो भएको अथवा सुसेलेको जस्तो थाहा पाउनु भएको छ ?

(अ) छ (आ) छैन

३ गत १२ महिनायता कति पटक जति दम जस्तो वा सुसेलेको आवाज थाहा पाउनु भएको छ ?

(अ) थाहा पाइन (आ) १-३ पटक (इ) ४-१२ पटक (ई) १२ भन्दा माथि

४ विगत १२ महिनायता दम र अरु श्वासप्रश्वास समस्याको कारणले वच्चाको निद्रामा असर परेको थिया ? (थिएन भने प्र.नं. ६ मा जाने)

(क) थिएन (ख) थियो

५ थियो भने कति दिन ?

(क) एक हप्ता (ख) एक हप्ता भन्दा बढी (ग) एक-दुई दिन

६ गत १२ महिनायता दम वा सुसेलेको जस्तो अवस्थाले सास फेर्ने क्रममा बच्चाको वोलिमा असर परेको थिया ?

(क) थियो (ख) थिएन

७ तपाँईको वच्चालाई कहिल्यै दम भएको थियो ?

(क) थियो (ख) थिएन

८ गत १२ महिनायता तपाँईको वच्चालाई खेल्दा, व्यायाम गर्दा कहिल्यै दम वा छाती घ्यार घ्यार जस्तो भएको थियो ?

(क) थियो (ख) थिएन

९ गत १२ महिनायता तपाँईको वच्चा रातीमा रुघा वा सुख्खा खोकीबाट विरामी परेको थियो ?

(क) थियो (ख) थिएन

खण्ड "ख"

<u>तलका उल्लेखित प्रश्नहरु वच्चाको समस्याको विषयमा छ जव उसलाई कुनै रुघाखोकी थिएन</u>

१० वच्चालाई रुघाखोकी नभएको वेला कहिल्यै हाँछ्यू आउने, सिंगान बगाउने र नाक बन्द हुने हुन्थ्यौ ?

(क) हुन्थ्यो (ख) हुँदैनथ्यो (यदि हुँदैनथ्यो भने प्रश्न नं. १५ मा जाने)

११ गत १२ महिनायता वच्चालाई रुघा खोकी नलागेको वेला उसलाई हाछ्यूँ आउने, नाक बाट पानी वग्ने अथवा नाक बन्द हुने हुन्थ्यो ?

(क) हुन्थ्यो (ख) हुँदैनथ्यो

१२ विगत १२ महिनामा तपाँईको वच्चालाई नाकको समस्या सँगै आँखा रसाउने, चिलाउने र पानी वग्ने समस्या आएको थियो ?

(क) थियो (ख) थिएन (यदि थिएन भने प्रश्न नं. १५ मा जाने)

१३ कुन महिनामा यस्तो समस्या देखिएको हो ?

पुष माघ ☐

माघ फागुन ☐

फागुन चैत्र ☐

चैत्र वैशाख ☐

वैशाख जेष्ठ ☐

जेष्ठ असार ☐

असार श्रावण ☐

श्रावण भाद्र ☐

भाद्र असोज ☐

असोज कार्तिक ☐

कार्तिक मंसिर ☐

मंसिर पुष ☐

१४ नाकको समस्याले वच्चालाई पढ्न वा खेल्न कुनै समस्या आएको थियो ?

(क) थियो (ख) थिएन

१५ तपाँईको वच्चालाई कहिल्यै एलर्जिक ज्वरो (एलर्जी भएर ज्वरो आउने) आएको थियो ?

(क) थियो (ख) थिएन

१६ तपाँईको वच्चालाई कहिल्यै छालाको एलर्जी (डाबर जस्तो आउने) भएको थियो जुन ३-६ महिना सम्म रह्यो ?

(क) थियो (ख) थिएन (यदि थिएन भने प्रश्न नं. २१ मा जाने)

१७ तपाँईको वच्चाको शरीरमा जस्तै कुइनाको वरिपरि, घुँडाको पछाडि, कुर्कुचा तिर, घाँटिको वरिपरि र कान र आँखाको तल पनि त्यस्तो किसिमको डाबर जस्तो देखिएको थियो ?

(क) थियो (ख) थिएन

१८ के त्यस्तोडाबर अचानक हराएको थियो ?

(क) थियो (ख) थिएन

१९ विगत १२ महिनामा त्यस्तो डाबरले वच्चाको निद्रामा केहि असर गरेको थियो ?

(क) थियो (ख) थिएन (थिएन भने प्र.नं. २१ मा जाने)

२० थियो भने कति समयसम्म असर गरेको थियो ?

(क) एक हप्ता भन्दा कम (ख) एक हप्ता भन्दा बढि

२१ वच्चालाई कहिल्यै छाला चिलाउने रोग लागेको थियो ?

(क) थियो (ख) थिएन

२२ तपाँईको घरमा कसैले धुम्रपान गर्नुहुन्छ ?

(क) गर्नुहुन्छ (ख) गर्नुहुन्न (गनुहुन्न भने प्र.नं. २४ मा जाने)

२३ यदि कसैले धुम्रपान गर्नुहुन्छ हुन्छ भने के घरभित्र नै गर्नु हुन्छ ?

(क) गर्नुहुन्छ (ख) गर्नुहुन्न

२४ खाना पकाउन तपाँई (गोबरको गुइठा, कोइला, दाउरा आदि) प्रयोग गर्नुहुन्छ ?

(क) गर्छु (ख) गर्दिन

खण्ड "ग"

विरामी खर्च र अन्य आर्थिक विषय सम्बन्धि प्रश्नावलि

२५. तपाँईको वच्चालाई श्वासप्रश्वास सम्बन्धि रोग १२ महिनायता कति पटक भएको थियो ?

(क) १-२ पटक (ख) २-४ पटक (ग) ४ पटक भन्दा बढि

२६. औषधि खरीद गर्दा र अस्पताल जाँच गर्दा जम्मा खर्च कति जति भएको थियो ? (नेपाली रुपैयाँमा लेख्नुस्)

_____

२७. सो उपचार गर्ने क्रममा यातायात खर्च कति जति भएको थियो ? (नेपाली रुपैयाँमा लेख्नुस्)

_____

२८. वच्चा विरामी भएको वेला (श्वासप्रश्वास समस्या) कति दिन जति स्कूल छुटेको थियो ?

(क) १-२ दिन (ख) २-४ दिन (ग) ४ दिन भन्दा बढि

२९. वच्चा विरामी भएको वेला (श्वासप्रश्वास समस्याले) तपाँईको कहिल्यै आफ्नो कार्यालय/दैनिक काममा असर गरेको थियो ?

(क) थियो (ख) थिएन

३०. यदि थियो भने तपाँईले आफ्नो कार्यालय कति दिन छोड्नु परेको थियो ? (दिनमा लेख्नुस्)

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Annex 3: Medical Examination Sheet

Title: **"Assessment of Impacts of Particulate Air Pollutants on Respiratory Health of School Children in Kathmandu Valley"**

ID No _____ Date: _____

Name of School:

Name_____

Age (in complete years)_____ Gender: Male/Female

History of Respiratory Problems:_____

_____

_____

History of taking prophylactic drugs:

_____

General Health:

_____

Height in cm: Weight in KG:

Anemia: None Mild Moderate Severe

Temperature:_____ Normal Raised Pulse: /min

Cardiovascular System (List any abnormality detected):_____

_____

_____

Respiratory System (List any abnormality detected):_____

_____

_____

Eye Irritation: None Redness of Eye Others_____

Skin Rashes: Absent Present Others_____

Any other problem_____

Comment:

_____

Signature of the Paediatrician

Dr Ajit Rayamajhi

Annex 4: PEFR recording form

Date:								Date:					
	Sun	Mon	Tues	Wed	Thur	Fri		Sun	Mon	Tues	Wed	Thurs	Fri
PEFR													
720							720						
700							700						
680							680						
660							660						
640							640						
620							620						
600							600						
580							580						
560							560						
540							540						
520							520						
500							500						
480							480						
460							460						
440							440						
420							420						
400							400						
380							380						
360							360						
340							340						
320							320						
300							300						
280							280						
260							260						
240							240						
220							220						
200							200						
180							180						
160							160						
140							140						
120							120						

Annex 5: Pictures on different activities of the study

Physical examination of the child by Consultant Pediatrician

Preliminary Information of the child before physical examination

Physical examination in progress

Team of Doctors, Investigators and Research Assistants

One of the Teachers involved in data collection

Research Assistant guiding the children to measure PEFR

A child taking PEFR reading

Principal (Father) of St. Xavier's School (School I – Urban Raodside)

Students of Santaneshwor Vidya Mandir (School II – Semi Urban)

Certificate of Participation to the Students

Certification of Participation to the Teachers