# Public Health Monitoring of the Metro Manila Air Quality Improvement Sector Development Program

# EXECUTIVE SUMMARY

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## 1. Introduction

The life and health of a person is shaped by situations and changes in his/her physical environment, social situations, occupational exposures, emotional relationships, and generally, lifestyle. Many of these factors are interacting and may result to a complex urban life. Protecting health is even more complex as it involves procedures of estimating the level of risks that these health hazards pose, and developing options to deal with health risks. In this project, it was decided to explore such complexity and interaction in the context of one aspect of environment and health: the health impact of air pollution and the modification of effects of air pollution by a number of markers of population heterogeneity.

Several epidemiological studies on the impact of air pollution on health have been conducted in Metro Manila in the early 1990's. In a study among drivers and commuters, symptoms of chronic obstructive pulmonary disease such as cough, phlegm, wheezing and shortness of breath were found to be more than twice prevalent among jeepney drivers as among commuters or air conditioned bus drivers (Subida and Torres, 1991). The study also reported that being a jeepney driver in Metro Manila increases the risk of abnormal pulmonary function by approximately 50 percent and the risk of chronic obstructive pulmonary disease more than doubles.

In 1993, another epidemiological study on school children and child vendors in Metro Manila reported that child vendors were at greater risk than the other child groups, both because of the roadside environments they work in and their low socioeconomic status and the risks associated with it (Subida and Torres, 1994). In general, it was reported that respirable particulate levels are above the acceptable levels in Metro Manila that the excess mortality attributable to urban air pollution expressed as mid-point of range, is 28 percent from respiratory diseases and 13 percent from cardiovascular diseases (Department of Health, 1996).

In a 1996 study among 630 infants in Metro Manila, it was reported that the cumulative incidences of acute lower respiratory infections (ALRI) and cough and colds in study areas were 81.5 per 1000 infants and 584.5 per 1000 infants respectively (Torres and Subida, 1996). These figures were much higher than the Metro Manila statistics on ALRI in 1992. From the same study, the major risk factors identified to be significant in the development of ALRI among infants were $PM_{10}$ level indoors, absence of breastfeeding, and the number of smokers in the household of infants.

A 2000 baseline health study in Metro Manila reported the inadequacies of recording and reporting health statistics particularly at the barangay health centers, and city/municipal health offices, as well as statistics at government and private hospitals on admissions and emergency room consultations (Department of Health, 2001). The study also noted that the incompleteness of health statistics is compounded by the lack of reliable air quality monitoring data in Metro Manila.

These studies have identified specific gaps that limit the identification of relationship between severity of air pollution and health effects of exposed communities in Metro Manila. Among these are:

- limited ambient air quality data in Metro Manila;
- limited exposure assessment data to estimate the presence and severity of health outcome related to air pollution and establishing exposure-response relationship coefficients;
- lack of complete, valid and reliable data for the geographic mapping of risk areas in Metro Manila air shed;

- limited implementation of a standardized health reporting and recording system on mortality and morbidity statistics both at the national and local levels;
- absence of a standardized system for monitoring, recording and reporting of health statistics at the hospital level (government and private) that is interfaced with the local government health unit and with the Department of Health; and
- lack of practical compliance monitoring and audit systems (incentives and disincentives) to ensure that all health providers (government and private) would comply with the health recording and reporting requirements.

It is envisioned that this project will address most of these gaps particularly on estimating the impact of air pollution on health, on improving the quality of reported health statistics, and on establishing baseline information for monitoring the implementation and impact of the Clean Air Act and other related policy actions on public health.

## 2. Objectives

The public health monitoring project aims to:

- identify low, medium and high-risk areas for exposure to air pollution in Metro Manila.
- assess the health effects of air pollution on populations in selected areas of Metro Manila.
- develop the capacity of the Local Government Units concerned to analyze the impact of air pollution on public health.
- delineate the public perception of the health risks associated with air pollution in selected communities in the Metro Manila air shed.
- enable government policy makers and agencies to act in ways that reduce the actual risks to public health from air pollution, while appropriately addressing public attitudes and concerns.

## 3. Project Components

To realize the set objectives, this project would consist of three components, namely, the (i) Health Risk Assessment, (ii) the Epidemiological Study on Sentinel Communities, and (iii) the Health Risk Perception Survey as illustrated in **Fig. 3.1** The results of the health risk assessment served as the basis for the epidemiological study. The third component, the Health Risk Perception Survey, aimed to define public perceptions of risks, concerns related to air pollution and health, and the roles of major stakeholders—government, private sector, non-governmental organizations among others—in reducing the health risks related to poor air quality in Metro Manila.

The expected outputs from these three components are seen to generate policy options, initiate policy actions, and strengthen program implementation on air quality improvement in Metro Manila. Among these are economic measures for reducing pollution and health risks and the continued health surveillance by Local Government Units.

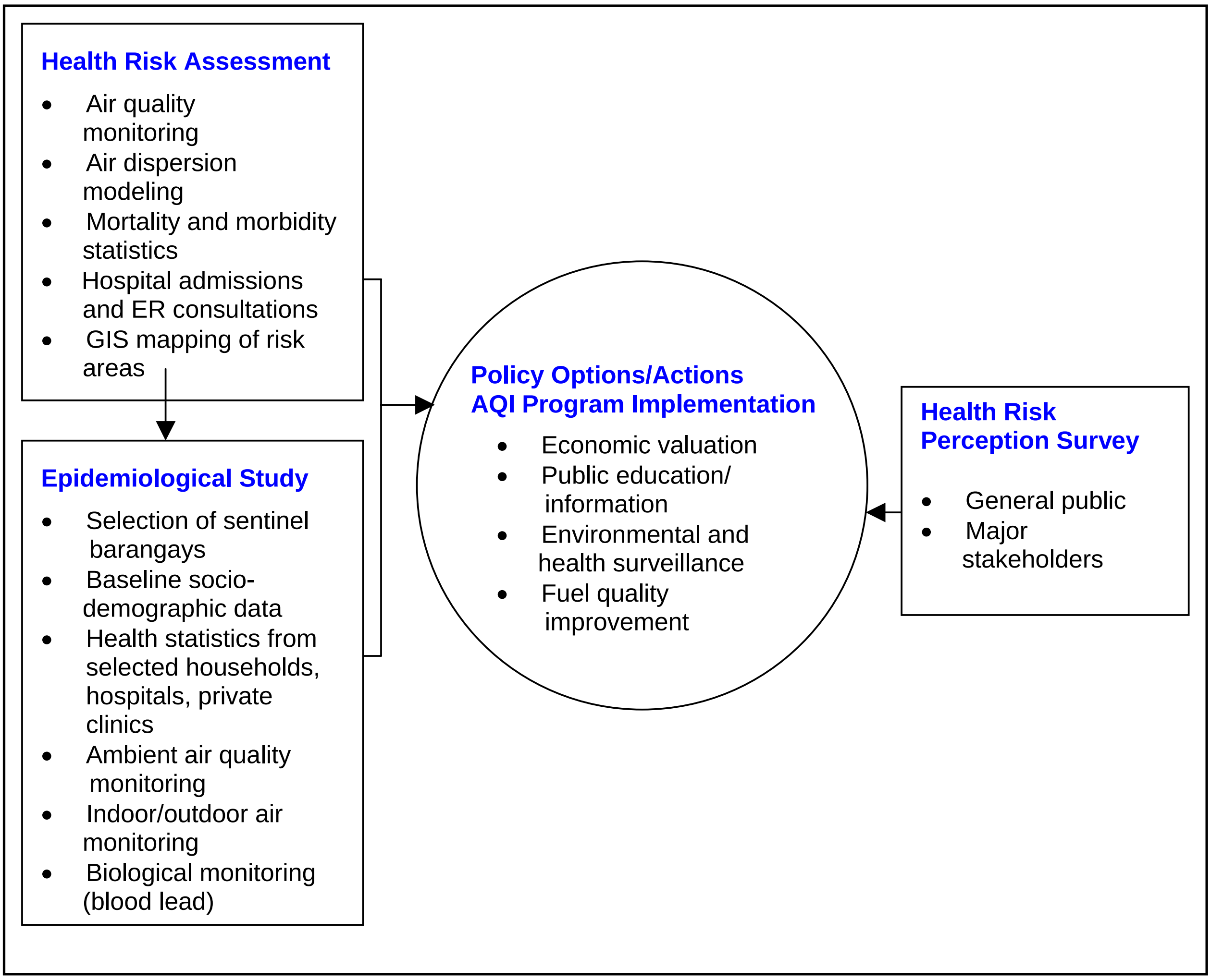


**Figure 3.1 Project components**

## 4. Methodology

### 4.1 Health Risk Assessment

To determine the different risk areas in Metro Manila, a health risk assessment (HRA) approach has been applied. This project component has an ecological design wherein exposure levels are ascertained for individual cities and barangays. The exposure levels were estimated based on an atmospheric dispersion model and ambient air monitoring results from 6 sites, and interpolated using the Geographic Information System. Apart from the ascertainment of the exposure levels, the HRA approach consists of three other elements. These are (i) the population at risk which is expressed as the number of people exposed; (ii) the baseline morbidity and mortality rates in the study area; and (iii) the exposure-response coefficients which are mostly derived from the literature.

Data collection and analysis

- Air Quality Assessment and Atmospheric Dispersion Modeling

Identifying the risk of exposure of Metro Manila residents to air pollution requires an estimate of ambient air quality levels at various points and times in the metropolis. An air quality dispersion model, the ISCLT3 was used to estimate the ambient fine particulate concentration on a 0.5x0.5km resolution grid over Metro Manila. In addition, an emissions inventory of point, mobile, and area sources was conducted to determine the relative impact of these on ambient air quality and as input to the ambient air dispersion modeling.

The atmospheric model is validated by actual measurements of the ambient air quality at select sites in Metro Manila and Antipolo City. These monitoring sites are located in (i) mixed institutional-residential area in Quezon City, (ii) traffic area of EDSA in Quezon City, (iii) mixed institutional-commercial are in the City of Manila, (iv) residential area in Las Piñas City, (v) industrial area in Valenzuela City, and (vi) remote and background area in Antipolo.

The major air pollutants measured in the six sites were particulate matter, $PM_{2.5}$ and $PM_{10}$. Levels of ozone, sulfur dioxide, nitrogen dioxide, benzene, toluene and xylene were monitored only in one site at the mixed institutional-residential area in Quezon City. Ambient air monitoring in these six sites took four months to come up with an applicable atmospheric dispersion model for the whole metropolis. The above air pollutants were regularly monitored at least once every six days from September 2002 to January except for $PM_{2.5}$ which was monitored for 3 months only.

Chemical composition data were obtained by X-ray fluorescence analysis of the filters used in monitoring $PM_{2.5}$. This enabled the determination of major sources of particulate matter as well as of other pollutants based on $PM_{2.5}$ as a proxy indicator.

- Health Data

Weekly morbidity data and the estimated exposed population from 414 health centers in the cities and municipalities of Metro Manila were collected for the period January to December 2002. Mortality data were obtained from official death registries maintained by the local government offices. The age- and sex-specific morbidity/mortality rates were then calculated for each disease condition. Hospital admissions during the same period in Metro Manila were obtained from 173 accredited hospitals of the Philippine Health Insurance Corporation (PhilHealth) in Metro Manila. The admissions data were specifically on respiratory and cardiovascular diseases which were classified according to the International Classification of Disease (ICD 10).

To assess the health risks due to exposure to air pollution, 3 indicators were estimated, namely: i) the age- and sex-specific morbidity/mortality rates, ii) the attributable risk fraction, and iii) the standardized morbidity/mortality ratios.

For the estimation of attributable risks the following equation was used:

**Attributable number of cases = exposure-response coefficient x excess exposure level x exposed population x baseline morbidity/mortality rates**

The exposure level data obtained from the six air monitoring sites were inputted into the GIS for interpolation. Two scenarios were used for estimating exposure: scenario 1 determines the excess morbidity/mortality using 50 $\mu g/m^3$ $PM_{10}$ as the benchmark and scenario 2, by maintaining the pollution level at 50 $\mu g/m^3$. This benchmark value is based on the black smoke average guideline for Europe (Air Quality Guidelines for Europe,1987). However, it should be noted that recent scientific literature on air pollution epidemiology has found no threshold for $PM_{10}$.

Although health effects due to chronic exposure are very important, this study concentrated only on the acute effects of air pollution on health because of the short period available for data collection. Such acute effects are categorized as upper respiratory symptoms and diseases; lower respiratory symptoms and diseases; and, asthma.

The standardized morbidity/mortality ratios (SMR) were estimated using an ecologically designed study. The SMR is calculated for each health center catchment area and city/municipality. The entire Metro Manila served as the standard population. Poisson regression analysis was used to determine the association of air pollution levels (measured as fine particulates) and disease (represented by SMR).

- Geographic Information System (GIS)

For this study, GIS was the main tool for the identification and mapping of the low-, medium-, and high-risk areas for exposure to air pollutants. Exposure levels were then estimated by GIS interpolation. In addition, GIS supported efforts aimed at modeling the distribution of air pollutants and estimating the likely number of people exposed and adversely affected.

The basic mapping unit is the barangay. The main GIS thematic layer acquired for and updated by the project is the map of Metro Manila that shows three thematic information, namely the barangay boundaries, the land use, and the major road network. The first has been generated already by the Public Performance Audit Project of the Metropolitan Waterworks and Sewerage System Regulatory Office and is updated as of the year 2000. The last two themes have been developed by the Metro Manila Urban Transportation Information System Project of the National Center for Transportation Studies of the University of the Philippines.

ArcView GIS 3.2 and other GIS equipment, which are available at the Department of Geodetic Engineering, University of the Philippines, were utilized to meet the GIS requirements of the project.

### 4.2 Epidemiological Study

The results of the health risk assessment component particularly on the air quality assessment and in the identification of low, medium and high exposure risk areas were used in the selection of sentinel barangays and study population, as well as the various data collection methods used to achieve the purposes of the epidemiological study.

<u>Study design</u>

To assess the health effects of air pollution in selected areas of Metro Manila, prospective collection of data and prevalence study were conducted for this project component. Prospectively collected data are the following: (i) ambient monitoring for $PM_{10}$ in six sites from January to May 2003 and modeling of $PM_{10}$ levels in the entire Metro Manila (ii) health monitoring of study children and adults from January to May 2003, (iii) monitoring of morbidity statistics in selected health centers in Metro Manila from January to May 2003, (iv) monitoring of hospital emergency room and private clinic consultation from January to May 2003. The prevalent study consists of (i) collection of primary socio-economic and demographic data as well as morbidity/mortality statistics in selected sentinel barangays. (ii) indoor and outdoor air monitoring for $PM_{10}$ and environmental lead, and (iii) biological monitoring for blood lead

Data collection methods

Data collection was conducted from January to May 2003, upon the completion of the health risk assessment component in December 2002. Generally, epidemiological studies would take at least one year of data collection to reflect seasonal variations in air quality and disease patterns. However, with limited resources, the project could undertake only five months of data collection. It should be noted that January and February are dry and cool months while March to May, dry and warm months.

A sample of twenty four (24) sentinel barangays are required for this study. These sentinel barangays are selected from the low, medium, and high exposure risk areas to air pollution. The sample size has been equally distributed according to the levels of air pollution, that is, eight sentinel barangays in each classification.

For the morbidity data collected from each barangay in January to May 2003, at least 250 qualified subjects (6-10 year old children; adults aged 18 to 64 years old and elderly aged 65 years and above) were selected. These were obtained from a cluster sample of 100 households in each barangay.

A summation of sample size for the 24 sentinel barangays-- a total of 2,400 sentinel households and maximum of 6,000 qualified subjects participated in the study. A qualified household in the sentinel barangays should have at least 1 person who is an adult (18 years old and over) and 1 child, aged 6-10 years.

**Table 4.1** lists the type of data collected and the specific variables as well as the methods of data collection for the epidemiological study.

Data analysis

- Comparison of high, medium and low exposure households using data from the household cross-sectional survey

The proportion of households with members complaining of breathing difficulty, wheezing, severe cough and chest pains were compared for three levels. Chi-square tests were done for these purposes. Likewise, the percentages of households with members who were hospitalized and/or brought to the health center/private clinic or doctor were compared.

To determine the association of the prevalence of these indicators of health problems with level of exposure and other household characteristics, Poisson regression analysis was done. The dependent variable in this model is the number of members who complained of each condition. The number of household members served as the offset variable for the Poisson regression analysis.

- Analysis of Exposure Associations

Indoor and outdoor $PM_{10}$ levels were compared. The difference of the means of these two variables were assessed using a paired t-test. The correlation between these variables was also computed. The same analysis was done for indoor and outdoor lead levels.

The mean indoor and outdoor $PM_{10}$ levels and blood lead levels were also compared among high, medium and low exposure barangays. Tests for the difference of the means were done using analysis of variance. Multiple comparisons was then performed to determine which pairs of means were different.

The determinants of indoor $PM_{10}$ levels were also identified using multiple linear regression analysis. Among the variables included in the regression are house

**Table 4.1 Summary of data requirements for the epidemiological study component**

| TYPE OF DATA | VARIABLE | SOURCE OF DATA |
|---|---|---|
| Environmental | • Ambient : $PM_{10}$, Ozone, $SO_2$, $NO_2$, benzene, toluene and xylene<br><br>• Indoor/Outdoor: 24-hr $PM_{10}$, 24-hr CO, and 8-hr $NO_2$, 24-hr lead levels | • Ambient air monitoring in 6 select sites for $PM_{10}$. For the 6 gases, only in one site (MO)<br><br>• Indoor/outdoor monitoring of sentinel households (120 HH) |
| Health | • Respiratory Symptoms: Cough, Phlegm and Wheezing<br><br>• Respiratory Diseases: asthma, acute bronchitis, ARI<br><br>• Emergency room consultations for all and cardio-respiratory causes<br><br>• Total and cardio-respiratory consultations<br><br>• Total and cardio-respiratory mortality<br><br>• Blood Lead levels | • Household morbidity questionnaire and health calendar (2400 HH)<br><br>• Emergency room and hospital records (5 hospitals)<br><br>• Health center (19 health centers) and private clinic (11 clinics) records<br><br>• Household Interview and City/municipal death registry<br><br>• Blood extraction and analysis (450 children) |
| Socio-economic | • Educational attainment of the subjects<br>• Income level of the household<br>• Smoking history of the subjects<br>• Medical history of the subjects<br>• Occupational history of the subjects<br>• Other relevant socio-demographic variables | • Household Interview questionnaire (2400 households) |

location, cooking fuel used, location of cooking facility, number of cigarette smokers who smoke inside the house and outdoor $PM_{10}$ levels.

The correlation between indoor CO levels and the number of cigarette smokers in the household as well as with the number of smokers who smoke inside the house was also obtained. Correlation analysis between $NO_2$ levels and the type of cooking fuel in the house was also done.

To determine which factors affect blood lead levels, multiple linear regression analysis was performed. The variables considered as predictors were the child's age and sex, location of the house, indoor lead and outdoor lead levels. The association of each variable was assessed first before they were included in the linear regression.

- Analysis of Child Data from Household Survey

An index child was identified for each household included in the survey. Information on health status of this child was obtained from the survey. These data included whether the child experienced frequent cough, chest tightness, wheezing and doctor-diagnosed asthma. Additionally, demographic and other relevant household characteristics such as age, the smoking behavior of the parents, type of cooking fuel, etc. were obtained. The characteristics were compared among the three levels of pollution exposure risk areas. Cross-tabulations were generated for qualitative variables. Assessment of the associations was done using chi-square tests. For quantitative characteristics, the analysis of variance was used.

To relate the presence of health problems (frequent coughing, chest tightness, wheezing, asthma) with the selected factors, logistic regression analysis was performed. A logistic regression model was fitted for each health outcome. The dependent variable was whether the child had experienced a specific health outcome at the time of interview.

- Analysis of child health calendar and adult data

Using the health calendar data, incidence of asthma and other respiratory symptoms were calculated. The association of asthma and other respiratory symptoms with selected risk factors were determined. These risk factors included age and sex of the child, location of the house (whether major or minor road), indoor $PM_{10}$ levels, indoor $NO_2$ levels, type of cooking fuel, location of cooking facility (whether inside or outside the house), crowding index, smoking behavior of father, mother and care taker, number of household members who smoke, and the income and educational attainment of respondent. The outcome variable was the number of occurrence of each health condition. For the children data, the total person-months of observation served as the offset variable. Each study factor was individually fitted in a Poisson regression. All significant variables were then considered for a multiple Poisson regression analysis. Backward selection was performed to determine which among these remained significant after controlling for the others.

- Analysis of data from health centers

Data on the daily consultations were obtained for 19 health centers. From these, weekly totals were generated from January to May, 2003 for a total of 20 weeks. The corresponding $PM_{10}$ levels in the areas where these centers are located were also determined. To relate the $PM_{10}$ levels to the incidence of respiratory diseases and symptoms, a Poisson regression model with an autoregressive component was used.

The dependent variable is the number of consultations for a specific disease in a specific age-group at different weekly periods. The independent variables were the corresponding $PM_{10}$ levels measured up to lag 2, that is, the $PM_{10}$ levels up to two weeks before the reported date of consultations were fitted separately. Again, the specific population size served as the offset variable for the regression analysis .

### 4.3 Health Risk Perception Component

<u>Study Design</u>

This component used a cross-sectional study design. Study variables collected are knowledge and perception of health risks associated with environmental pollution, specifically on air pollution as well as awareness to the national law, the Clean Air Act, and local ordinances pertaining to sources of air pollution, e.g. transportation, cigarette smoking, and garbage burning, among others.

A total of 1011 households which participated in the prospective study component were interviewed using a pre-tested questionnaire. Only the allocated adult member of the household acted as respondent. Allocation were based on gender, age groups and educational attainment of adult household members as well as the household's monthly income.

Purposive sampling was employed in choosing the key informants for the focus group discussions. There were 3 participating groups namely those from local government units in Metro Manila, from the youth sector, and from the civic/professional sector.

Data Analysis

Descriptive analysis (frequencies and association) of data was used particularly in comparing perceptions and attitudes across people who differ with regard to important personal and demographic characteristics such as age, sex, educational attainment and income. Similar treatment was done for information collected from focus group discussions.

## 5. Major findings and conclusions of the health risk assessment

- **Fine particulate matter and ozone are of serious health concern in Metro Manila**

As shown in **Table 5.1,** the results of the ambient air quality assessment indicate that coarse and fine particulate matter ($PM_{10}$ and $PM_{2.5}$ respectively) and tropospheric ozone pose considerable health risks to the population in Metro Manila. Extensive monitoring of particulate matter shows spatial differences in ambient levels. The high mean 24-hr levels of $PM_{10}$ were measured along the major road of EDSA in Quezon City at 96.9 µg/m$^3$ and in the industrial area in Valenzuela City at 70.5 µg/m$^3$. The low mean 24-hr levels were observed in the residential areas of Antipolo and Las Piñas at 31.9 µg/m$^3$ and 33.1 µg/m$^3$, respectively.

**Table 5.1 24-hour mean levels of particulate matter at the six monitoring sites**

| Site | PM10, µg/m$^3$ | PM2.5, µg/m$^3$ |
|---|---|---|
| NPO-EDSA, Quezon City | 96.9 | 78.3 |
| Mapulang Lupa, Valenzuela City | 70.5 | 56.6 |
| PGH, Taft Ave. Manila | --- | 44.3 |
| MO, Katipunan, Quezon City | 46.4 | 34.8 |
| BF Almanza, Las Piñas | 33.1 | 24.8 |
| Good Shepherd, Antipolo | 31.9 | 21.7 |

**Annual national air quality guideline value for $PM_{10}$ – 60 µg/m3*

Long term (i.e. annually averaged 24-hour) concentrations of $PM_{10}$ are likely to violate the national air quality guideline value of 60 µg/m$^3$. Despite the absence of guideline values for $PM_{2.5}$, it is also likely that both short (44.3-78.3 µg/m$^3$) and long-term levels of $PM_{2.5}$ in Metro Manila may be seriously unhealthy for the general public. It was also noted that the $PM_{2.5}$ and $PM_{10}$ ratio ranges from 59% to 73%.

Ambient ozone levels ranging from 0.015 to 0.045 ppm were measured in a relatively clean environment such as the Manila Observatory. The 98$^{th}$ percentile values for 1-hour and 8-hour are 0.12ppm and 0.084 ppm, respectively. These levels have exceeded the national guidelines of 0.07 ppm (1-hr) and 0.03 ppm (8-hr) and therefore non-attainment for this particular pollutant. Ambient levels of $NO_2$ and $SO_2$ do not show a similar trend or tendency so far.

- **Motor vehicles are the major source of particulate pollution in Metro Manila**

Whereas earlier studies in Metro Manila tended to attribute its poor air quality to both stationary sources and motor vehicles, the present study appears to prove that motor vehicles are more important. Source apportionment studies indicate the dominance of the transport sector as a source of air pollution in Metro Manila, as shown in **Table 5.2**.

**Table 5.2 Summary table for sources of particulate pollution in Metro Manila, 2003**

| Monitoring Site | Percent Contribution of Source of Particulate Pollution in Monitoring Sites | | | |
|---|---|---|---|---|
| | Traffic | Biomass burning | Construction | Soil |
| GS, background | 52.3 | 13.4 | 0.5 | 2.7 |
| MO, mixed | 74.9 | 10.9 | 0.6 | 1.6 |
| NPO, traffic | 84.6 | 5.4 | 0.7 | 0.6 |
| PGH, commercial | 82.3 | 4.9 | 1.3 | 0.8 |
| Valenzuela, industrial | 60.0 | 21.6 | 1.0 | 1.1 |
| Las Piñas | 72.5 | 5.6 | 0.1 | 2.8 |
| Range | 52.3-84.6% | 5.4-21.6% | 0.1%-1.3% | 0.6-2.8% |

- **Fine particulate levels lower in air dispersion modeling than in air monitoring**

Results of dispersion modeling tended to be lower than observed concentrations of fine particulates. Possible reasons for this tendency are the non-inclusion of background concentrations, of other types of sources (natural and anthropogenic) such as area sources and fugitive emissions, and/or the generation of fine particulates by secondary reactions driven by sunlight.

- **Considerable morbidity and mortality due to respiratory and cardiovascular diseases could have been prevented with better air quality in Metro Manila in 2002**

The impact of $PM_{10}$ on morbidity indicators is considerable. It was estimated that there were more than 10,000 excess cases of acute bronchitis, almost 300 excess cases of asthma and 9 excess cases of chronic bronchitis attributable to the air pollution with the $PM_{10}$ level above 50 µg/m$^3$ in Metro

Manila in 2002. For hospital admissions, there were 200 excess respiratory and 40 excess cardiovascular admissions. Based on the three diseases mentioned, the total morbidity attributable to air pollution in excess of the $PM_{10}$ level of 50 µg/$m^3$ was more 10,300 cases.

The impact on mortality is also quite substantial. It was estimated that the excess deaths due to cardiovascular causes attributable to the $PM_{10}$ level above 50 µg/$m^3$ were 40-200 persons and 300-330 persons for excess respiratory deaths for all of Metro Manila in 2002. The total excess deaths attributable to air pollution with the $PM_{10}$ level above 50 µg/$m^3$ in Metro Manila in 2002 were estimated to be 230-390 persons.

- **SMR analysis indicate relationship between exposure to particulate pollution and respiratory and cardiovascular diseases**

The results of the standardized mortality and morbidity ratio(SMR) analysis have shown evidence of a relationship between particulate pollution and health in Metro Manila. For mortality, it was shown that the incidence rates for respiratory and natural mortality increase by 2.6% and 3.9% respectively for every 10 µg/m3 increase in $PM_{10}$. With morbidity, comparing the most polluted with the least polluted areas, a 17% and 6.5% excess risks for asthma and acute bronchitis respectively were seen.

Secondary mortality data from the city registration office are quite reliable and can be used for this type of analysis. However, the secondary data on morbidity from the health centers, although it showed some association in the SMR analysis, lacked some level of reliability and accurateness and must be interpreted with appropriate caveats.

- **GIS important in identifying exposure-risk areas in Metro Manila**

The geographic information system(GIS) enabled the study to identify the low, medium, and high-risk to exposure areas by interpolation of ambient air monitoring results from six monitoring sites in Metro Manila and Antipolo City.

## 6. Major findings and conclusions of the epidemiological study

<u>Exposure assessment</u>

- **Exposure risk areas significantly associated with levels of fine particulate pollution**

The identified high, medium and low exposure to air pollution areas using the results of the health risk assessment component are listed in **Table 6.1**

The results of air particulate monitoring from January to May 2003 in these exposure areas show that the mean 24-hr levels in the high exposure area is 83.8 µg/$m^3$, medium exposure area at 56.8 µg/$m^3$, and low exposure area, 45.6 µg/$m^3$.

**Table 6.1 Sentinel barangays in the exposure areas**

| Exposure Area | Barangays | City/Municipality |
|---|---|---|
| High | Bagbaguin | Kalookan |
| | Mapulang Lupa | Valenzuela |
| | Paso de Blas | Valenzuela |
| | Parada | Valenzuela |
| | Paltok | Quezon City |
| | Nayong Kanluran | Quezon City |
| | Bungad | Quezon City |
| | Pinyahan | Quezon City |
| Medium | Bambang | Taguig |
| | Calzada | Taguig |
| | Ligid Tipas | Taguig |
| | Ibayo Tipas | Taguig |
| | Palingon | Taguig |
| | Tuktukan | Taguig |
| | Pineda | Pasig |
| | Martirez/Aguho | Pateros |
| Low | Sta. Cruz | Antipolo |
| | Mayamot | Antipolo |
| | Manbugan | Antipolo |
| | San Isidro | Antipolo |
| | Dela Paz | Antipolo |
| | San Luis | Antipolo |
| | Inarawan | Antipolo |
| | Bagong Nayon | Antipolo |

- **Outdoor and indoor $PM_{10}$ levels are highly correlated**

Estimation of exposure of household members to particulate matter shows that outdoor and indoor $PM_{10}$ levels are highly correlated (r = 0.847) indicating that as the outdoor $PM_{10}$ increases, the indoor $PM_{10}$ increases as well. However, no significant association can be established between outdoor $PM_{10}$ and the high, medium and low exposure areas (p = 0.193). The same is observed in the case of indoor $PM_{10}$ levels (p = 0.274).

- **Outdoor $PM_{10}$ and cigarette smoking influence indoor $PM_{10}$ levels**

Significant contributory factors of indoor $PM_{10}$ are the number of household members who smoke, the number of household members who smoke inside the house, and the outdoor $PM_{10}$ levels.

- **Cigarette smoking is a significant household health risk**

Cigarette smoking is highly practiced by the study households considering that the mean number of household members who smoke is 0.87 indicating that almost all households have at least one member who actively smokes. Majority of the smokers (65%) do smoke inside the house. More than half of these smokers are the fathers of the study children.

- **Better household cooking fuel quality reduces occurrence of hospital admissions**

Households using LPG as cooking fuel have statistically significant lower hospital admissions (19.3%) for the year 2002 as compared to households using primarily wood (27.3%) and kerosene (25.3%) as cooking fuel. Logistic regression analysis indicate that the two major predictors for hospital admissions of household members for 2002 are: (i) use of wood and/or kerosene as cooking fuel, and (ii) increase in household size.

Health impacts of particulate pollution

Child Health

- **Increasing incidence of respiratory symptoms and diseases from low to high exposure risk areas**

The trend of respiratory symptoms (cough, colds, chest tightness, wheezing) and diseases (sinusitis, acute bronchitis, pneumonia, and asthma) shows that incidences increase from the low exposure risk area to the high exposure risk area.

- **Frequent cough predicted by house location and quality of cooking fuel**

Frequent cough is reported to be more prevalent (31.8%) among children residing in households located in high pollution exposure risk areas than in the medium (26.5%) and low (27.7%) exposure risk areas. However the difference did not reach a significant level of confidence. The lowest prevalence of frequent cough (27.1%) in children can be found in households using LPG as main household cooking fuel as compared to households using other cooking fuel (32.8%) (p = .005).

- **Prevalence of wheezing influenced by cooking fuel quality**

Lower prevalence of wheezing (11%) among children residing in households using LPG as main cooking fuel as compared to other fuels (15.1%) with statistically significant difference (p = .005), As expected, higher prevalence of wheezing were reported amongst children living in households using wood as main cooking fuel as compared to other cooking fuels. The difference between groups is statistically significant (p = .022).

- **Higher doctor-diagnosed asthma reported in high exposure areas and with fathers who smoke**

More doctor-diagnosed asthma cases were reported among children residing in households located in high exposure risk areas (17.9%) as compared to medium (15.5%) and low (12.6%) exposure risk areas. Difference between areas is statistically significant (p = .013).

Health monitoring results indicate that children residing in the high exposure risk area have an asthma incidence rate of 14.9 per 1000 population as compared to those in medium exposure area (11.5) and in low exposure area (8.2).

Children with fathers who smoke have 60 percent higher risk of asthma episodes than those whose fathers do not smoke.

- **Significant risk factors for respiratory symptoms are age, indoor $NO_2$ level, cooking fuel quality and educational attainment of mothers**

For respiratory symptoms, younger children have 2.8% more risk to be sick than older ones. Indoor levels of nitrogen dioxide increase the risk of developing the respiratory symptoms by 1.7% Use of wood as cooking fuel increases the risk by 18.6% while kerosene increases the risk by 8.5%, using LPG as reference. Education is another important determinant of the risk of respiratory symptoms. Children in household with mothers who do not have formal schooling have 52% higher risk of experiencing respiratory symptoms, those with elementary education, 16.7%, and those with high school education, 8.5% as compared to those with college education.

The health monitoring calendars developed for the study proved useful for this project but not practical for monitoring purposes by LGUs due to extensive resource requirements for data collection.

- **Blood lead levels among children may have decreased but remains a health concern**

There is a significant improvement in blood lead levels among children in Metro Manila since 2000 when the unleaded gasoline policy has been implemented. In 2003, only 34.6% of study children exceeded the US-CDC guideline value of 10 µg/dl as compared to 90.3% in 2000.

Children living in high exposure areas are at risk of having higher blood lead levels compared with those living in the medium and low exposure risk areas. Results of regression analysis indicate that no child and household exposure variable is significantly associated with blood lead levels in children. This may be attributed to past exposures of children to lead and to other sources of lead such as lead in food and from industrial sources.

Adult health

- **Household cooking fuel and number of smokers are significant predictors of respiratory symptoms among adults**

Respiratory symptoms have been reported to be prevalent among study adults. Similarly among study children, wood as cooking fuel increases the risk by 13.3%, and kerosene by 12.2% as compared to those using LPG. Increasing number of smokers in the household significantly increases the risk by 6%. Socio-demographic characteristics that determine events of respiratory symptoms include, person's age and educational attainment. Asthma has not been reported to be prevalent among the study adults.

Health center morbidity monitoring

- **Fine particulate pollution contributes to events of respiratory symptoms and diseases**

Ambient $PM_{10}$ levels measured in six sites from January to May 2003 are positively associated with certain symptoms and illnesses as demonstrated in the weekly time series analysis, the significant results of which are shown in **Table 6.2**.

Daily time series analysis is generally used to best determine the association between $PM_{10}$ and health outcomes. However, in this study, the analysis was limited by the availability of ambient air monitoring data which were obtained only once every six days.

- **Health center data proved useful in health risk assessment**

The standardized health monitoring forms which included case definitions of illnesses proved to be reliable in obtaining health data at the health centers, thus, the results may be used in future health risk assessments in Metro Manila.

**Table 6.2 Significant association between $PM_{10}$ levels and respiratory symptoms and diseases**

| Symptoms | Age groups | P value |
|---|---|---|
| Cough with or without other symptoms | less than 15 years old | <0.05@ |
| Nasal discharge | less than 15 years old | <0.000@@ |
| Difficulty of breathing | less than 15 years old<br>15-64 years old | <0.000@@<br><0.05@ |
| Wheezing | less than 15 years old<br>15-64 years old | <0.05@<br><0.05@ |
| **Diseases** | | |
| Acute bronchitis | less than 15 years old<br>15-64 years old | <0.001@@<br><0.05@ |
| Acute respiratory illness | 1-4 years old<br>5-14 years old | <0.05@<br><0.05@ |
| Asthma | less than 15 years old | <0.05@ |
| Upper respiratory tract illnesses | less than 15 years<br>15-64 years old | <0.000@@<br><0.000@@ |

@ *statistically significant at 0.05,* @@ *highly statistically significant*

## 7. Major findings and conclusions of the health risk perception study

- **More perceived health risks to community than personal health**

There were more "high risk" evaluations made for community health than to personal and family health. This demonstrates the difference between personal risk and societal risk if people are not personally exposed or perceive that they are not exposed to the health risks.

- **Health-seeking behavior influenced by personal experiences**

The health-seeking behavior of the respondents is very distinct to the symptoms and the illnesses experienced. Almost all respondents would resort to self-medication when disease symptoms, except for difficulty of breathing, are experienced. Conversely, medical advice is sought when they are afflicted with specific illnesses.

- **Overall attitude of having some level of control over exposure to health risks**

Although only 43% have agreed that they have very little control over risks to their health, many of the health risks rated as "high risks" involved voluntary risks such as cigarette smoking (89%), alcohol intake (81%) and drug abuse (97%).

Issues generally rated as "high risks" are those factors in the environment by which the respondents think they have little control with, for example, pollution from industrial and vehicular emissions.

- **Gender, age, educational attainment and income influence "high risk" rating to environmental health issues**

Differences in rating "high-risk" to health issues are seen between genders, age groups, educational attainment and income groups. Females are more likely to rate lifestyle risks such as alcohol intake, multiple sex partners, and drug abuse as "high-risks". Respondents more than 55 years old tend to rate more risk factors as "high risk" than among those less than 30 years old. Those who have higher educational attainment tend to rate more risk factors as "high-risks" than those with less formal education. The higher income group tend to rate more risk factors as "high risk" than the lower income group.

Comparison of the above profile with the results of health risk perception surveys in developed countries such as Canada and Australia has shown that, similarly, females and those of older age tend to rate more health risks as "high-risk". However, in terms of educational attainment, the reverse is seen. Income was not included in the estimation of high-risk differences in studies conducted in developed countries. (Slovic, et al 1993; Starr, et al 2000).

- **Public buses and jeepneys are most risky to life**

Public buses and jeepneys are viewed as the most risky mode of public transportation due to their smoke emissions and reported involvement in traffic accidents while LRT and MRT are considered the safest transportation. Tricycles, which are seen as moderately risky, should not be phased out as a public transport according to the respondents as these are more convenient and affordable means of transport as well as a source of livelihood by many.

- **Anti-smoking policy supported by the general public**

The anti-smoking policy of the government is favorably supported by almost all respondents. However, some 25% think that they would still patronize restaurants without a no-smoking policy as long as a smoking area is made available or they feel that exposure to cigarette smoke is inevitable.

- **News media a major source of health information but perceived to be the least credible**

As source of information on environmental health, the broadcast and print media are depended upon by many people. However, the most credible source of information to their view are medical practitioners and other health workers. The print media and NGOs are perceived to be the least credible sources of information.

- **People are willing to pay for better air quality**

People's attitude toward air pollution control is positive considering that 70% are willing to pay for clean air through increasing taxes for cigarettes, increasing transport cost and making contributions to community fund.

Personal actions people are willing to undertake in improving air quality include maintaining a clean environment and compliance to regulations particularly on the anti-smoking policy. Although many see that solid waste management is more important than air quality management, a little less than half feel that the burning of garbage as a means of reducing garbage is unacceptable.

- **Local government units and community members, generally , are not aware of the provisions of the CAA**

Only 28% percent of the respondents are aware of the Clean Air Act (CAA) of 1999. The awareness on the provisions of CAA is likewise generally low among local government units, youths and professional groups

- **Government generally perceived to have not taken sufficient measures to improve air quality**

Various sectors of society are seen to play important roles in improving air quality through the implementation of the CAA. However, these sectors are generally viewed to have poorly fulfilled their responsibilities. Focus group discussions among LGUs, youth and professional groups indicated a perceived inadequacy of DENR and the industry sector to implement the CAA and programs to improve air quality.

## 8. Recommendations

Given the significant findings of the study and to effect behavioral change towards compliance to policies and regulations, the following recommendations are set forth for policy and decision makers as well as program implementers on air quality management, health risk management and communication, and on public health promotion. Most of these recommendations may be considered for short-term (next 2-3 years) implementation while those for policies and programs may take up to 5-10 years (medium to long-term) for implementation.

Air quality management

1. Meteorological and ambient air quality monitoring data with appropriate time and space resolutions should be collected to address the major data gaps in modeling air quality in Metro Manila. Validation will enhance confidence in the use of dispersion models as a tool for understanding and planning. It is expected that a new monitoring program to be implemented by the DENR from 2004 will fill this need. The DENR monitoring program should be sustained through the years in order that evaluating the impact of air quality particularly on health can be objectively assessed. Further, a data management system should be established to handle all air quality monitoring data and ensure quality assurance.

2. The simple procedure used to generate traffic data along Metro Manila's roads also should be improved and expanded to cover all major roads in the 17 cities and municipalities in Metro Manila.

3. Preliminary source apportionment studies pointed to the dominant contribution of transport sources in degrading Metro Manila's atmosphere. But these studies depended on source profiles derived in Bangkok, Thailand. In the short-term, therefore Philippine or Metro Manila-based source profiles should be generated to increase our confidence in the conclusions made by source apportionment modeling.

4. Data on stack dimensions and emission characteristics from industrial facilities should be collected to improve the accuracy of the modeling results of stationary sources. The DENR should sustain the program on emission inventory. A more accurate accounting of the use of industrial fuels sold in Metro Manila should be conducted by the Energy sector.

5. Source emissions are estimated from both activity data and emission factors. These values should be reviewed and updated. Such values include activity data such as number of vehicles and distance traveled per vehicle, emission factors per vehicle type, area source emission factors such as those that apply to dumpsites, biomass burning, household cooking, and other potentially important source activities.

6. Emissions data from other types of sources such as biomass incineration, fugitive emissions from road dust and the like, household cooking, and other potentially significant area sources should be gathered and estimated to provide a more complete appraisal of ambient levels in the city.

7. The current modeling effort focused only on particulate matter directly emitted as a primary pollutant. Fine particulate matter such as sulfates generated by secondary reactions should be investigated later using photochemical box or grid models. It is hoped that results of this method can

account for the missing background concentrations of fine particulate matter.

Health risk management

8. In the short- and medium-term, continuous modeling of air pollution levels should be performed so that local monitoring data are estimated at the city, municipality and barangay levels. This is particularly important in linking environmental quality with health monitoring data

9. The DOH should evaluate the experiences and lessons learned from the methods used in the project and decide as to its continuation and/or expansion to other sentrong sigla health centers and ultimately to the Metro Manila airshed. The DOH may likewise extend assistance in building-up capacities of LGUs on health monitoring in their locality. The health monitoring system that will be developed using the results of the project should be integrated into the larger public health monitoring system.

10. Based on the experiences of the project, the hospital data management system should be improved towards centralization and computerization while using the International Classification of Diseases (ICD10) in diagnosis. It is recommended that inclusion of a well-established and accurate hospital recording system and compliance to the ICD10 requirements be part of the PhilHealth accreditation requirements to ensure that vital hospital data are managed.

11. A complete and accurate health recording system of patients should be incorporated into a standard code of practice of private clinic practitioners. This can be implemented as part of the clinic's business permit registration at the local government level

12. Local health units should develop partnerships with sentinel private practitioners and hospitals in collecting and collating health data for use in developing a clearer picture of health status and trends in a community without compromising doctor-patient confidentiality.

Health promotion programs

13. The various programs of the DOH should be rationalized to best address the challenges of public health monitoring in the light of the devolution of its health services to the local government units. A point in case is the review of the healthy-setting programs, particularly on the healthy cities and the healthy homes, and to identify cohesive strategies for implementation by the LGUs. Meanwhile, the DOH must sustain provision of technical assistance to LGU on capacity-building particularly on public health monitoring and health promotion programs.

14. Although the blood lead levels of children in Metro Manila may have decreased by the elimination of lead in gasoline, it is still a public health concern in the country since there are still those who have elevated blood lead levels due to past exposures and that there are other sources of lead exposure. In view of this, the DOH should develop guidelines for screening and managing elevated blood lead levels in children to particularly advise medical and public health practitioners on the action areas for intervention and to guide the general public on the prevention and control of lead exposure.

15. The results of the project have shown that smoking is a significant predictor for asthma attacks and other respiratory diseases among children. Local government units should seize the opportunity in developing cohesive strategies and implementing the anti-smoking policy considering the enormous support afforded by the public to this policy. The experiences of other LGUs in enforcing the policy should be shared with other LGUs in Metro Manila and other neighboring cities.

16. The DOH should consistently pursue health promotion programs on anti-smoking in cooperation with LGUs while the national government should look at economic instruments to control the distribution, sale, and use of cigarettes and tobacco.

Other policy and program implications

17. There is a need to review the zoning plan of Metro Manila to identify industrial growth in the inner cities where the air pollution levels have consistently exceeded the national guidelines. The DENR should continue to provide technical assistance to the LGUs in this regard.

18. Alternative public transport expansion, better traffic management and road discipline, upgrades of existing traditional mode of transport (tricycles, jeepneys, and buses) to minimize air pollution emission should be vigorously pursued.

19. Although it is recognized that accessibility to cleaner cooking fuel is influenced by economic factors, there is a strong need to go up the energy ladder to prevent the unseen health risks from indoor air pollution. The use of cleaner fuel should be encouraged and made economically viable as household cooking fuel.

20. In addressing the need to phase out the more polluting transport vehicles, public concerns should be considered. Although the public perceived these to be risky to life and health, the factors of affordability, convenience and its being a source of livelihood by many, supersede the perceived risks.

Information dissemination and communication

21. Strategy to increase public awareness on health and environment in general and air pollution and health effects in particular should be instituted together with other priority health issues in the country. Effective risk communication can be tied up with the development in the public mind set of a "willingness to pay" attitude for better environment through increased taxes, registration fees, and transport costs.

22. There is a need to increase public awareness on the ways by which the public is exposed to various sources of air pollution and on how sickness may be acquired. Misconceptions should be corrected as these influence an individual's attitudes toward personal actions to control health risks. The local government health office with the technical assistance of the DOH should intensify such information campaign.

23. There is also a need for the national government to develop programs on increasing the level of awareness of the public and enhancing skills of institutions such as national and regional government agencies and LGUs on the CAA, being the main implementers of the law's provisions.

Sustainable public health monitoring system for air quality improvement program in Metro Manila

**24.** In the light of the experiences obtained and the lessons learned from the implementation of the project, a public health monitoring system should be in place and sustained by various stakeholders to ensure that the impacts of air pollution on the country's health and economic development are appropriately evaluated and addressed. **Table 8.1** describes the public health monitoring system that the project proposes for implementation by major stakeholders.

**Table 8.1 Proposed public health monitoring system**

| Component | Agency/Sector Responsible | Sources of technical and financial support |
|---|---|---|
| 1. Air quality assessment (AQA) | | |
| • Ambient air monitoring and emissions inventory | DENR(NCR and EMB) | Government of the Philippines (GOP) |
| • Air quality data management | -do- | -do- |
| • Air pollution dispersion modeling | -do- | Technical assistance from the academe (UP and Ateneo) |
| • GIS representation of ambient air quality data | -do- | -do- |
| 2. Health risk assessment (HRA) | | |
| • Health data collection at local health centers | Metro Manila LGUs | GOP |
| • Emergency room data collection in Metro Manila hospitals | NCR-DOH | GOP |
| • HRA analysis and management of health data collected from local health centers and hospitals | NCR-DOH | GOP<br>Technical assistance from Central-DOH and academe (UP-CPH) |
| • Capacity-building of NCR-DOH on health risk assessment | Central DOH | GOP |
| • Capacity-building of LGUs on health data collection | NCR-DOH | GOP |
| • Monitoring and feedback of HRA activities | Central-DOH | GOP |
| • Data linkage of AQA and health | Central-DOH | GOP |
| 3. Utilization of HRA results through policies and programs both at the: | | |
| • National level<br>• Local government level | DOH, DENR and IACEH<br>LGUs | GOP<br>Local government funds and GOP |

*DOH – Department of Health*
*NCR – National Capital Region*
*EMB – Environmental Management Bureau*
*DENR – Department of Environment and Natural Resources*
*IACEH – Inter-Agency Committee on Environmental Health*
*LGUs – Local Government Units*

## REFERENCES :

Department of Health, 2001. *Baseline Respiratory Health Profile of Communities in the Metro Manila Air Shed.*

*Philippines Environmental Health Assessment* 1996. The World Bank/Department of Health Philippines.

Slovic, P., Flynn, J., et al. *Health –Risk Perception in Canada*, Department of National Health and Welfare, 1993

Starr,G., Langley, A., and Taylor, A. *Environmental Health Risk Perception in Australia*, Commonwealth Department of Health and Aged Care, 2000

Subida, R.D. and Torres, E.B. 1991. *Epidemiology of Chronic Respiratory Symptoms and Illnesses Among Jeepney Drivers, Air-conditioned Bus Drivers and Commuters in Metro Manila.* World Health Organization/College of Public Health University of the Philippines, Manila.

Subida, R.D. and Torres, E.B. 1994. *Impact of Vehicular Emissions on Vulnerable Populations in Metro Manila*. World Health Organization/College of Public Health University of the Philippines Manila.

Torres, E.B. and Subida R.D. 1996. *Study on the Health Effects of Indoor Air Pollution Among Infants in Metro Manila.* European Commission and the Catholic University of Louvain, Brussels.

*Urban Air Quality Management Strategy in Asia (URBAIR)-Metro Manila*, 1997. IBRD/The World Bank.